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Omar Blanco*, Vicente Esteve**, María A. Prats***

Abstract

In this paper, we apply the methodology developed by Evripidou et al. (2022) to assess the co-explosivity of explosive processes between housing credit and housing prices in the Spanish economy from 1971 to 2024. Our findings highlight a significant pattern of co-explosivity: a stable bubble relationship emerges when housing credit precedes housing prices. This co-explosivity is evident for lead times of 2 to 5 years, with the strongest relationship observed at a 4-year lead. These results suggest that credit dynamics drive housing price bubbles, emphasizing the importance of targeting credit's leading effect for effective policy and market interventions to mitigate real estate bubbles.

Keywords: Housing market; Mortgages loans; Explosive behavior; Co-explosivity

JEL classification: C22; E31; E44; E51; E51; G21; R31

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Testing for co-explosive behavior between mortgages loans and house prices in the Spanish economy

1. Introduction

The global financial crisis of 2008-2009 thrust the interplay between housing prices and household borrowing into the forefront of economic policy debates. Originating from the collapse of an unanticipated housing bubble, the crisis followed a synchronized house price boom in the United States and several European countries, including Spain, Ireland, the UK, the Nether- lands, and Denmark, from 2003 to 2007. These booms, peaking in 2007, were fueled by rapid expansions of mortgage lending and securitization. Housing booms are widely recognized for their spillovers to non-housing sectors and their positive contributions to economic growth, making their transmission channels a critical focus for economists and policymakers (e.g., Jorda et al., 2015).

Financial crises often lead to persistent or permanent output losses (see, e.g., Cerra and Saxena, 2008; Baron et al., 2021). International evidence suggests that debt booms increase the risk of financial crises, and the subsequent output losses outweigh the growth benefits of debt-fueled booms that avoid crises. Spanish experience is particularly relevant for studying the impact of housing credit on economic growth, given its pronounced real estate boom from 1995 to 2007.[1]

The housing market has been a cornerstone of the Spanish economy over recent decades. Much of the literature on the Spanish housing market examines the determinants of house prices and the housing price bubble that persisted until 2007 (see, e.g., Estrada et al., 2009; Gimeno and Martinez- Carrascal, 2010; Rodríguez and

[1] On the origins of Spanish housing boom, see Jimeno and Santos (2014) and Santos (2017).

Bustillo, 2010; González and Ortega, 2013; Neal and García-Iglesias, 2013; Arrazola et al., 2015). More recent studies focus on the evolution of house prices since the 2014 recovery (see, e.g., Alves and Urtasun, 2019; Bank of Spain, 2024; López-Rodríguez and de los Llanos Matea, 2019). Other research explores the role of banks and credit supply in transmitting the housing boom, using bank-, firm-, and loan-level micro-data. For instance, Jiménez et al. (2020) argue that the Spanish housing boom enabled banks to expand credit supply through mortgage securitization of real-estate assets. Similarly, Martín et al. (2021) document that the housing boom in Spain affected the rest of the economy by increasing banks' net worth and expanding credit supply. They show that rising house prices increased bank net worth, initially crowding out credit to non-housing sectors but later expanding it across all industries.

This paper examines the interaction between housing prices and housing credit in Spain from 1971 to 2024, contributing to the empirical literature on the Spanish economy in two ways. First, we employ recursive unit root tests for explosiveness, proposed by Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2015), to investigate whether nominal house prices and housing credit exhibit bubble-like behavior at any point in the time series. Second, we apply the methodology of Evripidou et al. (2022) to assess co-explosiveness between housing credit and house prices. Thus, this study not only analyzes the univariate explosiveness of these series but also explores their interdependence. A (stable) asynchronous co-explosiveness would permit the construction of early warning indicators for upcoming explosiveness in housing markets.

The rest of the paper is organized as follows. Section 2 discusses the nexus between housing prices and housing credit. Section 3 presents the methodology. Section 4 reports the empirical results. Section 5 concludes.

2. Theoretical framework

Economic theory suggests a bidirectional relationship between housing prices and credit availability. First, the availability of bank credit stimulates housing demand and, consequently, prices due to lower lending rates, favorable economic expectations, and relaxed household liquidity constraints (Oikarinen, 2009). Banks assess borrowers based on their creditworthiness and the collateral value of properties, which influences lending rates. Increased credit availability and affordability, coupled with short-term supply rigidity, drive up housing prices (Arestis and González, 2012). Conversely, rising housing prices can boost bank lending by increasing credit supply or demand (Goodhart and Hofmann, 2008). However, central banks regulate debt standards to ensure sustainable financing and prevent over-leveraging. As housing debt constitutes a significant portion of bank portfolios, rising property prices strengthen bank balance sheets, encouraging further lending. In contrast, a housing price crash heightens default risks, prompting banks to curtail lending to the housing sector.

Second, the "financial accelerator mechanism" explains the two-way causality between housing market volatility and financial sector stability (Bernanke and Gertler, 1995; Bernanke et al., 1999). Higher housing prices increase the credit required for home purchases, exerting upward pressure on credit demand. Additionally, as most housing loans are secured by the property itself, rising prices enhance collateral values, boosting households' net worth and borrowing capacity. Simultaneously, higher property valuations reduce the riskiness of bank assets by lowering default risks, incentivizing banks to expand lending. This banking sector activity amplifies asset price appreciation through credit expansion (Herring and Wachter, 2003; Pavlov and Wachter, 2006).

Moreover, housing prices influence household borrowing through wealth effects. Consistent with this theory, credit cycles have aligned with housing price cycles across numerous countries (e.g., IMF, 2000; BIS, 2001; Goodhart and Hofmann, 2007; Alburquerque et al., 2025; Hoynck et al., 2025).

The empirical literature investigates whether bank lending Granger- causes housing price increases due to relaxed lending standards during asset price surges, or whether rising housing prices drive lending expansion (Anundsen and Jansen, 2013; Hoffmann, 2004). However, findings remain inconclusive (see Anundsen and Jansen, 2013, for a comprehensive review).

3. Methodology

3.1 Testing for explosiveness in the individual series

3.1.1 The bubble model

Kurozumi, Skorobotov and Tsarev (2023) analyze a time series process $\{y_t\}$generated by a data-generating process (DGP) that incorporates one explosive regime followed by a collapsing regime, as follows:

$$y_t = \eta + u_t \tag{1}$$

$$u_t = \begin{cases} u_{t-1} + \varepsilon_t, & t = 1, \ldots, \lfloor \tau_{1,0} T \rfloor, \\ (1+\delta_1) u_{t-1} + \varepsilon_t, & t = \lfloor \tau_{1,0} T \rfloor + 1, \ldots, \lfloor \tau_{2,0} T \rfloor \\ (1-\delta_2) u_{t-1} + \varepsilon_t, & t = \lfloor \tau_{2,0} T \rfloor + 1, \ldots, \lfloor \tau_{3,0} T \rfloor \\ u_{t-1} + \varepsilon_t, & t = \lfloor \tau_{3,0} T \rfloor + 1, \ldots, T, \end{cases} \tag{2}$$

$$\varepsilon_t = \sigma_t e_t \tag{3}$$

where $\delta_1 \geqslant 0, \delta_2 \geqslant 0, 0 \leq \tau_{1,0} < \tau_{2,0} \leq \tau_{3,0} \leq 1$. The process $\{y_t\}$ typically follows a unit root process but may exhibit a bubble at $\lfloor \tau_{1,0} T \rfloor + 1$ characterized by an explosive AR(1) coefficient $1 + \delta_1$. This is followed by a collapsing regime from $\lfloor \tau_{2,0} T \rfloor + 1$ to $\lfloor \tau_{3,0} T \rfloor$, during which the process behaves as a stationary process. This collapse represents a return to normal time series behavior. The parameter δ_2 determines the magnitude of the bubbles collapse, with the duration spanning the period from $\lfloor \tau_{2,0}T \rfloor + 1$ to $\lfloor \tau_{3,0}T \rfloor$.

In the presence of heteroskedasticity, the volatility of the innovations, σ_t, in (3), may be non-stationary, as used by Phillips, Wu, and Yu (2011) (2011, PPWY henceforth) and Phillips, Shi, and Yu (2015a, b, PSY henceforth), among other, implies that $\sigma_t = \sigma$ for all t.

Alternatively, the time series process $\{y_t\}$ can be expressed as,

$$y_t = (1 + \delta_t)y_{t-1} + \varepsilon_t \tag{4}$$

or

$$\Delta y_t = \delta_t y_{t-1} + \varepsilon_t \tag{5}$$

The null hypothesis, H_0 posits that no bubble is present in the series and y_t follows a unit root process throughout the sample period, i.e., $\delta_t = 0$ in (4).[2] The alternative hypothesis H_1 posits that a bubble is present in the series, corresponding to the case where δ_t in (4) is not stable at 1, and the model is given by $(1) - (3)$ with $\delta_1 > 0$.

3.1.2 Tests for explosive autoregression in the individual series

PWY and PSY developed tests for detecting explosive bubbles using recursive right-tailed Dickey-Fuller-type unit root tests, which identify evidence of explosive behavior in a time series $\{y_t\}$.

PWY proposed a test based on the maximum of Augmented Dickey-Fuller (ADF) test statistic computed over subsamples. Their testing procedure is derived from the regression model,

$$\Delta y_t = \mu + \delta y_{t-1} + \varepsilon_t \tag{6}$$

[2] The null hypothesis can be expressed using (2) in several ways such that $\tau_{1,0} = 1, \delta_1 = 0, \tau_{2,0} = 1$, or $\delta_1 = \delta_2 = 0$.

for $t = \lfloor \tau_1 T \rfloor + 1$ to $\lfloor \tau_2 T \rfloor$.

The parameter of interest is δ. The null hypothesis of a unit root, $H_0: \delta = 1$, is tested against the right-tailed alternative, $H_1: \delta > 1$, at least in some subsample. The model is estimated by Ordinary Least Squares (OLS) and the t-statistics associated with the estimated δ is referred to as ADF statistic.

The $SADF$ test is defined as the supremum of the ADF statistic from forward recursive regressions:

$$SADF(r_0) = \sup_{r_2 \in [r_0, 1]} ADF_0^{r_2} \tag{7}$$

where the right-tail is the rejection region. This test can be used for testing for a unit root against explosive behavior in some subsample. It is a test that aims to detect the existence of at least one speculative bubble in the time series.

PSY proposed a generalized version of the sup $ADF(SADF)$ test of PWY. Their Generalized Supremum ADF ($GSADF$) test is,

$$GSADF(r_0) = \sup_{r_2 \in [r_0, 1], r_1 \in [0, r_2 - r_0]} ADF_0^{r_2} \tag{8}$$

The statistic (8) is used to test the null of a unit root against the alternative of recurrent explosive behavior, as the statistic (7). It is a test that allows for the detection of multiple bubbles and collapses through the series.

Note that the $SADF$ is a special case of $GSADF$ test, obtained by setting $r_1 = 0$ and $r_2 = r_\omega \in [r_0, 1]$.[3]

[3] Phillips and Shi (2018) showed that, while the $GSADF$ procedure is designed to detect the bubble behavior, it can also identify crisis periods, as further explored in Phillips and Shi (2019, 2020). These periods are frequently observed in empirical applications.

3.1.3 Identification of explosive periods

To identify the onset and conclusion of explosive behavior, we apply the backward-expanding window $BSADF$ test proposed by PSY. It performs ADF-tests using a backward-expanding sample with a fixed endpoint r_2 and varying starting points r_2, defined as:

$$BSADFr_2(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \{ADF_{r_1}^{r_2}\} \tag{9}$$

The estimator of the initiation date of explosiveness, $\widehat{r_e}$, is the first point at which the test statistic exceeds its wild bootstrapped critical value sequence, $scr_{r_2}(\beta_r)$. The termination date estimator, $\widehat{r_f}$, is the first point at which the test statistic falls below its critical value. These are formally defined as follows:

$$\widehat{r_e} = \inf_{r_2 \in [r_0, 1]} \left\{ r_{r_2} : BSADF_{r2}\ (r_0) > scr_{r_2}(\beta_r) \right\} \tag{10}$$

$$\widehat{r_f} = \inf_{r_2 \in [\widehat{r_e}, 1]} \left\{ r_{r_2} : BSADF_{r2}\ (r_0) < scr_{r_2}(\beta_r) \right\}$$

The $BSADF$ test serves as our primary methodology, enabling precise identification and date-stamping of explosive bubble episodes in the time series.

3.2 *The co-explosive model*

We use the recent approach of Evripidou et al. (2022), who employ a KPSS test to evaluate co-explosiveness in a bivariate setting. Co-explosiveness occurs when two or more time series exhibit a shared explosive process. Three scenarios-synchronous co-explosiveness, asynchronous co-explosiveness (with a lead/lag structure) and no-co-explosiveness — can significantly impact financial markets stakeholders and economic policymakers.

Consider two observed time series y_t and x_t, where x_t includes an explosive episode. The DGP for the temporarily explosive time series y_t is defined as:

$$y_t = \mu_y + \beta_x x_{t-i} + \beta_z z_t + \varepsilon_{y,t} \tag{11}$$

where μ_y is a constant, x_{t-i} is a temporarily explosive time series with i as an integer (positive, negative, or zero) capturing potential lead-lag dynamics, z_t being a latent, unobserved process, and $\varepsilon_{y,t}$ is a mean zero I(0) error term. The co-explosive model allows for correlation among $\varepsilon_{y,t}$, $\varepsilon_{x,t}$, and $\varepsilon_{z,t}$. Under this DGP, y_t exhibits explosive dynamics driven by x_{t-i} if β_x>0 and β_z = 0, by z_t if β_z> 0 and β_x = 0, or both x_{t-i} and z_t if β_x> 0 and β_z > 0.

Regarding co-explosiveness in (11), if β_z = 0, and β_x>0, then y_t and x_{t-i} are co-explosive, meaning the linear combination $y_t - \mu_y - \beta_x x_{t-i}$ is *I(0)* . This implies stationarity across all sub-regimes of y_t and x_{t-i} indicating that co-explosiveness also entails cointegration in the *I(1)* regimes and a stationary linear combination in the explosive regimes.

Co-explosiveness can manifest as follows:

1. Contemporaneous: if i = 0, the explosive behavior occurs simultaneously.
2. Lagged: if i > 0, the explosive episode in x_t precedes that in y_t by i periods, with the explosive dynamics in x_t propagating to y_t after the lag.
3. Leading: if i < 0, the explosive episode in y_t precedes that in x_t by i periods, establishing a co-explosive relationship where y_t leads x_{t-i}.
4. No co-explosiveness: if β_z> 0 and β_x= 0, y_t and x_{t-i} are no-co-explosive.

3.2.1 Testing for co-explosivity

When testing for co-explosive behavior between the observed series, the hypotheses for model (11) are formulated as follows:

$$H_0: \ \beta_x > 0, \ \beta_z = 0 \text{ co} - \text{explosiveness (stationarity)} \qquad (12)$$

$$H_1: \ \beta_x = 0, \ \beta_z > 0 \text{ no co} - \text{explosiveness (non} - \text{stationarity)}$$

Under the null hypothesis H_0, y_t and x_t are co-explosive, such that the linear $y_t - \mu_y - \beta_x x_{t-i}$ is *I(0)*. Under the alternative hypothesis H_1, the processes are not co-explosive.

To test for co-explosivity, Evripidou et al. (2022) propose a modified KPSS-type statistic:

$$S = \hat{\sigma}_y^2 \ (T-|i|)^{-2} \sum_{t=\mathrm{i}\mathbf{1}(\mathrm{i}>0)+1}^{T+i\mathbf{1}(i<0)} \left(\sum_{s=i\mathbf{1}(\mathrm{i}>0)+1}^{t} \hat{e}_{y,s} \right)^{-2} \tag{13}$$

where T is the number of observations, $\hat{e}_{y,s} = y_t$- $\hat{\mu}_y$- $\hat{\beta}_X \, x_{t-i}$ are residuals obtained from regressing y_t on a constant and x_{t-i} , and the estimate variance $\hat{\sigma}_y^2 = \frac{1}{T-|\mathrm{i}|} \Sigma_{t=\mathrm{i}\mathbf{1}(\mathrm{i}>0)+1}^{T+i\mathbf{1}(i<0)} \hat{e}_y^2$. To account for serial correlation in the residuals, $\hat{\sigma}_y^2$ is replaced with the Newey-West (1994) long-run variance estimate. A KPSS statistic exceeding its wild-bootstrapped critical value leads to rejection of the null hypothesis of co-explosiveness.

3.2.2 Identifying the timing of explosive regime migration

Under the null hypothesis of co-explosiveness, the lag/lead parameter is typically unknown in practical applications. Evripidou et al. (2022) propose selecting i from a predefined range of values J, where i is chosen to minimize the residual variance $\left(\hat{\sigma}_{y,j}^2\right)$ from the regression of y_t on x_{t-i} and a constant.

$$i^* = \arg\min_{j \in J} \hat{\sigma}_{y,j}^2 \tag{14}$$

The value of i^* is used to compute the test statistic (13) and its corresponding wild-bootstrapped critical value, both essential for the co-explosiveness test. The range J typically includes negative lags (when y_t leads x_t) and positive lags (when x_t leads y_t), allowing for bidirectional relationships.

4. Empirical application

4.1 Data

We use time-series data on the Spanish economy from 1971 to 2024, a 54-year sample period that is well-suited for the econometric approach employed in this study.[4] The dataset includes the following variables: credit to housing (CTH_t), nominal GDP (Y_t), credit housing to GDP ratio (cth_t= CTH_t/Y_t), nominal house price index (nhp_t), and real house price index (rhp_t). Credit to housing is sourced from Jordà et al. (2017) for 1971-1991, based on mortgage loans to the non-financial private sector, and from the Bank of Spain (2025a, Table 4.12, column 15) for 1992-2024, reflecting credit to construction and housing. Nominal GDP is obtained from Prados de la Escosura (2017, Table 1) and Bank of Spain (2025a, Table 11.1, colum 12), while nominal and real house price indices are sourced from OECD (2025). Figure 1 illustrates the evolution of the nominal house price index (nhp_t) and the credit housing to GDP ratio (cth_t).

The data reveal three distinct house price cycles in recent decades. First, from 1995 to 2007, Spain experienced a pronounced housing boom, with nominal house prices, real house prices, and the credit housing to GDP ratio rising by 235.1%, 133.8%, and 310.4%, respectively (see Figure 2).[5] During this period, the Spanish economy grew robustly, with real GDP increasing by an average of 3.7% annually from 1994 to 2007. This economic expansion coincided with a credit boom, primarily driven by housing-related credit, which includes loans to construction firms, real estate, and mortgages. Domestic savings were insufficient to finance this credit surge, leading banks to tap international debt markets to channel capital inflows to firms and households. Total housing credit expanded nearly a thousandfold between 1994 and 2007, and its share of total credit rose from 39.1% in 1994 to 62.4% in 2007.[66] The accumulation of non-performing loans on bank balance sheets triggered a severe banking crisis, as documented by Baudino et al. (2023) and Bank of Spain (2017, 2019).

[4] Data are available upon request from the authors.

[5] Data from BIS (2025)

[6] Non-housing credit was influenced by factors such as declining interest rates following the euro's introduction and population growth.

Second, the housing and economic booms collapsed between 2007 and 2013, marked by declines in nominal house prices, real house prices, and the credit housing to GDP ratio of 35.1%, 41.3%, and 18.2%, respectively.

Third, from 2013 to 2023, nominal and real house prices rebounded by 66,6% and 33.6%, respectively, with nominal house prices reaching their 2007 peak, potentially signaling a new bubble. Sustained housing demand, driven by lower interest rates, robust job creation, and strong foreign demand, has outpaced the supply of new housing, which, despite recent expansion, remains insufficient. This demand-supply imbalance continues to drive house price escalation, as noted by the Bank of Spain (2024). Finally, from 2009 to 2024, the credit housing to GDP ratio plummeted by 64,1%.

4.2 Tests for explosive autoregression in the individual series

Since co-explosiveness requires explosive autoregressive regimes in the individual series, we first test for such behavior in the nominal house price index (nhp_t) and the credit housing to GDP ratio (cth_t). We employ the recursive unit root tests proposed by PWY and PSY to detect bubble-like behavior in these series, specifically using *SADF*, *GSADF*, and *BSADF* tests.

The *SADF* test identifies a single speculative bubble by applying the *ADF* test recursively with a fixed starting point and expanding endpoints. It is well-suited for detecting a single explosive episode. In contrast, the *GSADF* test extends this framework to detect multiple bubbles, even when closely spaced, making it more robust for comprehensive empirical and historical financial analyses. The *BSADF* test further generalizes the approach by varying both the starting and ending points of the estimation window, enabling precise identification and dating of multiple exuberance episodes via the datestamping procedure, which enhances historical diagnostics and empirical reliability.

For our empirical analysis, the minimum window size, $minw$, defines the shortest subsample for recursive right-tailed ADF tests in the SADF and GSADF procedures. Following PWY and PSY, we set $minw$ as a fraction of the total sample size T to balance statistical power and the number of estimable subsamples, calculated as:

$$minw = (\max 5\, \lfloor \delta . T \rfloor), \tag{15}$$

where $\delta \in [0.1, 0.2]$ (commonly $\delta = 0.2$) is a pre-specified proportion and $\lfloor . \rfloor$ is the floor operator. A minimum of 5 observations ensures reliable estimation in small samples. For our sample, $minw = 10.8$, corresponding to an 11-year minimum subsample length. The lag order p for the ADF test is selected automatically using the Bayesian Information Criterion (BIC), as recommended by PWY and critical values for the $SADF$ and $GSADF$ statistics are generated via Monte Carlo simulations with 500 replications, providing significance levels at 10%, 5% and 1%.

Table 1 reports the $SADF$ and $GSADF$ test results for $nhp_t$and cth_t, along with their right-tail critical values for the 1971-2024 sample. For nhp_t, the $SADF$ test fails to reject the unit root null hypothesis at the 95% significance level, indicating no evidence of a single explosive episode. However, the $GSADF$ statistics exceed its critical value, rejecting the null in favor of multiple explosive periods, suggesting robust evidence of recurrent bubbles in nominal house prices. The $GSADF$ test's superior statistical power makes it more reliable for detecting multiple bubbles.

For cth_t, both the $SADF$ and $GSADF$ tests reject the unit root null hypothesis at the 95% significance level, providing evidence of at least one bubble and multiple explosive periods, respectively, in the credit housing to GDP ratio.

Figures 3 and 4 illustrate the detected bubble episodes for both series, plotting the $BSADF$ statistic sequence against the 95% critical value sequence (derived from 500 Monte Carlo replications). Shaded areas show the periods of significant explosivity.

For nhp_t, Figure 3 identifies exuberance periods from 1988 to 1991 (coinciding with economic expansion before the 1992 Barcelona Olympics and Seville Universal

Exposition) and from 2001 to 2007 (preceding the subprime mortgage crisis and coinciding the "Spanish housing boom"). For cth_t, Figure 4 detects two exuberance episodes from 1992-1993 after the economic expansion the 1992 Barcelona Olympics and Seville Universal Exposition, and from 1999-2008 preceding the subprime mortgage crisis and coinciding the "Spanish housing boom". These findings reinforce the interconnected dynamics of housing prices and housing credit.

4.3 Evidence of co-explosivity

To examine co-explosive behavior between the series of housing credit and housing prices in Spain (1971-2024), we applied the methodology proposed by Evripidou et al. (2022). Their KPSS-based test enables the assessment of both simultaneous and lead/lag co-explosivity. We analyzed the relationship in both directions: housing prices leading housing credit and housing credit leading housing prices.

For our empirical analysis, we applied the KPSS test to the linear combination of the series, accounting for residual autocorrelation using a Bartlett kernel with a lag length selected by the "long" method ($l = \lfloor 12(T/100)^{\frac{1}{4}} \rfloor$) , following the recommendations of Kwiatkowski et al. (1992) and Newey and West (1994). Lags and leads i (ranging from -5 to +5 years) were computed by temporally shifting the series, aligning housing credit at time t with housing prices at $(t - lag)$ for positive lags (credit leading prices) and prices at $(t + |lag|)$ for negative lags (prices leading credit), following Evripidou et al. (2022). Robust critical values were obtained via wild bootstrap with 1,000 iterations, as proposed by Hafner and Herwartz (2009), ensuring robustness to heteroskedasticity and residual autocorrelation. Additionally, lag selection was further supported by Schwert (1989), who advocates for $T^{1/4}$-type rules in stationarity tests.

Table 2 presents critical values at the 5% significance level, derived from wild bootstrap with 5,000 Monte Carlo replications, compared to the modified KPSS-type statistic for co-explosivity (S) calculated as (13). The null hypothesis H_o posits that the linear combination is stationary, indicating co-explosivity and a persistent bubble relationship between the series. Conversely, the alternative hypothesis H_1 suggests non-stationarity, implying no co-explosivity and no stable long-term bubble relationship, even if the series are individually explosive. Table 2 also reports residual variance estimates $\hat{\sigma}^2_{y,i}$. The optimal delay (i^*) is identified by minimizing the residual variance in the regression, with lower variances indicating stronger co-movement.

First, when housing prices precede housing credit, the KPSS test statistics consistently exceed the critical values across all lags and leads, leading to the rejection of H_o. This outcome indicates non-stationarity of the linear combination, suggesting no co-explosivity in this direction.

Second, for housing credit leading housing prices, the results are mixed. For lags from -5 to -1 years, as well as at lag 0, the statistics exceed the critical values, resulting in the rejection of H_o. However, for leads of +2 to +5 years, the statistics fall below the critical values, leading to the non-rejection of H_o. In these cases, housing credit leads housing prices, with co-explosivity observed within this range, indicating a stable long-term bubble relationship driven by housing credit. The optimal lead, determined by the minimum residual variance (see Table 2), is i^* = +4 suggesting that explosive behavior in housing credit anticipates explosive behavior in housing prices by 4 years.

5. Conclusions

This study is the first to apply the methodology of Evripidou et al. (2022) to investigate co-explosivity in the Spanish housing market, using annual data from 1971 to 2024. We employ this methodology to examine co-explosivity between housing credit and house prices, analyzing both the univariate explosiveness of these series and their interdependence. The KPSS-based test developed by Evripidou et al. (2022) enables us to assess simultaneous and lead/lag co-explosivity behaviors.

First, to examine explosiveness in individual series, we use recursive unit root tests proposed by Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2015) to assess whether nominal house prices and housing credit exhibit bubble-like behavior. These tests identify periods of exuberance 1988-1991 and 1992-1993 (coinciding with economic expansion before the 1992 Barcelona Olympics and Seville Universal Exposition) and 2001-2008 (preceding the subprime mortgage crisis and the "Spanish housing boom").

Second, regarding co-explosivity, the KPSS test for co-explosivity reveals no co-explosivity when house prices lead housing credit, as the null hypothesis of stationarity is rejected across all lags (-5 to +5 years). However, a significant co-explosivity pattern emerges when housing credit leads house prices, with a stable bubble relationship observed for leads of 2 to 5 years. The strongest relationship occurs at a 4-year lead, indicating that credit dynamics precede and drive housing price bubbles.

This finding is central to our analysis, highlighting the critical role of credit in triggering housing price bubbles. It underscores the importance of addressing the leading effect of credit is essential for effective policy and market interventions aimed at mitigating real estate bubbles. The empirical evidence, particularly at the 4-year lead, reveals a feedback mechanism in which credit growth drives subsequent price increases.

Given that our econometric analysis identifies credit dynamics as a key driver of housing bubbles, policy interventions should encompass macroprudential and microprudential measures, alongside fiscal and structural policies.

Regarding macroprudential policies, Royal Decree-Law 22/2018 and Royal Decree-Law 102/2019 provide for the Bank of Spain to set limits on the standards applied by banks in new lending to households. For instance, for mortgages, the Banco de España could set limits on loan-to-price (LTP), loan-to-income (LTI) and loan service-to-income (LSTI) ratios, and establish the maximum terms for new mortgages, among other measures (Bank of Spain, 2025b).

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7. Appendix

Table 1

Tests for explosive behavior: the $SADF$ and $GSADF$ tests

Unit root test	Estimated value		Critical value 95%	
	nhp_t	cth_t	nhp_t	cth_t
$SADF$	1.11	3.61	1.524	1.62
$GSADF$	11.59	4.21	0.665	0.665

Table 2

Test for co-explosive behavior: test statistic *S*

a) Housing prices → housing credit ($y_t \sim x_{t-1}$)

Lag/lead (i) (years)	Test statistics	Critical Values (5%)	Decision H_o	Interpretation	Variance
-5	0.2847	0.2754	Rejected	non co-explosivity	0.2497
-4	0.2560	0.2625	Rejected	non co-explosivity	0.2419
-3	0.2543	0.2475	Rejected	non co-explosivity	0.2418
-2	0.2500	0.2329	Rejected	non co-explosivity	0.2505
-1	0.2488	0.2171	Rejected	non co-explosivity	0.2650
0	0.2510	0.2051	Rejected	non co-explosivity	0.2881
1	0.2378	0.1857	Rejected	non co-explosivity	0.2736
2	0.2302	0.1690	Rejected	non co-explosivity	0.2616
3	0.2286	0.1604	Rejected	non co-explosivity	0.2604
4	0.2319	0.1587	Rejected	non co-explosivity	0.2707
5	0.2355	0.1641	Rejected	non co-explosivity	0.2757

b) Housing credit → housing prices ($x_t \sim y_{t-1}$)

Lag/lead (i) (years)	Test statistics	Critical Values (5%)	Decision H_o	Interpretation	Variance
-5	0.3008	0.1764	Rejected	non co-explosivity	0.2087
-4	0.2851	0.1779	Rejected	non co-explosivity	0.1850
-3	0.2632	0.1719	Rejected	non co-explosivity	0.1690
-2	0.2434	0.1801	Rejected	non co-explosivity	0.1461
-1	0.2221	0.1807	Rejected	non co-explosivity	0.1373
0	0.1999	0.1730	Rejected	non co-explosivity	0.1312
1	0.1831	0.1814	Rejected	non co-explosivity	0.1191
2	0.1675	0.1803	Not rejected	co-explosivity	0.1110
3	0.1545	0.1754	Not rejected	co-explosivity	0.1059
4 (*)	*0.1470*	*0.1771*	*Not rejected*	*co-explosivity*	*0.1045*
5	0.1465	0.1709	Not rejected	co-explosivity	0.1063

Notes:
$y_t \sim x_{t-1}$ the regression of housing prices on lagged housing credit and $x \sim y_{t-1}$ the regression
of housing credit on lagged housing prices.
(*) The optimal delay *(i^*)*.

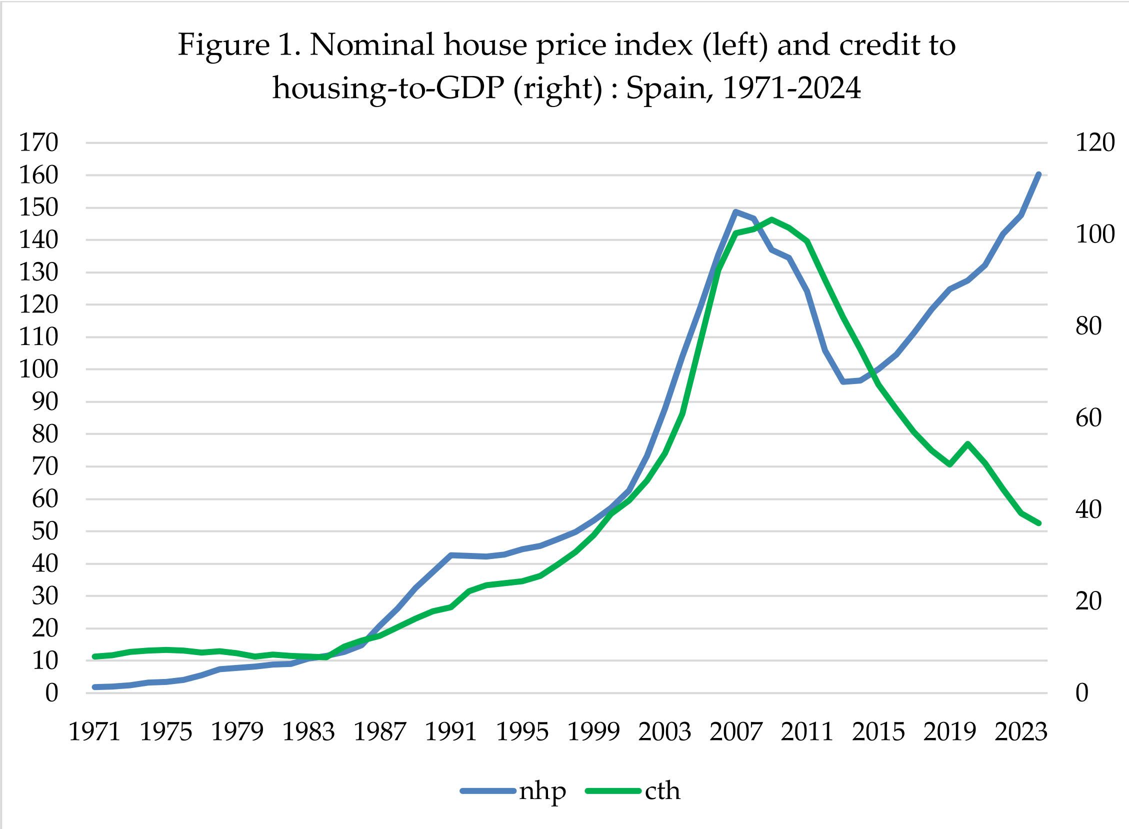
Figure 1. Nominal house price index (left) and credit to housing-to-GDP (right) : Spain, 1971-2024
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
120
100
80
60
40
20
0
1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023
nhp
cth

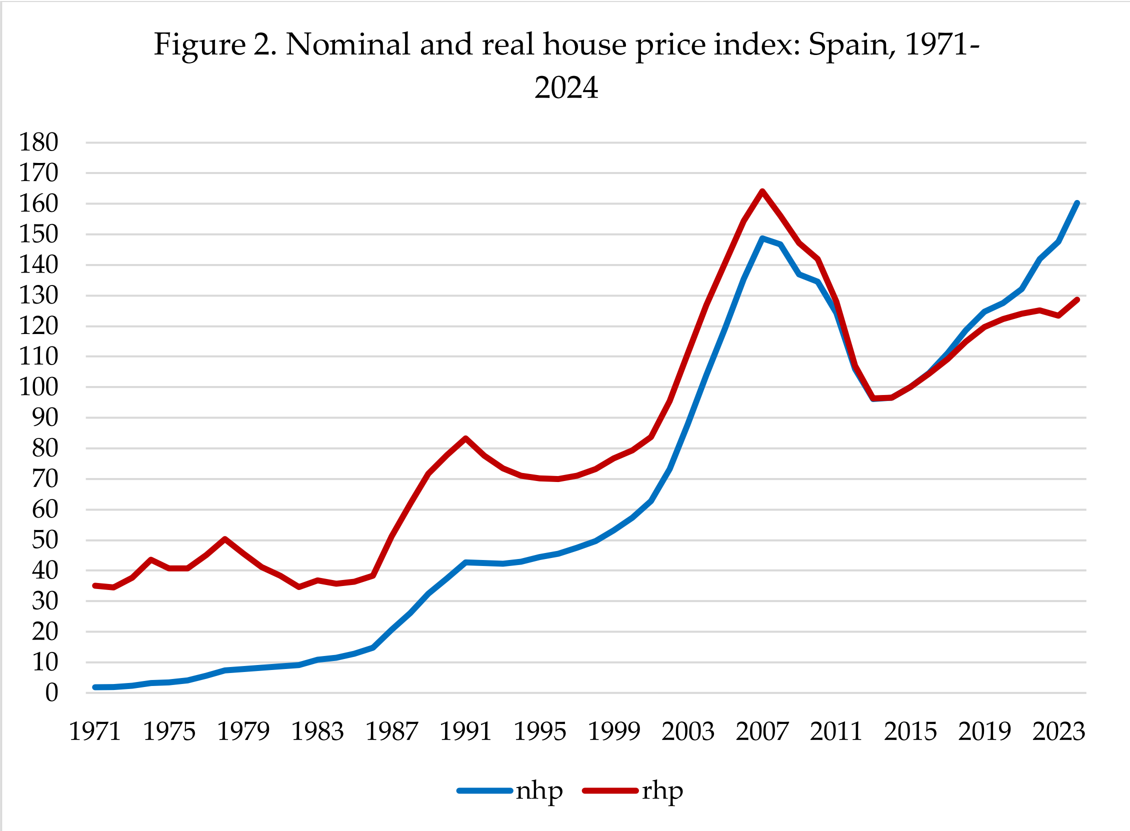
Figure 2. Nominal and real house price index: Spain, 1971-2024
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
nhp
rhp

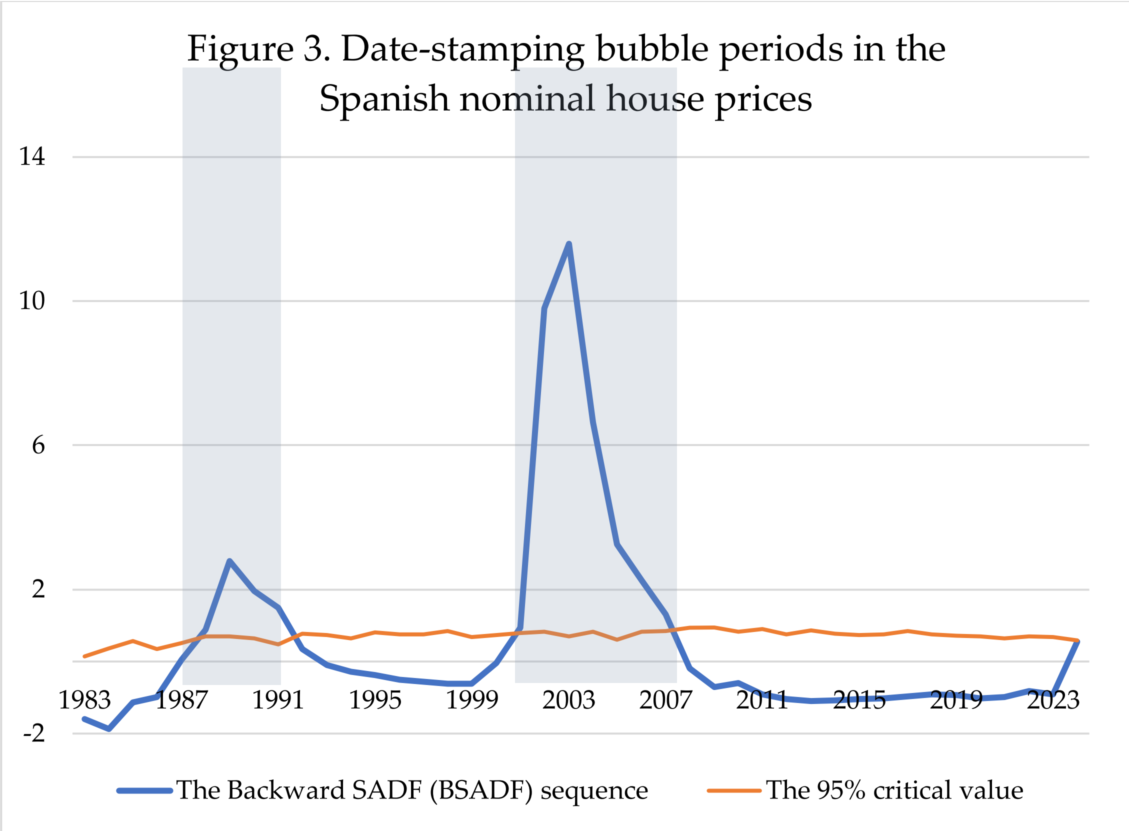

Figure 3. Date-stamping bubble periods in the Spanish nominal house prices
14
10
6
2
-2
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
The Backward SADF (BSADF) sequence
The 95% critical value

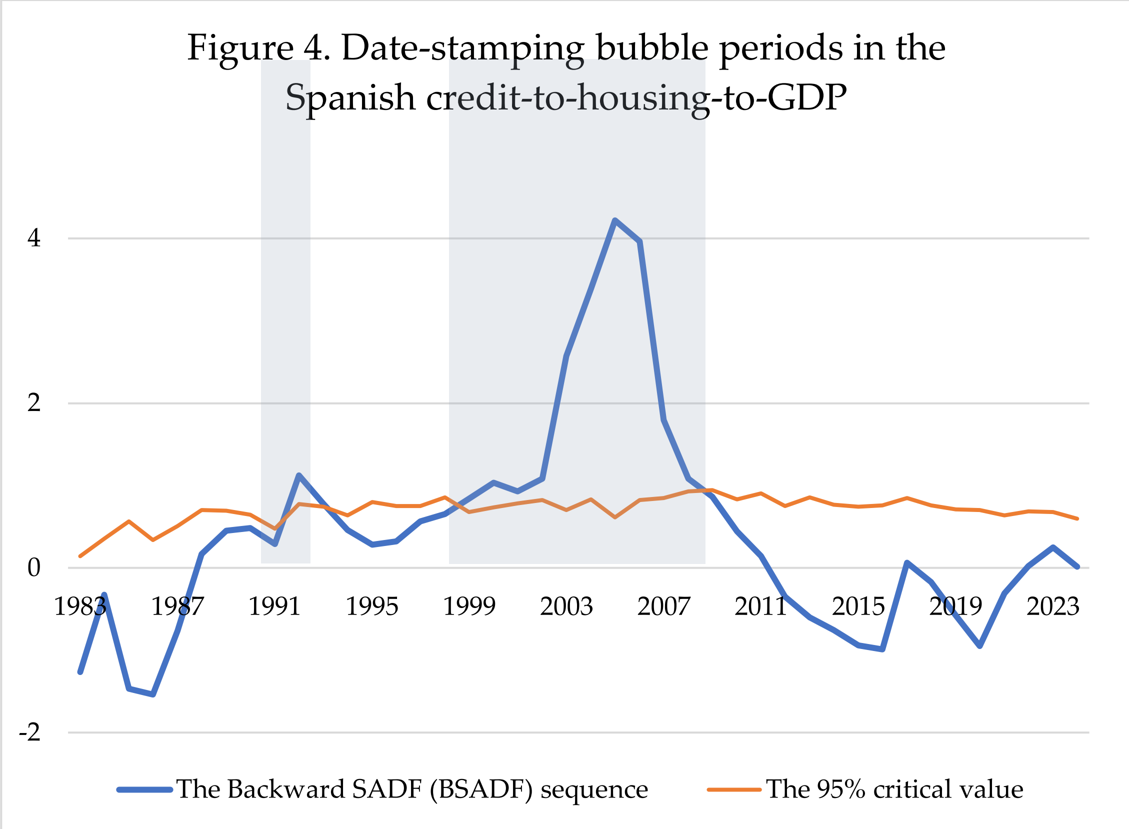

Figure 4. Date-stamping bubble periods in the Spanish credit-to-housing-to-GDP
4
2
0
-2
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
The Backward SADF (BSADF) sequence
The 95% critical value

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