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El Clásico of Housing: Price Explosiveness in Madrid and Barcelona's Real Estate Markets

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Abstract

This paper contributes to the literature on real estate market dynamics by analysing rental and sales price behaviour in Spain's two largest cities —Madrid and Barcelona— between May 2007 and December 2024. Using monthly data from Idealista.com, Spain's leading real estate platform, we detect episodes of explosive dynamics in both markets, examine their key determinants, and investigate contagion effects across cities and market segments. Our results show that, although relatively few episodes of price explosiveness occurred, they were of substantial duration. We also find evidence of contagion: explosive behaviour in rental markets precedes similar dynamics in sales prices, overall in recent years, highlighting the pivotal role of rental markets in driving housing price surges. Among the key determinants, a higher number of hotel stays is associated with a reduced probability of rapid housing price escalation, suggesting that more hotel-based tourists may help stabilise real estate markets in both cities. Additionally, rising interest rates are also linked to a lower risk of explosive episodes. In contrast, increasing resident numbers significantly raises the likelihood of a sharp housing price acceleration, whereas higher unemployment mitigates it. These findings offer critical insights for housing policy and market monitoring in major urban areas. Concretely, they suggest that housing policies should prioritise the rental market, not only because it impacts the most vulnerable groups, but also because pressures in the rental sector often extend into the sale market. On the other hand, policies that encourage the relocation of residents to areas with lower housing demand (e.g., improving the interurban transport network) or promote the issuance of housing certificates could help mitigate the risk of explosive housing price behaviour.

Keywords: Explosive price dynamics; Local Projections; Contagion; Real Estate Markets.

JEL Classification Codes: R31; G12; E44.

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1. Introduction

There is widespread agreement among economists and policymakers that the housing market plays a pivotal role in the onset of financial crises (see Leamer, 2007; Bernanke, 2008; Reinhart and Rogoff, 2009; and Brunnermeier and Oehmke, 2013, among others), with housing's sharp price increases attracting particular attention, especially in the aftermath of the Great Recession of 2008-2009. While the influential work of Case and Shiller (2003) marked a significant advance in our understanding of price dynamics in housing markets, the model developed by Phillips *et al.* (2011, 2015a, 2015b) made it possible to identify and time explosive price behaviour (i.e., periods of exuberance) in time series and to assess their potential contagion effects (Greenaway-McGrevy and Phillips, 2016).

This paper contributes to the literature on price explosiveness detection in real estate markets by examining the dynamics of rental and sales prices in Spain's two largest cities, Madrid and Barcelona.[1] It also assesses the key determinants of housing price acceleration and explores contagion effects across cities and market segments. Addressing these issues is crucial for assessing the risk of vulnerabilities in increasingly integrated housing markets.

Several reasons justify focusing on the Spanish housing market as an economically interesting case. Spain experienced one of the most significant housing price increases in the early 2000s, culminating in the 2008 Global Financial Crisis (Estrada *et al.,* 2009). The dramatic price decline that followed triggered a severe economic recession, a banking crisis, and a long-lasting impact on the housing market (Neal and García-Iglesias, 2013). Moreover, in recent years, Spain has witnessed a strong recovery in housing prices, particularly in major cities like Madrid and Barcelona (see, e.g., Lajer Baron *et al.*, 2024) to the extent that Barcelona has come to be known as "ground zero" for housing problems in Europe.[2]

Indeed, the Spanish real estate market has been gaining momentum in recent years, particularly since 2023, and especially from the second half of 2024, mainly due to falling interest rates. This was coupled with several factors that sustained strong housing demand, including significant migration flows, a robust job market, and foreign housing demand. Meanwhile, as the supply of new housing begins to rise, it remains insufficient to meet the high demand. This imbalance between strong demand and limited supply has been driving up housing prices (see CaixaBank Research, 2025). In that context, in July 2025, according to the Barometer of the Spanish Centre for Sociological Research (CIS), housing was once again the first problem that worried Spaniards, quickly approaching to the historical maximum level of 2008. This concern is grounded in stark realities, recent statistics published by Eurostat[3] revealed that, in the first quarter of 2025, house prices in Spain rose by 12.3% year-over-year —more than twice the European Union (EU) average of 5.7%; recording the fourth-highest price growth in the EU, following Portugal (16.3%), Bulgaria (15.1%), and Croatia (13.1%).

This upward trend, coupled with increasingly stringent mortgage lending conditions since 2008, has pushed homeownership further out of reach for many. Consequently, demand for rental housing has intensified. At the same time, the increased attractiveness of Barcelona and Madrid as economic, cultural and tourist centres — particularly after the pandemic— has translated into a notable growth in the resident population, due to both internal and international migration which puts constant pressure on prices, especially in the rental market, where

[1] We focus on price explosiveness and intentionally avoid labelling it as a *real estate bubble*, a term commonly used when sales prices consistently and disproportionately exceed rental prices. Our interest lies in examining the price dynamics across both housing markets' segments and cities, shedding light on the complex forces and evolving trends that shape these patterns. This approach enables us to offer meaningful insights that transcend reductive labels and support more informed decision-making.

[2] See *"City of Lost Homes: Barcelona's housing crisis"*, front page of *The New York Times,* April 2, 2025.

[3] https://ec.europa.eu/eurostat/web/products-euro-indicators/w/2-04072025-bp

the presence of new residents is higher. This higher demand has not been accompanied by a proportional increase in supply, leading to a sustained rise in rental prices. In December 2024, they rose by 12.34% and 9.59% year-over-year in Madrid and Barcelona, respectively. Therefore, rising rental prices have forced many households to spend an excessive high portion of their income on housing (in 2022, 40% of tenants spent more than 40% of their disposable income on housing in Spain[4]); being the burden especially severe among low-income households. The fact that, unlike in previous expansionary cycles, the most recent price acceleration in the Spanish real estate market is occurring in both the sale and rental markets has motivated the study of the possible existence of periods of exuberant price growth in both segments of the real estate market.[5] To the best of our knowledge, few studies have analysed explosive behaviour in both housing prices and rents. Notably, Fabozzi and Xiao (2017) emphasise that while both rents and dividends represent asset-related cash flows for real estate and stocks, respectively, they differ significantly in their determination: dividends are set endogenously by corporate boards, whereas market forces of supply and demand determine rents. Therefore, rents should not be treated as equivalent to dividends when analysing housing price dynamics. Examining how market participants behave across the sale and rental markets allows for a more accurate capture of distinct explosive patterns in each market. It helps explore potential contagion effects between them. In turn, Zhang *et al.* (2021) apply a co-explosive Vector Autoregressive (VAR) model to investigate bubbles in the UK housing market. They find explosive behaviour in both sales and rental prices. However, since both series exhibit explosive behaviour, analysing the ratio of sales to rental prices does not allow for a definitive identification of a speculative bubble.

There are several reasons to analyse the dynamics of sale and rental prices separately. The sale and rental housing markets operate under distinct dynamics. Sales markets are shaped by long-term factors like interest rates and investment strategies, while rentals respond to short-term needs, migration, and affordability. As a result, each market may react differently to economic and social pressures. Policy also affects them differently: rent controls directly impact the rental market, while monetary policy mainly influences home sales and mortgage costs. Market participants differ too. Home buyers often seek long-term investment, while renters tend to be younger, more mobile, and budget-constrained. Supply structures reflect this, rental housing is urban and seasonal, while sales markets are broader and more diverse. Prices behave differently as well: rental rates change slowly due to regulations and leases, whereas sale prices are more volatile and sensitive to interest rates. Buying a property is viewed as an investment; renting, as a consumption cost. Finally, regulatory frameworks differ. Rental markets face tighter controls (like Spain's 2023 Housing Law), while sales markets are generally more flexible and less regulated.

Given these conceptual and empirical distinctions, treating rental and sales markets as separate analytical domains offers a necessary and valuable complement to analysing their ratio. Accordingly, this study examines the dynamics of both rental and sales prices for dwellings across various districts in Madrid and Barcelona from May 2007 to December 2024. Using monthly data sourced from Idealista.com, Spain's leading real estate platform, we employ the price explosiveness detection method proposed by Chen *et al*. (2023), which builds on the framework developed by Phillips *et al*. (2011, 2015a, 2015b), to investigate the presence of explosive price dynamics in both cities and

[4]The OECD considers that a household is overburdened if it spends more than 40% of its disposable income on housing, and this applies to 40% of tenants in 2022 (Banco de España, 2024).

[5] From January 2022 to December 2024 while sale prices registered an accumulated increase of 30% and 18%, in Madrid and Barcelona, respectively, rental prices accumulated increase was even higher: 38% and 46%, respectively (see Idealista.com).

market segments. Subsequently, we examine the key determinants of the episodes of explosive price behaviour and investigate contagion effects across cities and market segments.

Our analysis reveals that while only three to five episodes of price explosiveness behaviour emerged during the sample period, they were notably persistent, with an average duration of 26 months. When examining the key determinants of explosive housing price dynamics, we find that higher levels of hotel stays are associated with a reduced probability of exuberant price behaviour. This suggests that more tourists choosing hotels over private rentals can help stabilize real estate markets. Several factors may explain this relationship. First, when hotel capacity is lacking, excess demand shifts to short-term rentals, pushing up housing prices. Second, hotel-related taxes may support infrastructure and affordable housing, so reduced tourism revenue can strain city budgets and limit housing development. Finally, investors may shift funds to residential real estate if hotel sector returns drop, increasing housing demand—especially in popular cities with limited supply.

Rising interest rates is also linked to a lower risk of exuberant episodes, while the number of building completion certificates does not have any persistent impact on these episodes. In contrast, an increase in the resident population significantly raises the likelihood of housing price explosive dynamics, whereas higher unemployment tends to mitigate it. These results remain robust when using alternative proxies for the determinants. Leveraging the local projections method of Jordà (2005), we further show that most of these effects are long-lasting. Finally, we examine contagion patterns across cities and market segments, finding that sharp price accelerations in the rental market consistently precede similar dynamics in sales prices, highlighting the critical role that rental markets play in shaping broader house price dynamics, and justifying why studying both sales and rental markets separately allows us to uncover important dynamics and spillovers.

The results of this study have important implications for several stakeholders. For academics and policymakers, examining these phenomena within the Spanish context provides valuable insights into the dynamics of housing prices and their potential macroeconomic effects, while also revealing structural vulnerabilities in the real estate sectors of developed and European economies (European Systemic Risk Board, 2024). For real estate investors, the findings offer evidence on the consequences of specific housing market patterns.

Broadly, the results of our analysis suggest that housing policies should prioritise the rental market, not only because a strained rental market affects the most vulnerable population, but also because tensions in this market eventually spill over into the sale market. Moreover, measures aimed at restricting the number of visitors to major urban centres may inadvertently increase the likelihood of explosive housing price dynamics, given the stabilising effect that tourism staying in hotels appears to exert on the local economy and consequently on housing markets.[6] Conversely, policies that incentivise the relocation of residents to areas with lower housing demand —e.g., improving the interurban transport network—, or that facilitate the process of issuing building completion certificate, may help reduce the risk of exuberant price behaviour.

The paper proceeds as follows. Section 2 outlines the econometric framework to detect common episodes of explosive dynamics in the price of renting and buying a dwelling, to examine their key determinants, and to investigate contagion effects across cities and market segments. Section 3 presents our data. In Section 4, we

[6] Our analysis indicates that increased tourism accommodated through hotel stays contributes to stabilising real estate markets in the cities under study. Nonetheless, we do not discount the potential for short-term rental platforms, such as Airbnb, to destabilise housing price behaviour. Consequently, policy interventions aimed at regulating tourism in short-term holiday apartments may be justified. However, it is important to note that due to the unavailability of comprehensive data on short-term rentals, this study does not empirically assess their impact on housing price exuberance.

report the empirical results. Finally, Section 5 summarises the findings and offers some public policy recommendations that can be drawn from the conclusions reached in our study.

2. Methodology

2.1 Detection of episodes of explosive price dynamics

Phillips *et al*. (2011, 2015a, 2015b; hereafter PSY) introduced a new class of recursive right-tailed Augmented Dickey-Fuller (ADF) tests—the supremum, generalised supremum, and backward supremum ADF tests—designed to detect phases of mild explosiveness in asset prices. This framework represents a major advancement, as it enables real-time identification of exuberant price episodes while addressing key shortcomings of earlier approaches. The PSY methodology has since been widely adopted across diverse asset classes, including equities (Bohl *et al*., 2013; Phillips et al., 2015a; Escobari *et al*., 2017), real estate markets (Jiang *et al*., 2015; Greenaway-McGrevy and Phillips, 2016; Engsted *et al*., 2016; Hu and Oxley, 2018a; Tsai and Lin, 2022; Zhang et *al*., 2024; Hansen *et al*., 2024), dual-market studies of stocks and housing (Deng *et al*., 2017; Hu and Oxley, 2018b), commodities (Etienne *et al*., 2014; Fan *et al*., 2024) and emerging markets such as cryptocurrencies (Bouri *et al*., 2019; Gronwald, 2021; Shahzad *et al*., 2022).

The PSY methodology offers distinct advantages over earlier approaches. First, it avoids reliance on restrictive assumptions about the nature of explosive price dynamics, enhancing both its accessibility and practical implementation. Second, it is firmly grounded in the limit theory of mildly explosive processes (Phillips and Magdalinos, 2007), allowing it to effectively capture the behaviour of periodically collapsing exuberant price episodes—a feature frequently observed in financial markets. As a result, the method significantly reduces the risk of false positives and enables precise dating of the emergence and collapse of episodes of explosive price dynamics. Moreover, its flexibility allows for broad applicability across competing theories of speculative behaviour, encompassing models of rational asset price deviations, herding behaviour among irrational traders, information asymmetries in financial markets, and rational reactions to shifts in economic fundamentals.

Following Chen *et al*. (2023), we identify the common explosive price dynamics shared across different districts and market segments in Madrid and Barcelona. To implement this methodology, we first compute the first principal component of the price indices for each market (rental and sales) and city (Madrid and Barcelona), using data from all districts within each region (see Section 3 below).[7] Then, we apply PSY methodology to date these common episodes of explosive price behaviour.

The framework of PSY is based on ADF regressions with varying window lengths. Defining r_1 as the starting point and r_2 as the end point, the following regression is run recursively,

$$\Delta p_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} p_{t-1} + \sum_{k=1}^{K} \gamma_{r_1,r_2}^{k} \Delta p_{t-k} + \varepsilon_t, \quad (1)$$

[7] We use separate prices for renting and buying a dwelling, rather than relying on the sales-to-rental (or price-to-rent) ratio. This approach enables us to capture the distinct explosive price dynamics more accurately within each market. Our focus is on understanding the specific behaviour of sales and rental prices rather than on whether a bubble exists and whether it is unexpected or rationally anticipated. Sections 4.2 and 4.3 will further address this distinction when examining the determinants of the exuberant behaviour in each market segment. Moreover, analysing the two markets separately allows us to investigate potential contagion effects between the sales and rental markets, as discussed in Section 4.4.

where p_t is the log price of an asset at time t and $\Delta p_t = p_t - p_{t-1}$. K is the maximum lag order and ε_t is the residual. The coefficient of interest is β_{r_1,r_2} from which the ADF test statistic is calculated as $ADF_{r_1,r_2} = \beta_{r_1,r_2}/s.e.(\beta_{r_1,r_2})$, with $s.e.(\beta_{r_1,r_2})$ being the standard errors of β_{r_1,r_2}. Defining $r_{w0} = 0.01 + 1.8/\sqrt{T}$, where T is the sample size, as the minimum required window size and fixing the end point r_2, the starting point can vary between the first observation until $r_2 - r_{w0} + 1$ in such a way that there are $r_2 - r_{w0} + 1$ ADF t-statistics for a fixed r_2. We employ a lag order of one in Equation (1), i.e., $K = 1$, to remove any serial correlation in the price series. Unreported results using $K = 4$ indicate that this choice has minimal influence on the overall findings; for instance, the correlations between the β_{r_1,r_2} estimates across markets and cities consistently exceed 75%.

PSY defines the supremum ADF (SADF) test as the supremum of all the $r_2 - r_{w0} + 1$ ADF t-statistics for a fixed r_2, i.e., $SADF_{r_2} = Sup_{r_1 \in [1, r_2 - r_{w0} + 1]} ADF_{r_1,r_2}$. Varying the end point r_2 between r_{w0} and T, a set of $T - r_{w0} + 1$ SADF statistics are calculated from a backward expanding window (BSADF). The origination ($\tilde{r}_{1e}$) and end days ($\tilde{r}_{1f}$) of the explosive episode are defined as follows,

$$\tilde{r}_{1e} = inf_{r_2 \in [r_{w0}, T]} \{ r_2 : SADF_{r_2} > cv_{r_2}^{\rho} \},$$

$$\tilde{r}_{1f} = inf_{r_2 \in [\tilde{r}_{1e} + h, T]} \{ r_2 : SADF_{r_2} < cv_{r_2}^{\rho} \}, \quad (2)$$

where $cv_{r_2}^{\rho}$ is the ρ% critical value of the BSADF statistic based on r_2 observations[8], and h denotes the minimum window size, implying that an episode must last at least h consecutive periods (e.g., months) to qualify as explosive behaviour. We employ the BSADF test as our main methodological tool, given its ability to accurately detect and date episodes of explosive behaviour in housing prices.

Unlike the conventional ADF test, which imposes a constant structural specification over the whole sample period, the BSADF test employs a recursive estimation strategy over rolling and expanding subsamples. This methodological flexibility enhances the test's ability to detect multiple episodes of price explosiveness or exuberant behaviour, an empirical regularity commonly observed in financial time series as well as in housing markets. Within this framework, explosive or exuberant behaviour is not interpreted normatively, but rather as a statistical property of the time series, indicating periods of rapid price acceleration. This interpretation of PSY test has been widely used in the finance literature.

Finally, we adopt a conservative minimum window length of six months to capture episodes of price explosiveness. In addition, we set the significance threshold ρ% at 95%. Recognizing that prices may not consistently rise during episodes of explosive dynamics and following the framework of Etienne *et al.* (2014), we classify an episode as positive if the average price during the explosive period exceeds the price at its onset, and as negative if the average price falls below the initial level. While positive episodes of explosive dynamics typically garner greater scholarly and media attention (primarily due to their pronounced price escalations and speculative intensity), negative episodes are equally significant analytically for diagnosing market dysfunction, assessing systemic risk, and understanding investor behaviour under stress. The ability of the PSY methodology to detect both upward and downward explosive episodes substantially enhances its utility for empirical economic research, the formulation of macroprudential policy, and the development of robust investment strategies.

[8] The critical value sequence of the BSADF statistics is obtained from a Monte Carlo simulation with 2,000 replications. We thank Prof. Shuping Shi for providing the MATLAB codes to calculate the critical values.

2.2 Assessing the determinants of explosive price dynamics occurrence

To analyse the potential factors driving the occurrence of explosive price dynamics, we employ a multinomial logit model (see e.g., Etienne *et al.*, 2015; or Fan *et al.*, 2024). We employ a categorical variable, B_t, which takes a value of 1 when there is a positive episode of price explosive dynamics, 2 when there is a negative episode of price explosive dynamics, and 0 when the market is in a non-explosive price dynamics state. This can be expressed as follows,

$$B_i = \begin{cases} 0, when\ a\ non-explosive\ price\ dynamics\ \ occurs \\ 1, when\ a\ positive\ explosive\ price\ dynamics\ occurs \\ 2, when\ a\ negative\ explosive\ price\ dynamics\ \ occurs \end{cases} \tag{3}$$

The model to estimate is the following,

$$\Pr(y_{i,t} = B_i | \boldsymbol{x}_{i,t}, \alpha, \boldsymbol{\beta}_j, \varepsilon_{i,t}) = F(y_{i,t} = B_i | \alpha + \boldsymbol{\beta}_j \cdot \boldsymbol{x}_{i,t} + \varepsilon_{i,t}) = \begin{matrix} \frac{1}{1 + \sum_{j=1}^{2} \exp(\alpha + \boldsymbol{\beta}_j \cdot \boldsymbol{x}_{i,t} + \varepsilon_{i,t})} \ if\ B_i = 0 \\ \frac{\exp(\alpha + \beta_{B_i} \cdot x_{i,t} + \varepsilon_{i,B_i})}{1 + \sum_{j=1}^{2} \exp(\alpha + \boldsymbol{\beta}_j \cdot \boldsymbol{x}_{i,t} + \varepsilon_{i,t})} \ if\ B_i > 0, \end{matrix} \tag{4}$$

where $\boldsymbol{x}_{i,t}$ is a vector of independent variables for the *i*-th city at time *t*, $\varepsilon_{i,t}$ are the residuals and $\{\alpha, \boldsymbol{\beta}_j\}$ are the coefficients to estimate.

2.3 Local projections approach

Considering the importance of anticipating the emergence of explosive house price dynamics, we further analyse the estimated impulse response functions using the local projections methodology introduced by Jordà (2005). Local projections provide an intuitive and tractable framework, relying on the estimation of multinomial logistic regressions over multiple forecast horizons *h* (see e.g., Jordà, 2023; Jordà and Taylor, 2025, for recent surveys). In particular, we modify the multinomial logistic regression specified in Equation (4) by shifting the dependent variable forward by *h*={0, 1, 2, …, 24} months,

$$\Pr(y_{i,t+h} = B_i | \boldsymbol{x}_{i,t}, \alpha_h, \boldsymbol{\beta}_{j,h}, \varepsilon_{i,t+h}) = F(y_{i,t+h} = B_i | \alpha_h + \boldsymbol{\beta}_{j,h} \cdot \boldsymbol{x}_{i,t} + \varepsilon_{i,t+h}) = \begin{matrix} \frac{1}{1 + \sum_{j=1}^{2} \exp(\alpha_h + \boldsymbol{\beta}_{j,h} \cdot \boldsymbol{x}_{i,t} + \varepsilon_{i,t+h})} \ if\ B_i = 0 \\ \frac{\exp(\alpha_h + \beta_{B_i,h} \cdot x_{i,t} + \varepsilon_{i,B_i,t+h})}{1 + \sum_{j=1}^{2} \exp(\alpha_h + \boldsymbol{\beta}_{j,h} \cdot \boldsymbol{x}_{i,t} + \varepsilon_{i,t+h})} \ if\ B_i > 0. \end{matrix} \tag{5}$$

Once we estimate the multinomial logit regressions for all the horizons, *h*, we plot the cumulated estimated coefficients, $\boldsymbol{\beta}_{j,h}$, and its confidence bands.

2.4 Analysing contagion effects across cities and market segments.

Finally, to analyse the contagion of explosive price dynamics between cities and market segments, we adopt the non-parametric regression with time-varying coefficients developed by Greenaway-McGrevy and Phillips (2016). This approach combines rolling windows with local kernel regressions to detect contagion dynamics between pairs of price series over time.

Consider two markets, A and B. The non-parametric regression model proposed by Greenaway-McGrevy and Phillips (2016) is given by:

$$\tilde{\beta}_{B,t} = \delta_{t,T}\tilde{\beta}_{A,t-d} + \varepsilon_t \tag{6}$$

where $\tilde{\beta}_{k,t} = \hat{\beta}_{k,t} - \frac{1}{T-w+1}\sum_{t=w}^{T}\hat{\beta}_{k,t}$, and $\hat{\beta}_{k,t}$ represents the rolling estimation of the coefficient in Equation (1) for a fixed window of length *w*, between $[r_1, r_2]$ with $r_1 = t - w + 1$ and $r_2 = t$, *d* is a non-negative delay parameter that captures the lag in market contagion from the market A to the market B, and ε_t are the residuals.

The time varying coefficient $\delta_{t,T}$ is estimated by local kernel regression, such that

$$\hat{\delta}_{t,T} = \hat{\delta}(r; s, d) = \frac{\sum_{j=w+d}^{T} K_{sj}(r)\tilde{\beta}_{B,j}\tilde{\beta}_{A,j-d}}{\sum_{j=w+d}^{T} K_{sj}(r)\tilde{\beta}_{A,j-d}^2} \tag{7}$$

where $K_{sj}(r) = \frac{1}{s}K\left(\frac{j/T - r}{s}\right)$, $K(\cdot) = (2\pi)^{-1/2}e^{-\frac{1}{2}(\cdot)^2}$ is a Gaussian kernel, *s* is the bandwidth, and *r* is the fraction date, i.e., *r*=$\{(w+d)/T, (w+d+1)/T, \ldots, T/T\}$ where each of these values are plugged into Equation (7) one by one to capture the time-varying evolution of $\hat{\delta}_{t,T}$. If $\hat{\delta}_{t,T} > 0$, the two real estate markets are connected, indicating potential explosive price behaviour contagion, where the larger $\hat{\delta}_{t,T}$, the stronger the contagion. Conversely, $\hat{\delta}_{t,T} < 0$, the markets are not connected, implying no explosive price dynamic contagion.

Without loss of generality, we set $w = r_{w0}$ as the fixed window. The kernel bandwidth (*s*) is optimised following the method proposed by Bowman and Azzalini (1997), while the delay parameter (*d*) is set to one month. Unreported results show that the choice of these parameters does not affect the qualitative findings.

3. Data

We use estimates of the average price of renting and buying a dwelling in euros per square metre provided by Idealista.com, one of Spain's largest and most recognised real estate portals.[9] The data covers twenty-two districts

[9] Specifically, we utilised monthly estimates of the average residential prices for properties listed on the online real estate portal Idealista.com, categorised into sales and rental transactions, offering a complete perspective on different market segments. Its broad coverage makes it a representative source of real estate market prices in different country regions, allowing for timely and reliable estimates. The estimated prices show strong correlations with other real estate market indicators, such as the quarterly price per square meter of free-market housing published by the Ministry of Transport, Mobility and Urban Agenda, as well as the regional quarterly Housing Price Index and the annual Rental Housing Price Index at the municipal level, both provided by the National Institute of Statistics. It is important to note that the data processing approach developed by Idealista.com mitigates biases stemming from marketing practices or changes in the composition of listed properties over time (e.g., variations in the number of units by property type), and instead, the alternative available indicators do not offer details by district, nor are they available monthly, nor do they cover a period as broad as the one studied in this paper.

in Madrid (Arganzuela, Barajas, Carabanchel, Centro, Chamartín, Chamberí, Ciudad Lineal, El Encinar de los Reyes, Fuencarral, Hortaleza, Latina, Moncloa, Moratalaz, Puente de Vallecas, Retiro, Salamanca, San Blas, Tetuán, Usera, Vicálvaro, Villa de Vallecas, and Villaverde) and ten districts in Barcelona (Ciutat Vella, Eixample, Gràcia, Horta-Guinardó, Les Corts, Nou Barris, Sant Andreu, Sant Martí, Sants-Montjuïc, and Sarrià-Sant Gervasi), where most districts span the period from May 2007 to December 2024. The extent of available data determines the temporal coverage of the sample.

As noted above, we analyse sales and rental prices separately, rather than relying solely on the price-to-rent ratio. Econometric tools, such as the BSADF tests, are designed for individual time series and may mask the explosive behaviour of a component when applied to ratios (see, e.g., Zhang *et al.,* 2021). For instance, when sales prices experience explosive growth while rents remain stable, the phenomenon is classified as a positive bubble in the price-to-rent ratio. When both market segments exhibit explosive behaviour, with a more pronounced effect in the rental market compared to the sales market, this is typically interpreted as a negative signal. Nevertheless, such classifications may fail to capture the complex dynamics of housing market behaviour adequately, as the underlying dynamics of these two scenarios differ markedly.

Consequently, policies designed to address one type of bubble may prove ineffective (or even counterproductive) when applied to the other, potentially leading to unintended adverse consequences. Furthermore, as already stated in the introduction, the sale and rental markets are driven by distinct economic fundamentals. A separate analysis captures explosive episodes in one segment of the housing market that may not be fully reflected in the other. Recognising this distinction is crucial for policy design. Speculative excess in the sales market may warrant financial oversight or fiscal reforms, whereas explosive behaviour in the rental market may call for increased housing supply or strengthened tenant protections. Consequently, such analysis complements price-to-rent ratio metrics, supporting more informed investment decisions and allowing for a more nuanced understanding of housing market dynamics in their two primary segments (sale and rental).

Since our district-level house price data are unbalanced, we implement two powerful and complementary approaches to construct a robust data matrix without missing values, thereby maximising the length of the sample. First, we use the multiple imputation techniques developed by King *et al.* (2001), which approximate missing data and provide more accurate estimates. Second, we apply the simultaneous nearest-neighbour predictors introduced by Fernández-Rodríguez *et al.* (1999), which infer omitted values based on patterns identified in other concurrent time series. These procedures effectively infer missing values by recognising patterns in related time series, ensuring no valuable information is overlooked. Together, these strategies enable us to construct a comprehensive and accurate dataset from May 2007 to December 2024 without losing observations and leading to insightful conclusions.[10]

[Insert Figure 1 and Table 1 here]

Figure 1 illustrates the evolution of the price of renting and buying a dwelling across all districts of Madrid and Barcelona, as well as the city-wide averages. Despite substantial variation in price levels, the price dynamics exhibit similar patterns across districts within each city and market. Table 1 presents the average prices and standard deviations by district. Notably, both rental and sales prices are, on average, higher in Barcelona than in Madrid.

[10] The proportion of imputed observations differs across markets and districts, with approximately 10% of the data imputed at the start of the sample period. Since March 2011, Idealista.com has consistently provided price data for all districts. However, due to the application of rolling and expanding windows in the BSADF statistic, the minimal missing data at the beginning of the sample is unlikely to have a significant impact on the results.

However, if we analyse in more detail, we can see that sales price dispersion between districts is higher in Madrid than in Barcelona. Thus, the price per square metre in the most expensive district of Madrid (Salamanca, 5,183.12€ per square metre) is higher than that of the most expensive district of Barcelona (Sarrià-Sant Gervasi, 4,860.86€). At the other end of the ranking, we can observe that Madrid's most affordable districts also have lower prices than those in Barcelona. Concretely, in six districts of Madrid (Vicálvaro, Latina, Carabanchel, Usera, Puente de Vallecas and Villaverde), one can find lower sale prices than in the most affordable district of Barcelona (Nou Barris, 2,372.22€).

Although not as pronounced, a similar pattern is observed in the market for renting a dwelling. The city centre is the most expensive district to rent a house, both in Madrid (Centro, 16.98€ per square metre) and Barcelona (Ciutat Vella, 16.98€). However, the price of the second most expensive district to rent a house in Barcelona (Sarrià-Sant Gervasi, 15.50€) is lower than the second and third (Salamanca and Chamberí, respectively) highest-priced districts in Madrid. Again, at the other end of the ranking, we can also observe that the most affordable districts present lower rental prices in Madrid than in Barcelona. Concretely, eleven districts in Madrid (San Blas, Barajas, Puente de Vallecas, Usera, Latina, Carbanchel, Villa de Vallecas, Moratalaz, Villaverde, and Vicálvaro) have rental prices lower than those of the most affordable district to rent a house in Barcelona (Nou Barris, 11.36€).

Using these disaggregated data from various districts, we analyse the real estate market dynamics through the first principal component (PC1) of the price indices for a city's districts. This approach presents several advantages compared to relying on a single, generalised index for the entire city. First, it reduces dimensionality, condensing complex data into a singular indicator that effectively captures price dynamics citywide. Second, PC1 integrates the variability across districts, reducing distortions caused by heterogeneity. Third, by leveraging data from all districts, PC1 provides a more comprehensive representation of overall market conditions than a generalised index, which may overlook local nuances. Lastly, PC1 identifies shared patterns or trends across districts, such as economic changes or market dynamics, which might be more difficult to detect with a general index. Empirically, the computed PC1s capture a significant portion of price variations, explaining the variance between 85% in the sales market in Barcelona and 97% in the rental market in Barcelona. This high explanatory power confirms that price indices within each region and market are highly integrated. Henceforth, we use the first principal components for each city and market in our analysis.

4. Results

4.1 Explosive price dynamics in rental and sales markets

Table 2 and Figure 2 present the results of the explosive price dynamics detection analysis using the PSY approach explained in Section 2.1.

[Insert Table 2 and Figure 2 here]

Table 2 reports the statistics of the BSADF test results, using a conservative minimum window length of six months (unreported robustness checks indicate that the qualitative findings remain consistent when using shorter minimum durations of one and three months for identifying exuberant price episodes). The first row presents the number of explosive price behaviour episodes identified across the markets under study. The results indicate that the incidence of sharp price acceleration is relatively low, with each market experiencing between three to five

exuberant episodes over the nearly 20-year sample period.[11] The market for renting a dwelling in Barcelona displays two more episodes of explosive behaviour than Madrid's. Conversely, the sales market reveals the opposite pattern. Regarding the number of months characterised as exuberant episodes (second row in Table 2), we find that this is larger in Madrid than in Barcelona, being the total number of months with explosive price dynamic in the rental market in Madrid 104 months out of 212 months in our sample, whereas the rental market in Barcelona shows such behaviour for 57 months. Focusing on the sales market, we find that Madrid experienced a rapid and intense price escalation for a total of 118 months, while in Barcelona, the figure is 91 months. These values stand in contrast to findings in other asset classes, where exuberant episodes typically account for only a small fraction of the sample (see, e.g., Fan *et al.*, 2024). However, our results align with the real estate literature, which documents prolonged periods of explosive price behaviour (see, e.g., Greenaway-McGrevy and Phillips, 2016; Gómez-González *et al.*, 2018; Phillips and Shi, 2020). The third and fourth rows of Table 2 differentiate between positive and negative episodes of explosive dynamics. Our findings indicate a higher number of months with sharp upward price episodes in both the rental and sales markets in Madrid compared to Barcelona, 80 versus 26 months in the rental market, and 71 versus 50 months in the sales market. In contrast, the number of months with downward explosive episodes shows no substantial difference between the two cities. Finally, the last row of Table 2 reports the duration of detected exuberant behaviour across the different markets. On average, these episodes last longer in Madrid's rental market, with a mean duration of 34.67 months, compared to 11.40 months in Barcelona. In contrast, the sales markets in both cities exhibit similar average durations: 29.50 months in Madrid and 30.33 months in Barcelona. Overall, the average duration of explosive price dynamics is relatively long, at approximately 26 months.

Figure 2 plots the detected exuberant episodes across both markets and cities over the sample period. The figure displays the BSADF statistic (solid black line), its corresponding critical values (dashed black line), the average house price index (red line), and the periods of explosive price, shaded in grey. Panel A shows that, in Madrid's rental market, the BSADF statistic identifies an initial downward explosive episode from April 2012 to March 2014, followed by two subsequent episodes of sharp price acceleration, spanning from September 2015 to June 2020 and from March 2023 to the end of the sample period. In contrast, Panel B shows that Barcelona's rental market experienced an episode of rapid and intense price decrease from May 2011 to January 2014, followed by three upward explosive price episodes spanning July 2015 to February 2016, June 2016 to April 2017, and December 2023 to June 2024. It is worth noting that in the rental market in Barcelona, the BSADF statistic exceeds the 95% critical value during the final five months of the sample. However, since this duration falls short of the minimum six-month threshold required by the algorithm, it is not classified as a period of price explosiveness. With a longer sample, it would be possible to evaluate whether the rental market is undergoing a sustained episode of positive price explosiveness, but the current data do not allow for such confirmation. Turning to the sales market, Panel C indicates a downward explosive episode in Madrid from June 2011 to April 2015, followed by three episodes of sharp price acceleration spanning October 2016 to May 2020, March 2022 to August 2022, and April 2023 to the end of the sample. Meanwhile, Panel D shows that in Barcelona, the BSADF statistic identifies a negative explosive price dynamics episode lasting from April 2011 to August 2014, along with two episodes of intense surge in housing prices from July 2015 to October 2018 and from March 2024 to the end of the sample. Notably, the timing and emergence of these exuberant episodes do not align perfectly across market segments and urban centres,

[11] Note that the first 15 months of observations are excluded due to the minimum window length required by the PSY detection methodology.

underscoring the importance of studying these markets separately rather than aggregating them into a single real estate market price index.

The identified episodes of downward explosive price dynamics largely coincide with the sharp downturn in the Spanish real estate market following the expansionary phase that culminated in 2008 with the Global Financial Crisis and its severe impact on the sector (Martín *et al.*, 2021). Notably, the findings suggest that negative explosive price episodes tended to last longer in the sales markets, indicating that rental markets are relatively more insulated from significant price declines. Conversely, the upward explosive price episodes reflect rapid housing price appreciations that outpaced economic fundamentals, implying that valuations were driven more by expectations of capital gains than by intrinsic value (Raya *et al.*, 2014). These episodes were further fuelled by a renewed influx of both domestic and international investors, including institutional buyers and real estate investment trusts, stimulated by historically low interest rates and favourable credit conditions. Additionally, limited land availability and regulatory constraints on new construction contributed to supply-side pressures. The sharp rebound in housing prices in 2023-2024, driven by pent-up demand, increased household savings, and continued access to favourable financing, further reinforced these dynamics.

Although the price-to-rent ratio is not the primary variable of interest in this study, for completeness, we also apply the price explosiveness detection approach to the price-to-rent ratios for both Madrid and Barcelona. The results, reported in Appendix A, reveal two significant price episodes of explosiveness in both cities, although the episodes appear less continuous in Barcelona. The first episode spans from late 2011 to early 2017, while the second extends from mid-2023 to early 2024. Interestingly, the first episode is marked by a sharp decline in the price-to-rent ratio. When disaggregating this episode—following the approach used in our main analysis—we find it encompasses two distinct phases: a price decline following the European sovereign debt crisis, and a strong subsequent recovery. This highlights the value of analysing sales and rental prices separately to uncover underlying market dynamics. The second episode, which occurred in the final years of the sample (2023–2024), coincided with a significant increase in rental prices at a pace higher than that of sales prices. As a result, the price-to-rent ratio declined, too. As with the earlier episode, policymakers focusing solely on the ratio might interpret this as an undervalued housing market, and not encourage policies aimed at mitigating their prices. However, such a policy response would be inconsistent with the reality uncovered in our analysis, namely, that both sales and rental prices experienced substantial increases during this period. Once again, this underscores the importance of studying the sales and rental markets independently, rather than relying exclusively on their ratio.

The following section provides a more detailed analysis of the factors driving these episodes of explosive price dynamics in the rental and sales markets.

4.2 Determinants of explosive price dynamics occurrence.

Following the housing literature, we include city-specific control variables in Equation (4), as shown in Section 2.2, where we are limited by the availability of the city-specific information. Building on the findings of Campbell *et al.* (2009) and Shi (2017), we consider variables that reflect overall economic conditions, such as interest rates, population growth, tourism, unemployment rates, and housing supply, as potential determinants of the occurrence of episodes of explosive price dynamics. Specifically, we control for the annual growth in the number of hotels stays, the annual growth in building completion certificates, changes in EU interest rates, the annual growth of resident population, and the annual unemployment rate where all these variables, except the EU interest rates,

are at the city level. By using annual growth measures, we eliminate the effects of seasonal variations and remove the unit root, allowing us to work with deseasonalised, stationary variables. Table 3 presents the definitions of the variables and their sources.

[Insert Table 3 here]

All continuous variables are winsorised at the 1st and 99th percentiles to mitigate the influence of outliers. Furthermore, we normalise these controls to facilitate interpretation across the diverse set of explanatory variables. Table 4 presents the estimates from the multinomial logistic regression, with robust *t*-statistics reported in parentheses.[12]

[Insert Table 4 here]

The following findings can be drawn from Table 4. First, an increase in tourists opting for hotel accommodation decreases the probability of both upward and downward explosive price dynamics, except for the sales market in Madrid, which appears unaffected. However, this finding contradicts recent public demonstrations against mass tourism in major European cities, particularly in Barcelona.[13] Several factors may explain why limiting the number of hotel accommodation stays may be detrimental to real estate price stability. First, when hotel capacity is insufficient to meet rising tourist demand (i.e., if an increase in hotel stays cannot keep pace with the increase in tourism), the overflow may be absorbed by the private residential sector—mainly through short-term rentals—thereby increasing demand and exerting upward pressure on housing prices. Second, revenues generated from hotel taxes and tourism-related business levies are often earmarked for public goods such as transportation infrastructure and affordable or social housing initiatives. A decline in these revenue streams may constrain municipal budgets, thereby limiting the capacity to invest in expanding housing supply or improving transportation infrastructure, which could enhance access to more affordable areas with lower housing demand pressure. Third, institutional and private investors often regard the hotel sector as a relatively low-volatility, professionally managed vehicle for capturing returns from tourism. However, when income from this sector declines—such as through a reduction in hotel stays—capital may be reallocated to higher-yield segments like residential real estate, thereby contributing to upward pressure on housing prices, especially in cities where the fundamental appeal to both tourists and investors remains strong, and the housing supply is limited.

Short-term rentals include mainly those associated with tourism or student purposes. Regarding short-term rentals in tourism, we should recall that in recent decades, tourism has experienced significant growth, with urban tourism showing particularly pronounced trends. Between 2009 and 2018, tourism in top global cities grew steadily at a rate of about 6.5% per year, and, despite challenges such as economic fluctuations and climate issues, the travel industry continues to thrive (Mastercard, 2019). Moreover, over the past 12 months ending March 2024, Mastercard's ranking of the 10 "trending markets" placed Spain in fifth position, after Japan, Ireland, Romania and Italy (Mastercard, 2024)[14]. As a result, short-term rental platforms like Airbnb have emerged in response to the

[12] A building completion certificate is a formal document that verifies a construction project has been finalised in compliance with the approved plans and relevant building codes. It indicates that the property is fit for occupancy and plays a vital role in both legal and practical matters, such as utility connections and property transactions, and can be seen as a proxy for the housing supply.

[13] See e.g., "Protesters in Spain told tourists to 'go home.' Instead, more arrived." *CNBC.com,* October 13, 2024; and "Another summer of disruption? Spain's anti-tourism protests reignite ahead of Easter break" Euronews, April 8, 2025.

[14]The Mastercard Global Destination Cities Index ranks 200 cities based on third-party research and proprietary analysis regarding the total number of international overnight visitor arrivals and cross-border spending by these

rising demand for urban tourism. These platforms facilitate the overlap between the tourism and housing markets by enabling residential property owners to participate in the hospitality sector. This trend not only caters to the growing influx of visitors but also transforms traditional housing dynamics in city environments.[15] Unfortunately, since the Airbnb website[16] provides data for both Barcelona and Madrid but not for an extensive period such as the one studied (May 2007-December 2024), we could not include this variable in our study. However, García-López *et al*. (2020) examine data on both rents and sales prices, combining these data with information on the location of Airbnb activity within Barcelona between April 2015 and February 2018. Their analysis reveals that Airbnb activity in Barcelona has increased rents and sales prices, with larger impact on sales prices than on rents.

Regarding short-term rentals for study purposes, it should be noted that, according to the European Commission, Spain is the main recipient of Erasmus students (with Barcelona and Madrid being the main receiving cities). Unfortunately, this Eurostat database is only available on an annual basis, and 2022 is the last year for which official data is available.[17] Therefore, the stabilising effect of hotel-based visitors on the real estate markets in Madrid and Barcelona may underestimate the possible triggering effect that short-term rental visitors (for holiday or study purposes) could have on the likelihood of exuberance price episodes. We leave this question open for future research.

Second, a higher number of building completion certificates is associated with a lower probability of negative explosive price dynamics in the Barcelona markets. This could indicate that the supply of new housing is increasing at a slower pace than demand, which in turn lowers the probability of a downward explosive price behaviour. It may also indicate some asymmetry in the housing market, which may be less prone to price declines than increases in the face of a change in supply. In this sense, at present, the supply of new housing is still insufficient to meet the high demand in Spain, and this mismatch is indeed driving up house prices (see CaixaBank Research, 2025).

Third, increases in interest rates are associated with decreases in the probability of a positive explosive price dynamics, except for the rental market in Barcelona. This result is expected, given the negative relationship between interest rates, credit mortgage costs, and house prices. In fact, with the beginning of the normalisation of interest rates in 2024, demand for housing was reactivated, and house prices increased again in Spain (see Lajer Baron *et al*., 2024).[18]

Fourth, growth in the resident population is strongly associated with a higher probability of upward explosive price dynamics and a lower probability of downward ones across both markets and cities. This result is also expected,

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same visitors in the destination cities over the previous year. According to it, in 2019, Barcelona ranked 17th after Milan and ahead of Palma de Mallorca (Spain).

[15] The Government of Catalonia (https://portaldogc.gencat.cat/utilsEADOP/PDF/9339/2068659.pdf) estimated that in the third quarter of 2024, temporary rentals registered a sharp increase of 37.5% compared to the same quarter of the previous year.

[16] http://insideairbnb.com/about

[17] The Eurostat database shows that Spain (with about 143,000 students hosted during 2022), Italy and Germany are the main destinations chosen by students signing up for the Erasmus Program: https://ec.europa.eu/eurostat/databrowser/view/EDUC_UOE_MOBS03__custom_4490028/bookmark/table?lang=en&bookmarkId=8fc0b290-d9ef-4506-bea6-4bdac63d9413

[18] Lajer Baron *et al*. (2024) show that following the tightening of monetary policy in the euro area, a significant decline in the relative weight of externally financed house purchases was observed from 2022 onwards, with the ratio standing at below 45% in 2023. However, the most recent data indicate a recovery of the ratio, which reached a value of 48% in July 2024, reflecting an improvement in mortgage financing conditions.

as higher housing demand, higher prices, and therefore, a higher probability of a positive explosive price behaviour (see e.g., Hansen *et al.*, 2024). In this regard, Cuadrado *et al.* (2024) highlight that Spain has become one of the EU's leading immigrant-receiving countries in recent years.[19] In absolute terms, Spain ranked fifth among destination countries with the highest number of permanent immigrants in 2023, behind the United States, the United Kingdom, Germany, and Canada (see OECD, 2024).

Finally, rising unemployment rates reduce the likelihood of positive explosive price dynamics, and in the case of Madrid's rental market, increase the probability of downward explosive price behaviour. This is an anticipated result, as higher unemployment typically discourages home purchases and may prompt individuals to seek more affordable rental options.

To enhance the robustness of this analysis, Table 5 presents an alternative model that incorporates city-specific variables closely related to those used in Table 4. In particular, we include the annual growth in hotel overnight stays, the annual increase in the number of housing units[20], changes in the 3-month EU interbank interest rate, the annual growth rate of immigration, and the annual growth in affiliations to the Spanish Social Security system.

[Insert Table 5 here]

The results of the multinomial logistic regression using these alternative variables, presented in Table 5, are generally consistent with those reported in Table 4. Specifically, increases in the number of hotel overnight stays stabilise the markets (except for a higher probability of negative episodes of explosive dynamics in both rental markets), higher interest rates reduce the likelihood of upward explosive price behaviour, and increases in both immigration and social security affiliations enhance this likelihood.

4.3 Local projections results

So far, we have studied the variables associated *contemporaneously* with the occurrence of explosive house price dynamics, but anticipating their occurrence is crucial. As explained in Section 2.3, we also examine the impulse response functions estimated using local projections, as proposed by Jordà (2005), to shed light on these patterns.

We use the same independent variables as in Equation (4) that have been used in the previous Section. Note that the multinomial logistic regression results for h=0 (Equation (5) in Section 2.3) coincide with those in Table 4.

[Insert Figures 3 here]

Figures 3 illustrate local projections capturing the effect of a one-standard-deviation shock to each variable on the probability of a positive or negative explosive price dynamics in each city (Madrid or Barcelona) and market (rental or sales). Overall, the relationships observed contemporaneously in Table 4 mostly remain persistent over the following two years, as shown in Figure 3. The key findings drawn from these figures are as follows. First, the stabilising effect of visitors (hotel overnight stays) on both upward and downward explosive price behaviour proves to be quite persistent, overall in Barcelona's markets. This finding confirms the previous results that restricting the number of visitors in major urban centres could have a detrimental impact on the housing market.

[19]Cuadrado *et al*. (2024) highlight that in 2022, Spain recorded one of the highest rates of foreign inflows per thousand inhabitants in the EU, even ahead of Germany, and ranked in the middle –below Germany and above France and Italy– in the share of the foreign population residing in the country (17.1%).

[20]These certificates are official accreditations of completion issued by professional architectural or engineering associations in Spain.

Second, the effects of house certifications on upward explosive price dynamics are not entirely clear, as they vary across markets and cities. For example, in the rental market of Madrid, the likelihood of a positive explosive price behaviour increases in the first year following a rise in building completion certificates, though this effect is transitory. Conversely, in the Barcelona sales market, the probability of upward explosive price dynamics decreases after 24 months, as housing supply catches up with rising demand.

Third, increases in interest rates reduce the probability of a positive explosive price dynamics, but this effect is transitory and fades after a few months. Interestingly, the transitory impact of rising interest rates on upward explosive price behaviour lasts longer in the sales market than in the rental market. This may reflect the greater flexibility of the rental market in adapting to interest rate changes, compared to the relative stability of the sales market. Instead, increases in interest rates do not affect the probability of negative explosive price behaviour.

Fourth, increases in the number of residents raise (reduce) the probability of a positive (negative) explosive price dynamics, although this effect generally dissipates after two years. Notably, the effect on upward explosive price behaviour lasts longer in the rental market than in the sales market in Barcelona, suggesting that new residents primarily target the rental housing market rather than the sales market. This finding aligns with a recent report from Banco de España (2024), which identifies immigrants and young people as the main renters. Together with the significant migration Spain has experienced in recent years, this helps account for the prolonged impact of increases in residents on the likelihood of positive explosive price dynamics in the rental market.

Finally, rising unemployment rates exert a persistent negative influence on the probability of upward explosive price dynamics, while having no statistically significant effect on the likelihood of downward dynamics. This finding suggests that prolonged periods of unemployment negatively impact the local economy, making positive explosive price dynamics highly unlikely in such contexts.

4.4. Contagion effects across cities and market segments

In the preceding sections, we analysed the determinants of explosive price dynamics in the real estate markets of Madrid and Barcelona. Although we identified the key variables driving these price explosiveness trends, we did not address the potential interdependence between price movements in the two cities and market segments. This section investigates the existence of contagion effects across these urban markets.

The results of the contagion analysis are presented in Figure 4. This figure displays the contagion results for both the rental and sales markets in Madrid and Barcelona, as represented by $\hat{\delta}_{t,T}$ in Equation (7). Positive values suggest interdependence between the two real estate markets, pointing to potential contagion in explosive price dynamics. Conversely, negative values indicate a lack of connection, implying the absence of such contagion effects. To enhance interpretability, the periods exhibiting the strongest contagion in price dynamics are shaded in grey, those corresponding to the highest positive decile of $\hat{\delta}_{t,T}$ across all market pairs.

[Insert Figure 4 here]

Our results reveal a compelling pattern: contagion effects are most pronounced in the transmission from rental to sales markets. While elevated contagion does not, in itself, constitute definitive evidence of explosive price dynamics, our analysis suggests that the most recent upward phase in 2023-2024 was characterised by significant spillovers originating in the Madrid rental market, subsequently propagating to both the Madrid and Barcelona sales markets (Panels G and J, respectively), and from the Barcelona rental market to both the Madrid and Barcelona sales markets (Panels H and K, respectively). Therefore, our results suggest that in both cities, the rental market

is the primary driver of price increases. At certain price levels to rent a dwelling, the appeal of renting diminishes for tenants, prompting them to consider purchasing a home, which in turn boosts demand in the sales market, and consequently the sales prices. This finding is significant, as it implies that housing policies should primarily focus on the rental market. This focus is already being addressed in current policy efforts, though these initiatives have yet to produce the expected outcomes as of this writing.

In this sense, the Spanish Law 12/2023 of 24 May 2023 on the Right to Housing[21] includes a progressive increase in the social rental stock among their objectives, with public-private collaboration playing a more prominent role in its development. The stimulus to private rental supply is articulated in the form of greater tax incentives for individuals who rent housing with price reductions in the so-called *stressed* areas. Moreover, it also sets out measures to reduce tenants' effort with existing contracts. Specifically, new limitations are introduced on annual rent increases and the possibility of establishing rent control measures in stressed areas if decided by the Regional Governments with competence in this area and within the price range set by the central government.[22]

Lastly, within markets, we have found contagion from Madrid to Barcelona both in the rental and the sales market (see Panels D and L, respectively), but not the other way round. These periods lasted mostly during late 2019 and the first months of the COVID-19 pandemic in 2020. Several factors can explain this contagion episode. Both cities are closely connected economically and demographically, with price trends in one city often influencing the other due to investor movement and migration. Investors treat both markets as complementary, and price increases in Madrid often lead to expectations of similar trends in Barcelona. Additionally, the scarcity of affordable housing in Madrid pushed some buyers and investors to consider Barcelona, increasing demand and driving prices upward. Both cities experienced similar disruptions during the early pandemic, such as reduced supply and market uncertainty, synchronising their housing market behaviour. Finally, the European Central Bank's monetary policies, including low interest rates and financial stimulus, provided similar conditions in both cities, further fuelling the price contagion.

5. Concluding remarks and policy recommendations.

In this study, we examine the behaviour of the price of renting and buying a dwelling across various districts in Madrid and Barcelona from May 2007 to December 2024. Rather than relying on the sales-to-rent (or price-to-rent) ratio, we analyse disaggregated price series for the rental and sales markets. This approach enhances the detection of explosive price dynamics within each market segment, enables a more nuanced understanding of the drivers behind exuberant behaviour, and facilitates the analysis of potential spillover effects between rental and sales markets. This complementary analysis yields valuable insights for informed decision-making and strategic planning, beyond the price-to-rent ratio analysis.

[21] https://www.boe.es/eli/es/l/2023/05/24/12/

[22] For example, the Government of Catalonia (where Barcelona is located), who already introduced rent control policies in late 2020 that remained in effect for a year and a half, reinstated rent control measures in March 2024 under the above-mentioned Spanish Law. The first phase of rent controls in Catalonia (it covers the period 2020-2022) offered a valuable opportunity for policy evaluation, though findings were sometimes contradictory (see Jofre-Monseny *et al*., 2023; and Kholodilin, 2022). However, while the second phase (from March 2024) may present more relevant results for consideration, comprehensive evaluations are not yet available. Nevertheless, criticism has arisen over partial compliance with rental regulations, particularly due to a shift from regulated long-term leases to temporary rentals that are exempt from the policy; short-term rents increased by 37.5% in the third quarter of 2024, in Catalonia, compared to the same period in 2023.

Utilising monthly data from Idealista.com, Spain's leading real estate platform, we apply the price explosiveness detection method proposed by Chen *et al*. (2023), which builds on the framework established by Phillips *et al*. (2011, 2015a, 2015b), to identify potential explosive price dynamics in both market segments and cities. Our analysis reveals that while only three to five exuberant episodes emerged during the sample period, they were notably persistent, with an average duration of 26 months. When investigating the key drivers of these explosive price dynamics, our findings indicate that a lower likelihood of a sharp price acceleration is associated with more visitors choosing hotel accommodation, suggesting that increased hotel tourism helps stabilise housing markets in both cities. A lower risk of rapid price escalation is also associated with rising interest rates, while the number of building completion certificates has no persistent impact on these episodes. Conversely, growth in the resident population significantly amplifies the likelihood of upward explosive price dynamics, whereas higher unemployment tends to exert a dampening effect. These findings remain robust when alternative proxies for the explanatory variables are employed. Using the local projections method proposed by Jordà (2005), we further show that many of these effects have persistent, long-term implications. Finally, we examine contagion patterns across cities and market segments, revealing that episodes of exuberance in rental markets consistently precede those in sales markets, highlighting the pivotal role of rental dynamics in shaping broader housing price behaviour.

We believe that our paper offers an interesting and relevant case study for several stakeholders. For academics and policymakers, analysing the rental and sales market prices separately within the Spanish context offers valuable insights into the dynamics of housing prices and their macroeconomic impact, while also highlighting structural vulnerabilities within the real estate sectors of European economies.

Finally, regarding policy recommendations, our findings suggest that policymakers need to differentiate between price explosiveness driven by sales prices and that driven by rental prices in order to design targeted and effective policy responses. Indeed, real estate markets are integral to the functioning of the economy and have significantly influenced the evolution of the financial system. Notably, our analysis suggests that housing policies should prioritise the rental market, not only because it impacts the most vulnerable groups, but also because pressures in the rental sector often extend into the sale market. Moreover, measures that restrict the influx of visitors to major urban centres may inadvertently increase the likelihood of explosive housing price dynamics, given the stabilising effect that hotel-based tourism exerts on the local economy and, consequently, on housing markets. On the other hand, policies that encourage the relocation of residents to areas with lower housing demand (e.g., improving the interurban transport network) or promote the issuance of housing certificates could help mitigate the risk of explosive housing price behaviour.

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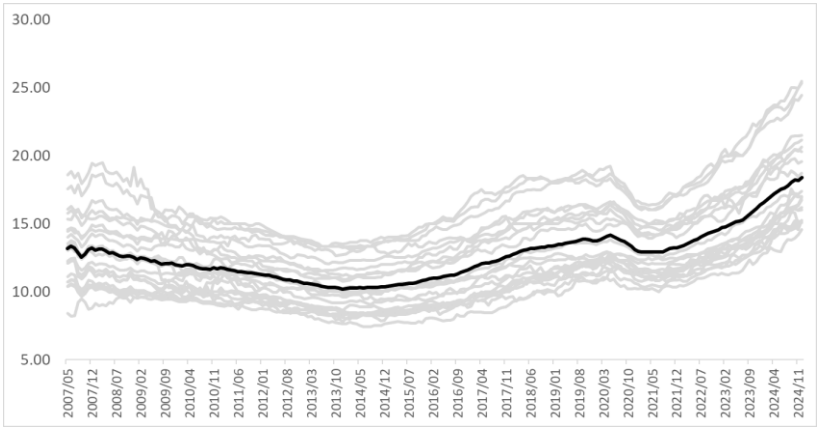
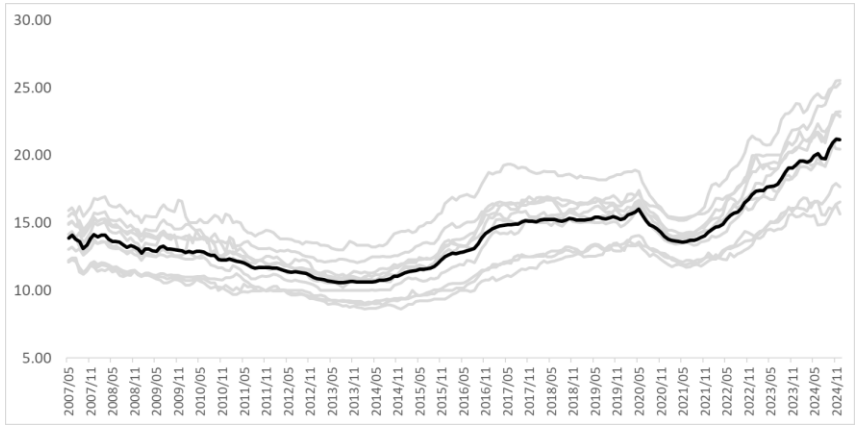
Figure 1. Rental and sales prices for Madrid and Barcelona

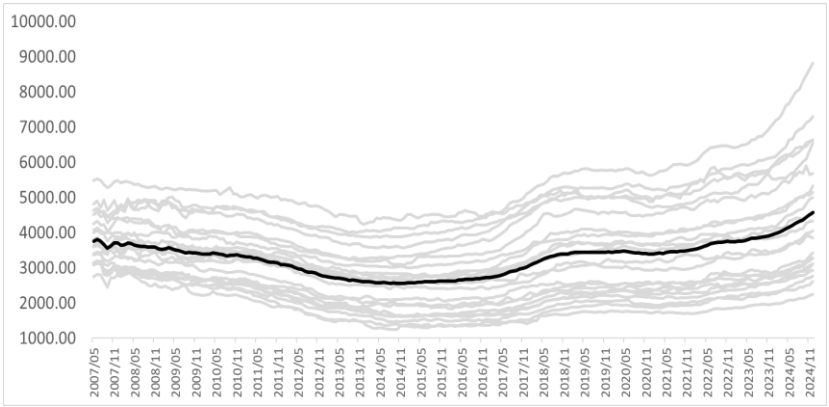
This figure plots the rental and sales prices for Madrid and Barcelona. The black line represents the average prices across districts and the grey lines are the prices at district level. The sample is from May 2007 to December 2024.



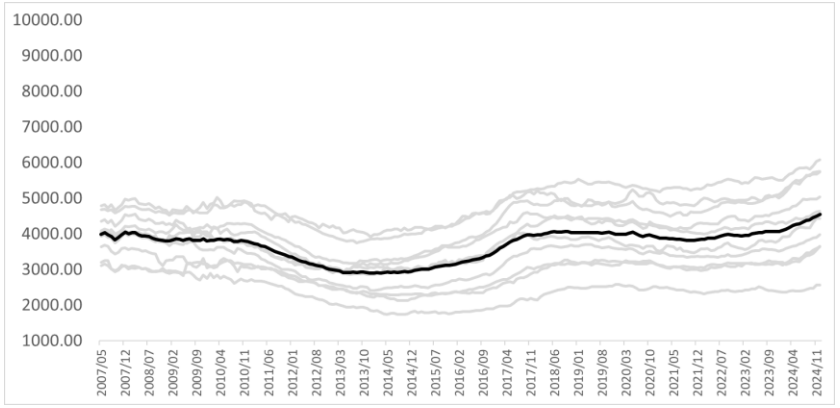
Panel A: Rental market in Madrid



Panel B: Rental market in Barcelona



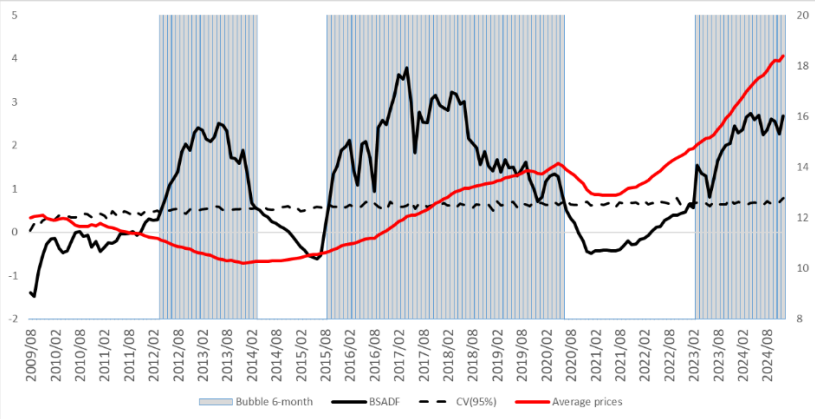
Panel C: Sales market in Madrid



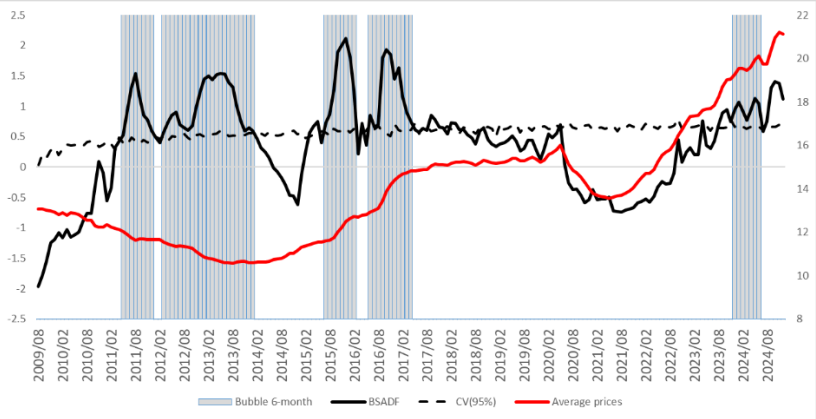
Panel D: Sales market in Barcelona

Figure 2. Explosive price dynamics in rental and sales markets

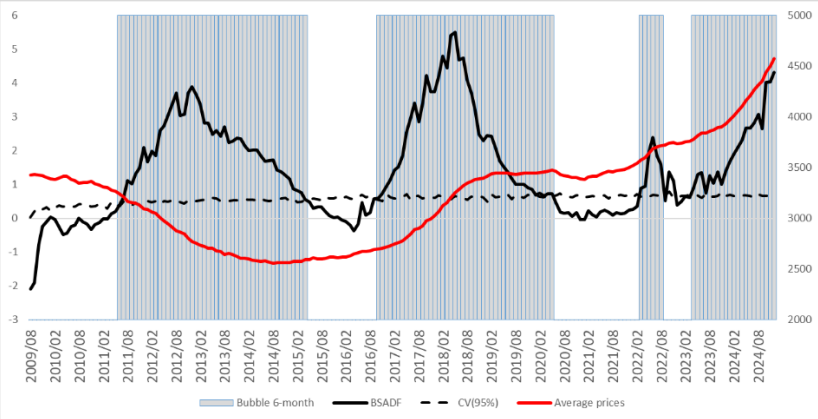
This figure plots the results obtained from the price explosiveness detection tests for rental and sales markets in both Madrid and Barcelona (using the minimum length of 6 months) with episodes of explosive price dynamics shaded in grey. The average price is in the solid red line, and the BSADF statistic in the solid black line. We also report the Monte Carlo critical values for significance at the 5% level in the dash black line. The sample period is from August 2009 to December 2024.



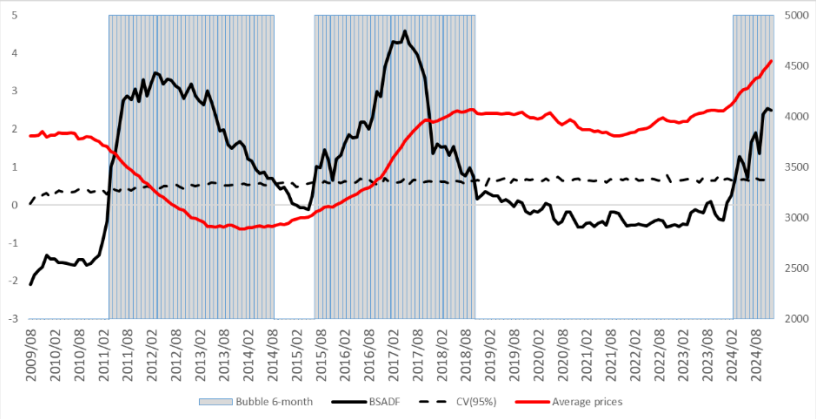
Panel A: Rental market in Madrid



Panel B: Rental market in Barcelona



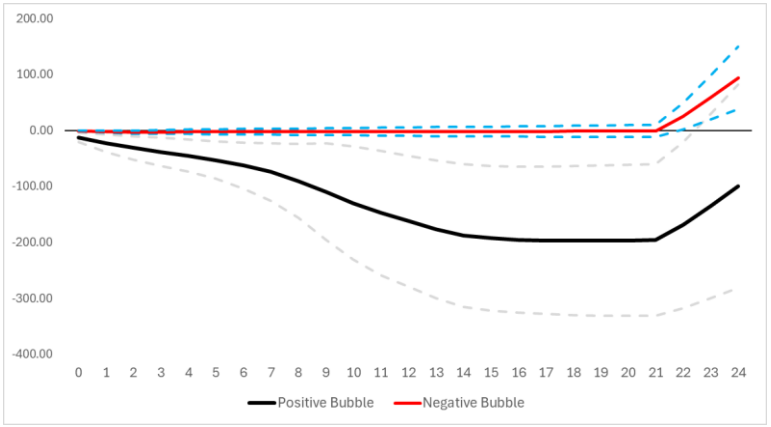
Panel C: Sales market in Madrid



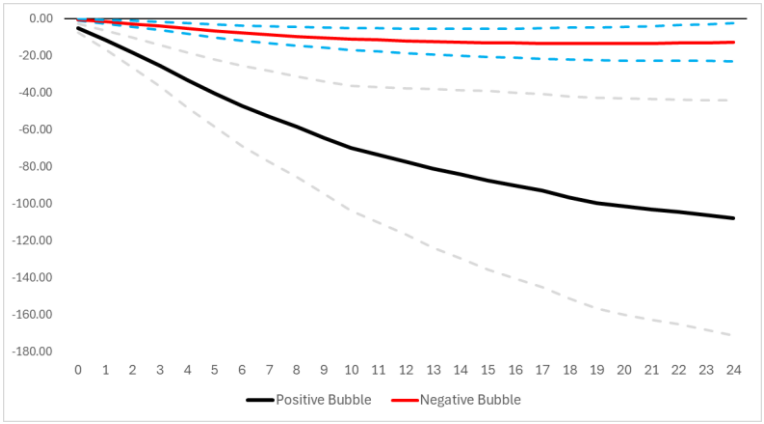
Panel D: Sales market in Barcelona

Figure 3.a Local projections impulse-response: Shocks to hotel-based visitors

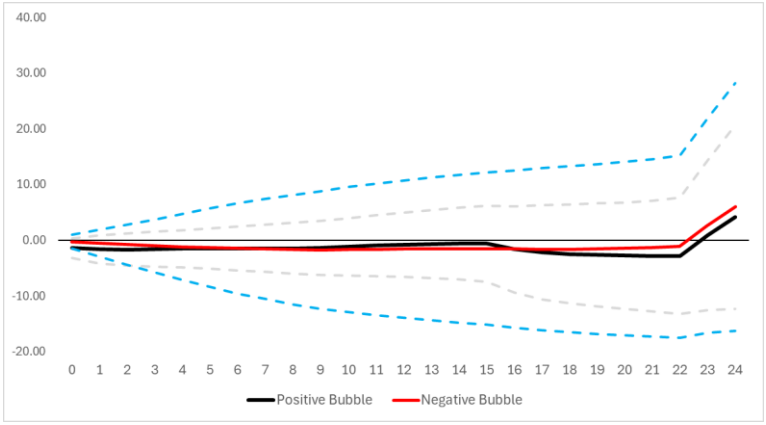
This figure plots the local projection estimates to one standard-deviation shock in hotel-based visitors on positive (black line) and negative (red line) explosive price episodes from zero to 24 months ahead. The 95% confidence bands for positive (negative) explosive price episodes are in dash grey (blue) lines.



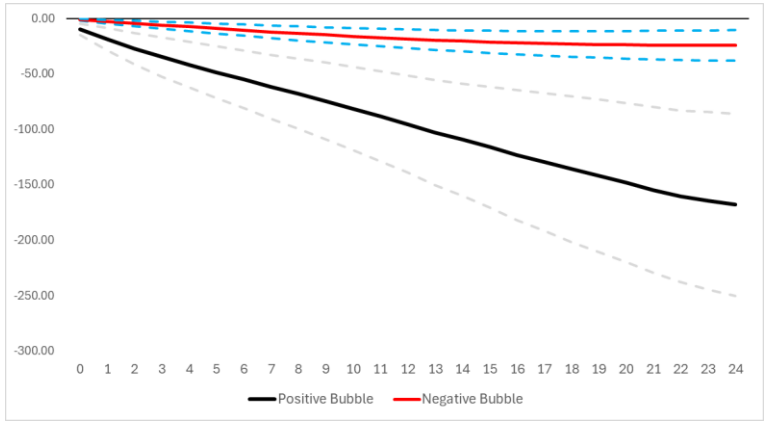
Panel A: Rental market in Madrid



Panel B: Rental market in Barcelona



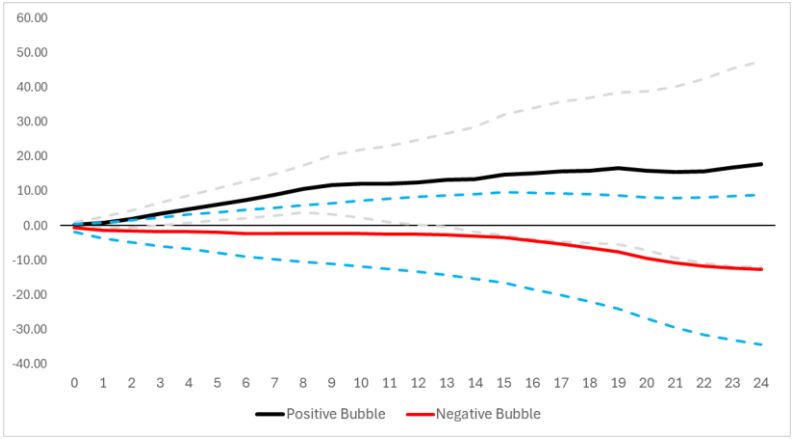
Panel C: Sales market in Madrid



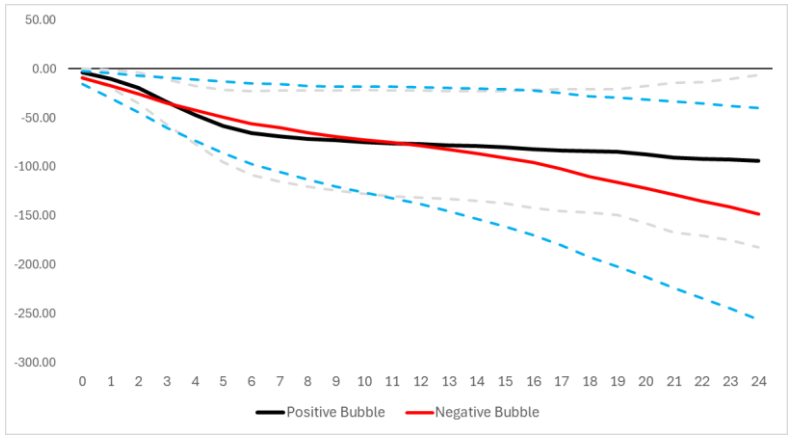
Panel D: Sales market in Barcelona

Figure 3.b Local projections impulse-response: Shocks to house certification

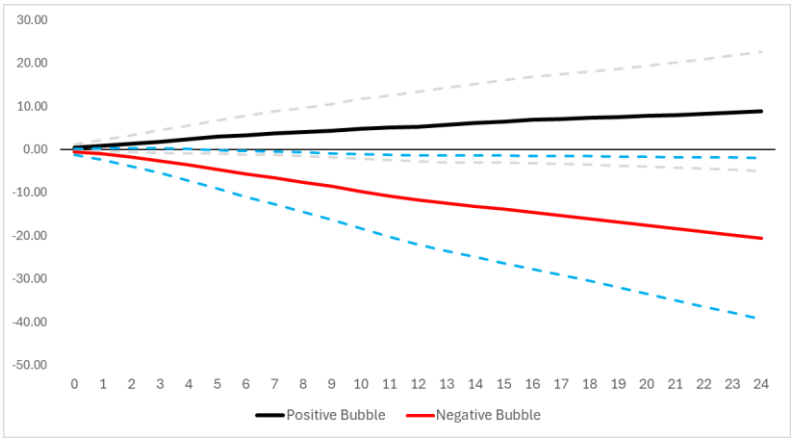
This figure plots the local projection estimates to one standard-deviation shock in house certification on positive (black line) and negative (red line) explosive price episodes from zero to 24 months ahead. The 95% confidence bands for positive (negative) explosive price episodes are in dash grey (blue) lines.



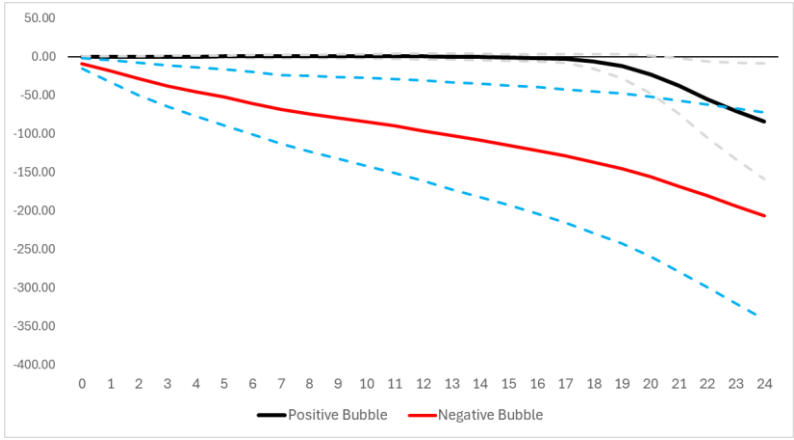
Panel A: Rental market in Madrid



Panel B: Rental market in Barcelona



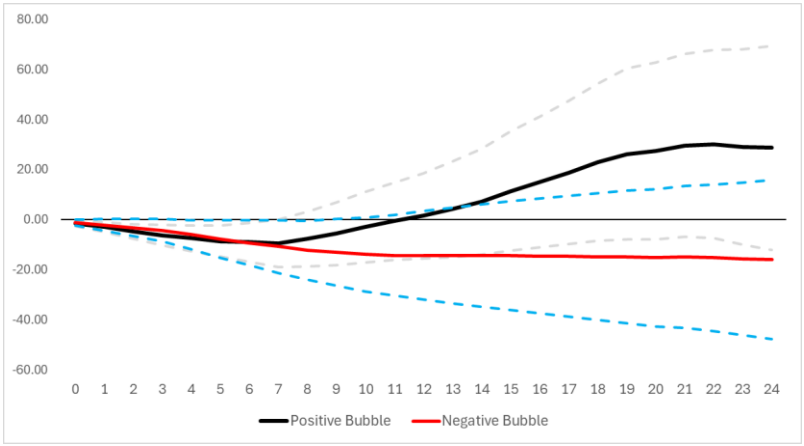
Panel C: Sales market in Madrid



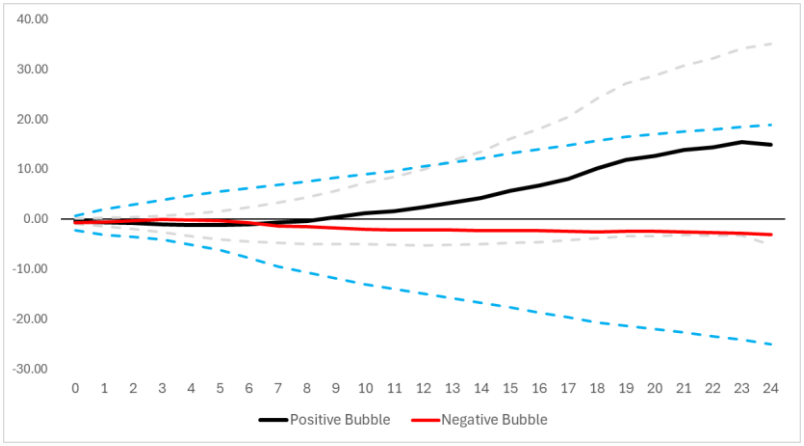
Panel D: Sales market in Barcelona

Figure 3.c Local projections impulse-response: Shocks to EU interest rates

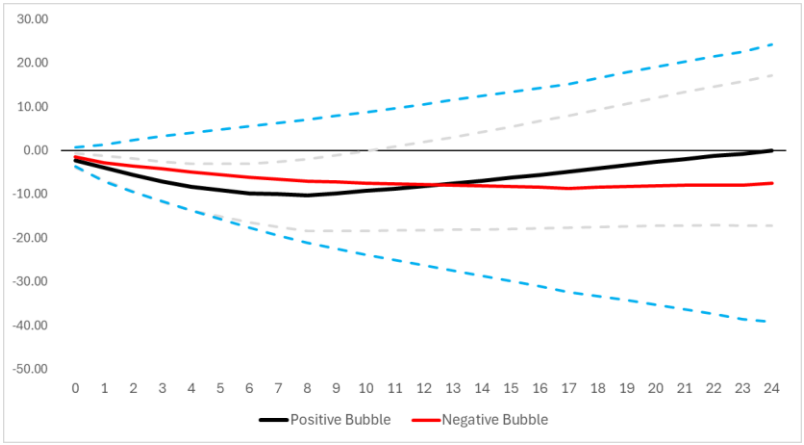
This figure plots the local projection estimates to one standard-deviation shock in EU interest rates on positive (black line) and negative (red line) explosive price episodes from zero to 24 months ahead. The 95% confidence bands for positive (negative) explosive price are in dash grey (blue) lines.



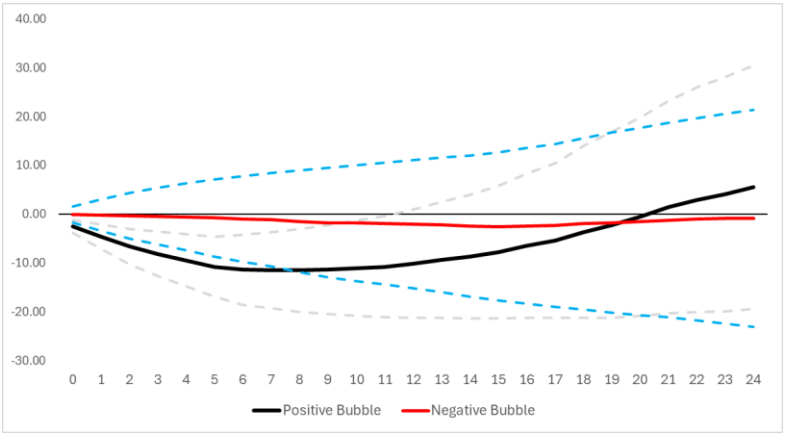
Panel A: Rental market in Madrid



Panel B: Rental market in Barcelona



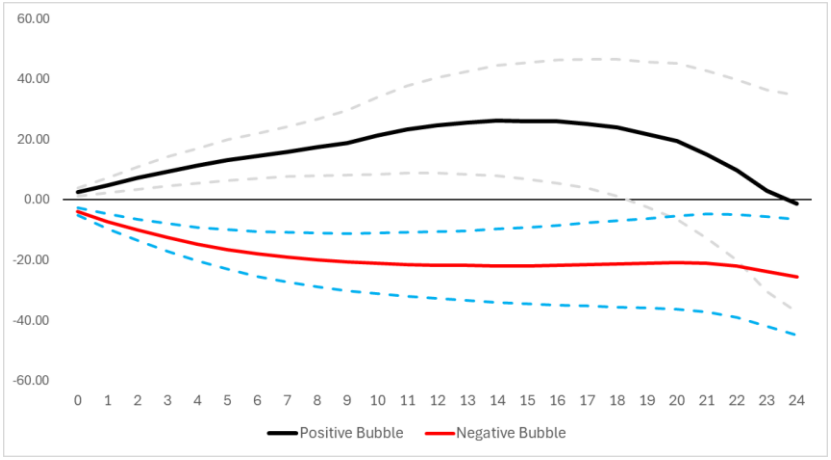
Panel C: Sales market in Madrid



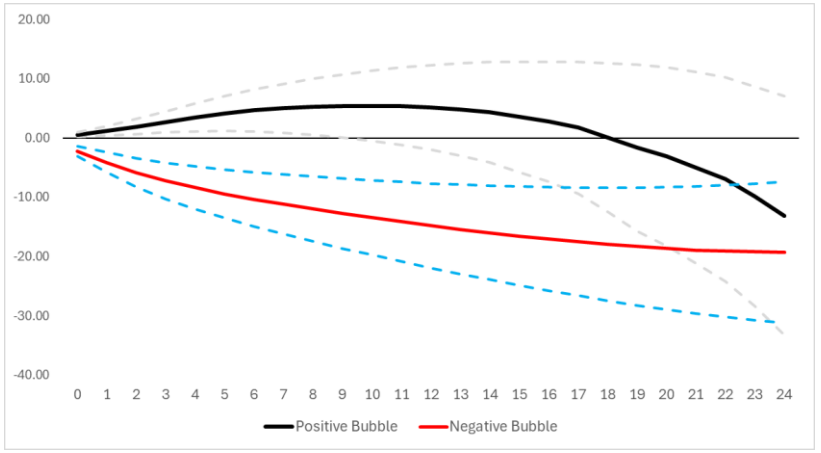
Panel D: Sales market in Barcelona

Figure 3.d Local projections impulse-response: Shocks to resident population

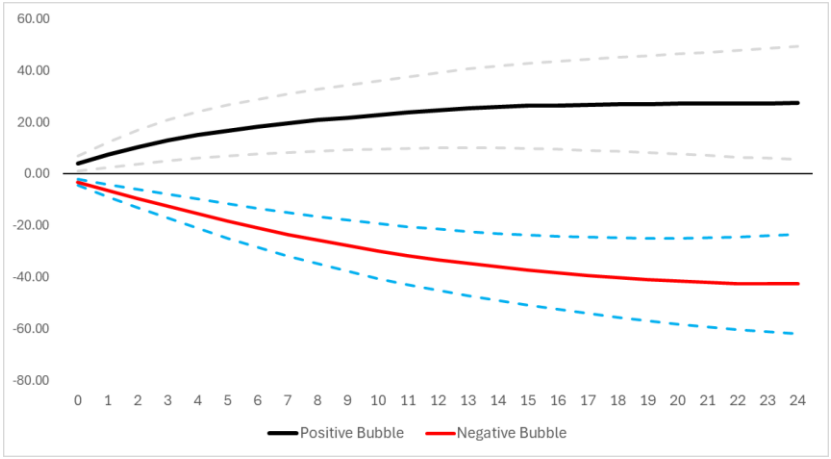
This figure plots the local projection estimates to one standard-deviation shock in resident population on positive (black line) and negative (red line) explosive price episodes from zero to 24 months ahead. The 95% confidence bands for positive (negative) explosive price episodes are in dash grey (blue) lines.



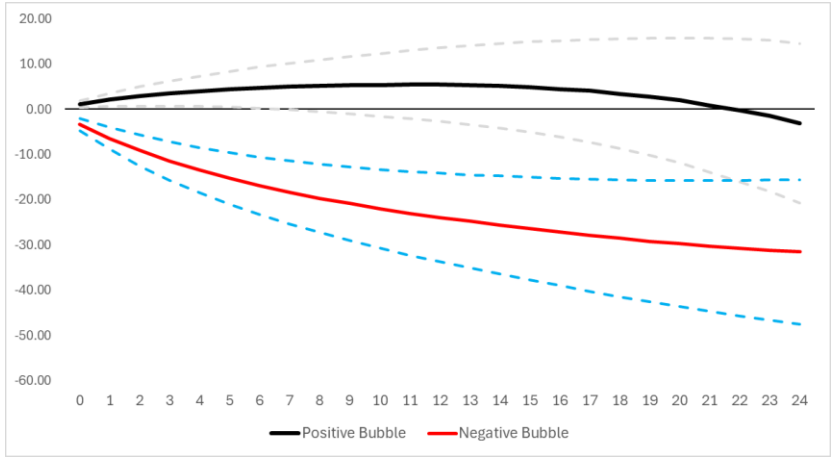
Panel A: Rental market in Madrid



Panel B: Rental market in Barcelona



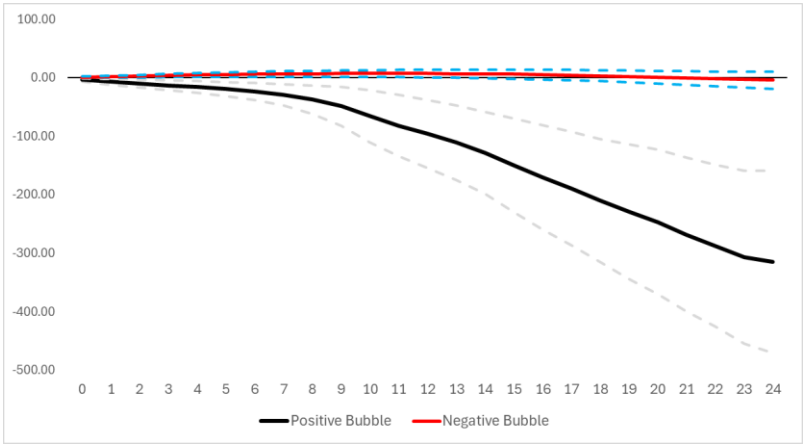
Panel C: Sales market in Madrid



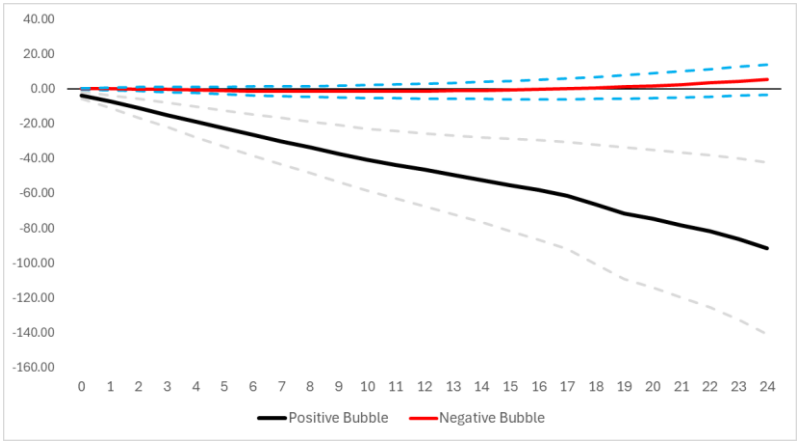
Panel D: Sales market in Barcelona

Figure 3.e Local projections impulse-response: Shocks to unemployment rate

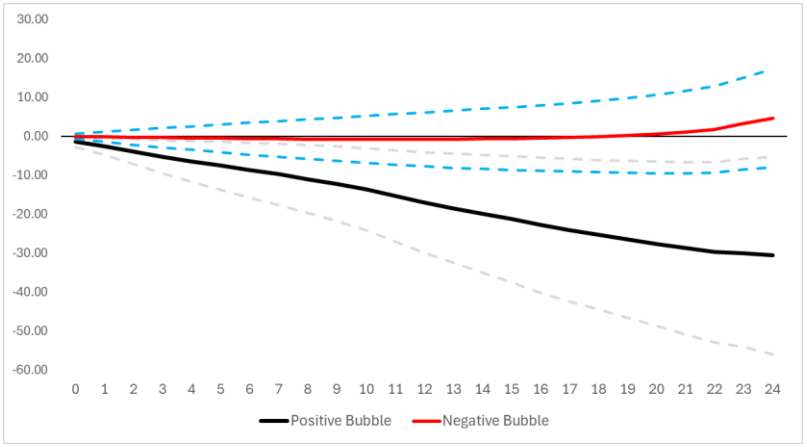
This figure plots the local projection estimates to one standard-deviation shock in unemployment rate on positive (black like) and negative (red line) explosive price episodes from zero to 24 months ahead. The 95% confidence bands for positive (negative) explosive price episodes are in dash grey (blue) lines.



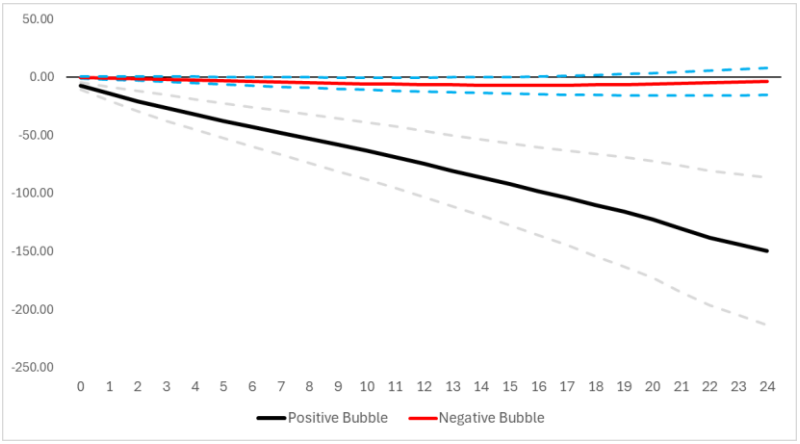
Panel A: Rental market in Madrid



Panel B: Rental market in Barcelona



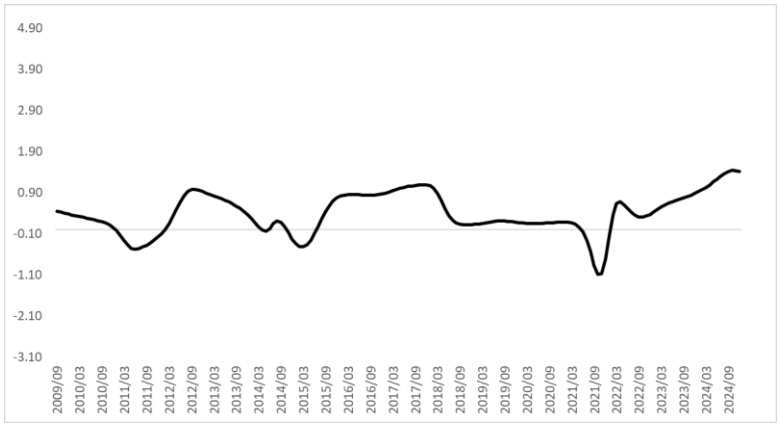
Panel C: Sales market in Madrid



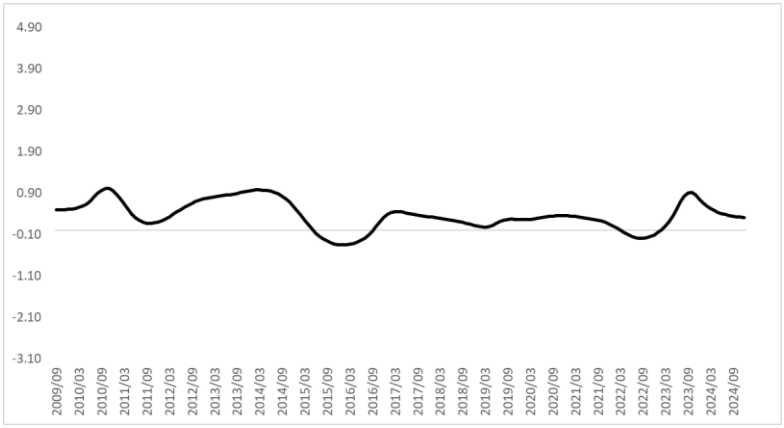
Panel D: Sales market in Barcelona

Figure 4. Contagion of explosive price dynamics in rental and sales markets

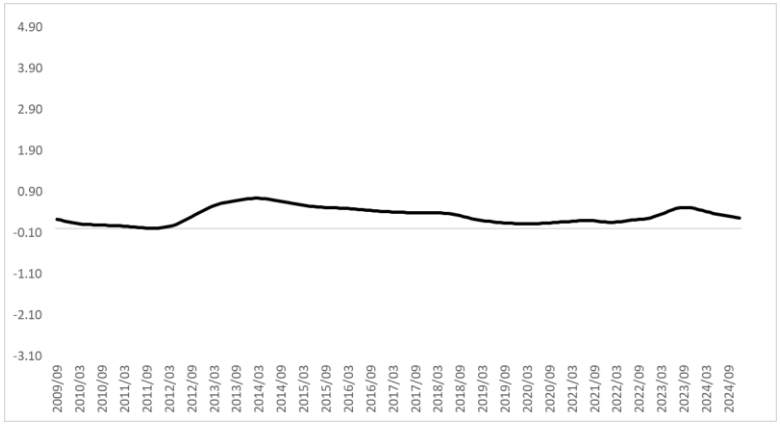
This figure plots the results of contagion of explosive price dynamics for rental and sales markets in both Madrid and Barcelona as represented by $\hat{\delta}_{t,T}$ in Equation (7). The periods shaded in grey corresponds to the highest positive decile of $\hat{\delta}_{t,T}$ across all market pairs. The arrows represent where the contagion comes from. The sample period is from August 2009 to December 2024.



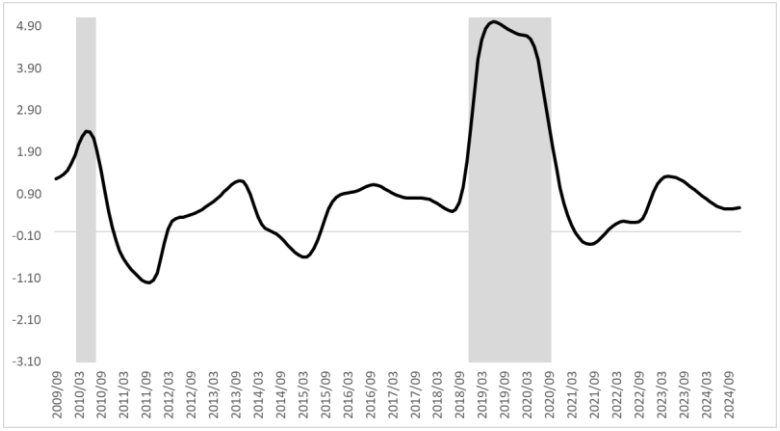
Panel A: Rental market in Barcelona ➔ Rental market in Madrid



Panel B: Rental market in Madrid ➔ Sales market in Madrid

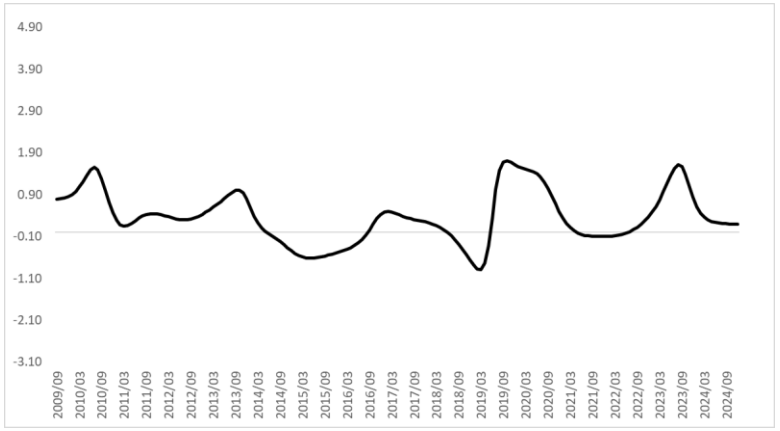


Panel C: Sales market in Barcelona ➔ Rental market in Madrid

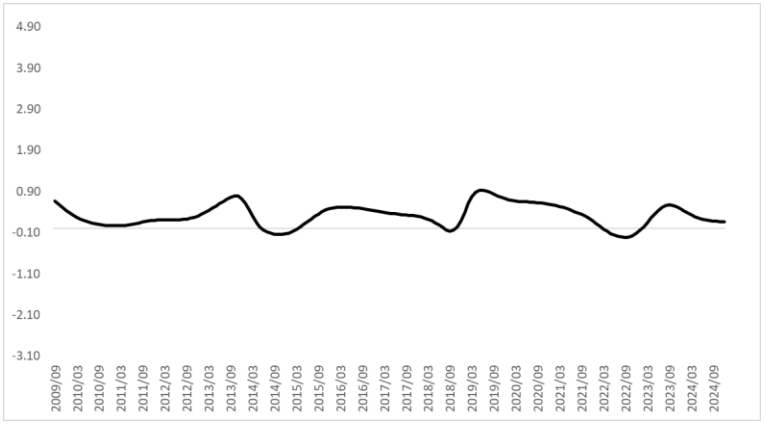


Panel D: Rental market in Madrid ➔ Rental market in Barcelona

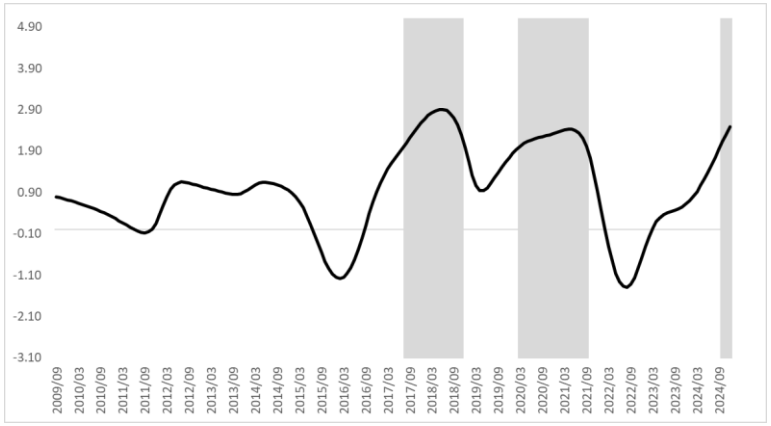
Cont. Figure 4. Contagion of explosive price dynamics in rental and sales markets



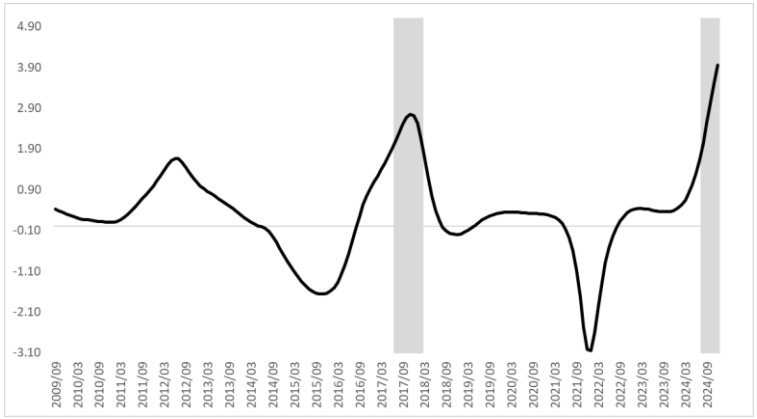
Panel E: Sales market in Madrid ➔ Rental market in Barcelona



Panel F: Sales market in Barcelona ➔ Rental market in Barcelona

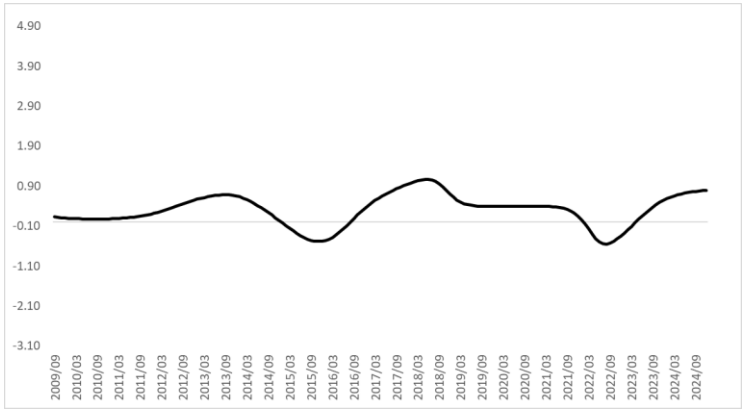


Panel G: Rental market in Madrid ➔ Sales market in Madrid

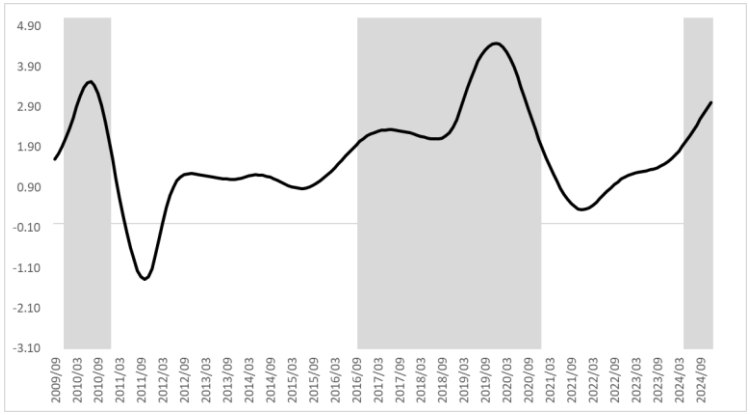


Panel H: Rental market in Barcelona ➔ Sales market in Madrid

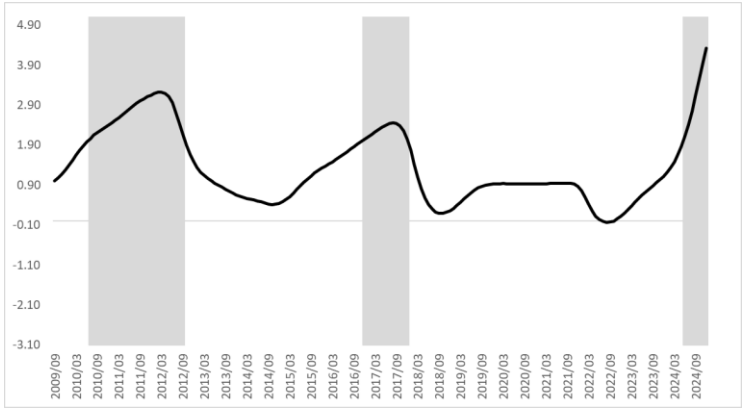
Cont. Figure 4. Contagion of explosive price dynamics in rental and sales markets



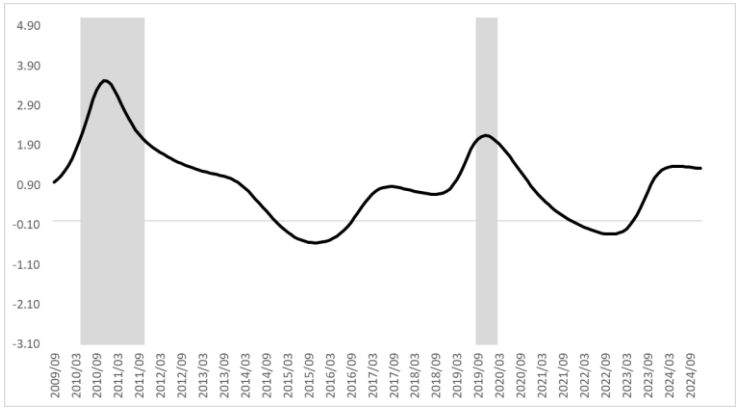
Panel I: Sales market in Barcelona ➔ Sales market in Madrid



Panel J: Rental market in Madrid ➔ Sales market in Barcelona



Panel K: Rental market in Barcelona ➔ Sales market in Barcelona



Panel L: Sales market in Madrid ➔ Sales market in Barcelona

Table 1. Descriptive statistics

This table reports the mean and standard deviation of the rental and sales market prices (in euros per square metre) per district in Madrid (Panel A) and Barcelona (Panel B), respectively. The sample period is from May 2007 to December 2024.

	Panel A: Madrid					Panel B: Barcelona			
	Rental		Sales			Rental		Sales	
	Mean	Std.	Mean	Std.		Mean	Std.	Mean	Std.
Arganzuela	13.62	2.24	3612.94	623.40	Ciutat Vella	16.98	2.95	3912.81	478.11
Barajas	11.31	1.26	3082.78	336.69	Eixample	15.02	3.20	4307.02	634.27
Carabanchel	10.66	1.78	2219.72	422.41	Gràcia	14.51	2.72	3889.84	547.15
Centro	16.98	2.67	4355.98	802.90	Horta Guinardó	11.83	2.07	2955.08	383.22
Chamartín	14.84	2.05	4736.65	633.39	Les Corts	14.12	2.23	4705.46	384.18
Chamberí	16.27	2.52	4757.52	852.28	Nou Barris	11.36	1.87	2372.22	383.44
Ciudad Lineal	12.36	1.77	2973.95	390.21	Sant Andreu	11.84	1.90	2882.79	366.90
Encinar de los Reyes	14.68	1.52	5020.78	408.12	Sant Martí	14.73	2.98	3599.57	388.56
Fuencarral	11.44	1.57	3320.09	380.99	Sants-Montjuïc	13.43	2.55	3294.70	474.99
Hortaleza	12.06	1.39	3452.49	429.02	Sarrià-Sant Gervasi	15.50	2.49	4860.86	582.77
Latina	10.71	1.97	2276.15	417.79					
Moncloa	13.60	1.99	3739.98	501.73					
Moratalaz	10.18	1.60	2457.30	376.65					
Puente de Vallecas	10.90	1.91	1962.89	459.11					
Retiro	14.67	2.26	4131.07	709.76					
Salamanca	16.90	2.71	5183.12	1034.15					
San Blas	11.33	1.48	2617.16	392.15					
Tetuán	14.29	2.23	3397.62	546.10					
Usera	10.74	1.97	2082.39	447.28					
Vicálvaro	9.86	1.34	2332.85	467.85					
Villa de Vallecas	10.35	1.49	2414.92	337.35					
Villaverde	9.99	1.84	1846.40	428.26					
Average	*12.62*	*1.84*	*3271.58*	*466.77*	*Average*	*13.93*	*2.46*	*3678.04*	*423.48*

Table 2. Explosive price dynamics occurrences

This table reports the statistics of explosive price dynamics occurrences. The number of explosive price dynamics refers to those lasting at least six months in the rental and sales markets of Madrid and Barcelona. The sample period is from August 2009 to December 2024.

	Rental market in Madrid	Rental market in Barcelona	Sales market in Madrid	Sales market in Barcelona
Number of explosive price dynamics	3	5	4	3
Number of explosive price dynamics months	104	57	118	91
Number of months with positive explosive price dynamics	80	26	71	50
Number of months with negative explosive price dynamics	24	31	47	41
Average length of explosive price dynamics (in months)	34.67	11.40	29.50	30.33

Table 3. Variables definition and source

This table defines the variables used in multinomial logistic regressions. The sources are included in the last column.

Variable	Description	Source
Hotel-based visitors	The annual growth rate in the number of people registered at hotel establishments per city.	National Institute of Statistics (INE): Hotel occupancy survey
House certifications	The annual growth rate in the issuance of building completion certificates per city.	Ministry of Transport and Sustainable Mobility
EU interest rate	Changes in the ECB's interest rate for its primary refinancing operations.	European Central Bank (ECB)
Resident population*	The annual rate of growth in the resident population per city.	National Institute of Statistics (INE): Population Figures
Unemployment	The annual growth rate in the number of individuals officially registered as unemployed per city.	State Public Employment Service (SEPE)
Overnight stays	The annual rate of growth in the number of nights spent by a person in a hotel establishment per city.	National Institute of Statistics (INE): Hotel occupancy survey
House numbers	The annual rate of growth in the number of houses issued completion certificates per city.	Ministry of Transport and Sustainable Mobility
3-month interbank rate	Changes in the 3-month Spanish interbank interest rates.	Bank of Spain
Immigration*	The annual growth rate of immigration per city.	Ministry of Inclusion, Social Security and Migration
Affiliation Social Security	The annual rate of growth in the number of affiliations to the Social Security system per city.	Ministry of Inclusion, Social Security and Migration

*Quarterly series are interpolated into monthly.

Table 4. Determinants of explosive price dynamic episodes

This table presents the estimates from the multinomial logistic regression in Equation (4). Positive (Negative) represents the probability of positive (negative) explosive price dynamics. The independent variables are defined in Table 3. All continuous variables are standardised and winsorised at the {1%, 99%}. Robust t-statistics are reported in parenthesis. ***, **, and * represent significant levels at the 1%, 5% and 10%, respectively. The sample is from August 2009 to December 2024.

	Rental market in Madrid		Rental market in Barcelona		Sales market in Madrid		Sales market in Barcelona	
	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Hotel-based visitors	-12.579***	-0.875*	-5.168***	-0.831***	-1.411	-0.280	-9.708***	-1.397***
	(-2.99)	(-1.87)	(-4.44)	(-3.21)	(-1.57)	(-0.45)	(-3.76)	(-3.27)
House certifications	0.230	-0.639	-3.639*	-9.061***	0.453	-0.534	0.013	-8.945***
	(0.55)	(-1.10)	(-1.90)	(-2.61)	(1.35)	(-1.49)	(0.10)	(-2.49)
EU interest rate	-1.554***	-1.133*	-0.372	-0.744	-2.297***	-1.489	-2.489***	-0.041
	(-3.17)	(-1.75)	(-1.44)	(-1.02)	(-2.76)	(-1.33)	(-3.72)	(-0.05)
Resident population	2.540***	-3.857***	0.573***	-2.203***	4.112***	-3.275***	1.153***	-3.408***
	(3.59)	(-5.84)	(2.90)	(-5.00)	(2.81)	(-5.12)	(2.91)	(-5.12)
Unemployment	-3.690***	1.044**	-3.665***	0.081	-1.491**	-0.102	-7.376***	-0.306
	(-2.71)	(2.34)	(-3.77)	(0.43)	(-2.27)	(-0.30)	(-4.59)	(-0.92)
Constant	-3.062***	-5.615***	-4.188***	-5.148***	-1.190***	-2.63***	-4.746***	-5.064***
	(-2.84)	(-5.76)	(-5.28)	(-4.11)	(-3.25)	(-5.43)	(-3.91)	(-3.71)
Pseudo R^2	0.62		0.39		0.60		0.59	
Observations	184		184		184		184	

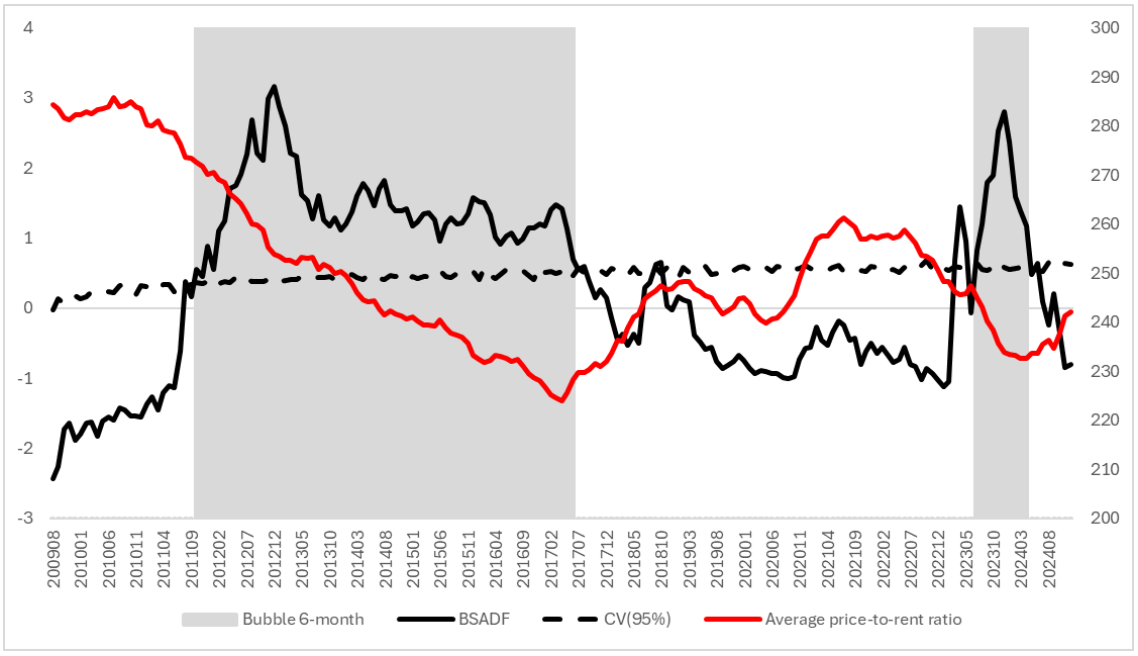
Table 5. Determinants of explosive price dynamic episodes: alternative variables

This table presents the estimates from the multinomial logistic regression in Equation (4). Positive (Negative) represents the probability of positive (negative) explosive price dynamics. The alternative independent variables are defined in Table 3. All continuous variables are standardised and winsorised at the {1%, 99%}. Robust t-statistics are reported in parenthesis. ***, **, and * represent significant levels at the 1%, 5% and 10%, respectively. The sample is from August 2009 to December 2024.

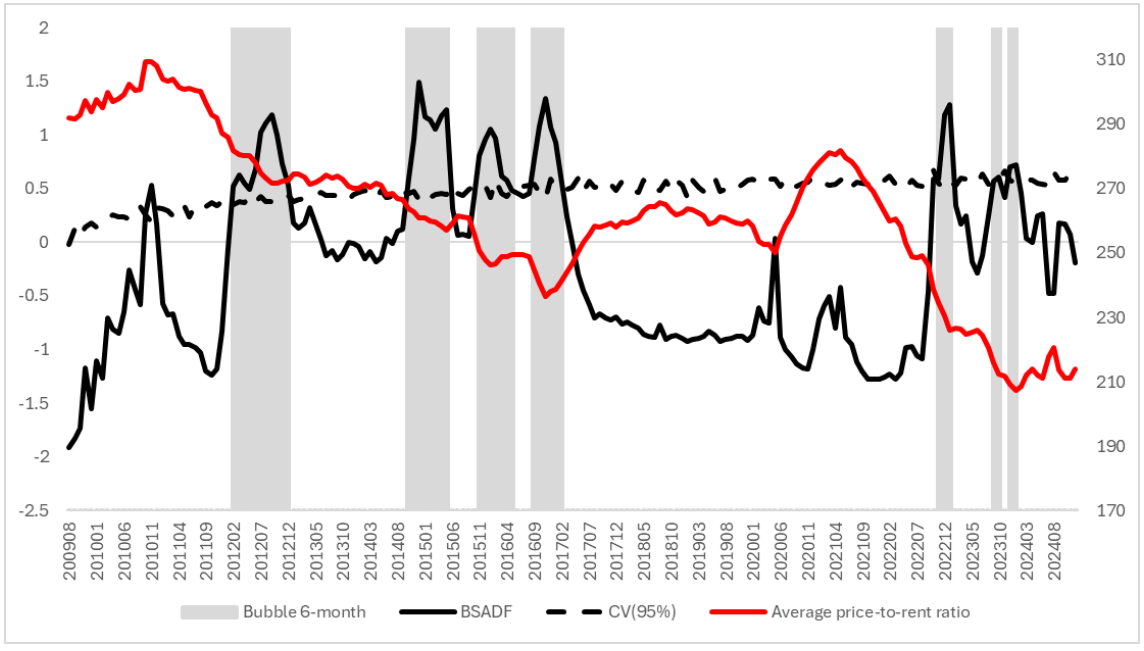
	Rental market in Madrid		Rental market in Barcelona		Sales market in Madrid		Sales market in Barcelona	
	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Overnight stays	-17.549***	0.751**	-1.951***	0.661***	-1.278***	0.009	-21.070***	0.071
	(-2.73)	(2.12)	(-5.00)	(3.14)	(-3.44)	(0.05)	(-2.91)	(0.44)
House numbers	-0.422	-0.134	-7.334*	-0.146	0.283	-0.488	2.45	2.489
	(-0.74)	(-0.21)	(-1.72)	(-0.45)	(1.02)	(-1.10)	(0.54)	(0.52)
3-Month Interbank Rate	-6.206**	-0.622	-1.406***	0.040	-2.534***	-2.378***	-9.089***	-1.017*
	(-2.55)	(-1.15)	(-2.70)	(0.08)	(-3.13)	(-3.68)	(-3.16)	(-1.91)
Immigration	5.333***	-0.012	0.166	0.017	3.049***	0.366	3.291***	-0.217
	(3.19)	(-0.06)	(0.39)	(0.07)	(4.57)	(1.50)	(3.13)	(-0.98)
Affiliation Social Security	15.130***	-2.971***	5.196***	-2.543***	3.764***	-0.685***	14.169***	-1.270***
	(3.62)	(-3.49)	(4.04)	(-5.98)	(2.76)	(-2.61)	(3.81)	(-4.53)
Constant	-7.855**	-4.120***	-5.935***	-3.195***	-1.271	-0.406	-13.940***	-1.033
	(-2.17)	(-4.00)	(-4.70)	(-6.90)	(-1.46)	(-1.30)	(-3.32)	(-1.37)
Pseudo R^2	0.73		0.44		0.48		0.55	
Observations	179		179		179		179	

Appendix A. Explosive price dynamics in price-to-rent ratios

This figure plots the results obtained from the price explosiveness detection tests for price-to-rent ratios in both Madrid and Barcelona (using the minimum length of 6 months) with episodes of explosive price dynamics shaded in grey. The average price-to-rent ratio is in the solid red line, and the BSADF statistic in the solid black line. We also report the Monte Carlo critical values for significance at the 5% level in the dash black line. The sample period is from August 2009 to December 2024.



Panel A: Price-to-rent ratio in Madrid



Panel B: Price-to-rent ratio in Barcelona