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Housing markets in Portugal and Spain: Fundamentals, overvaluation and shocks

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Abstract
Since 2013, real housing prices have increased by more than 80% in Portugal and less than 30% in Spain. What could explain such discrepancy, given that both economies have experienced similar macroeconomic dynamics in recent years? Using two complementary methodologies — the Phillips and Shi (2020) test and quantile regressions to estimate the conditional quantiles of house prices — it is observed that housing prices in Portugal display signs of overvaluation since 2017, which is not the case for Spain. Furthermore, it is also observed that housing prices in Portugal are "misaligned" relatively to what macroeconomic determinants would predict. Additionally, the contribution of demand and supply shocks to the dynamics observed in each country is quantified using a structural Bayesian vector autoregressive model with sign restrictions. It is concluded that housing price growth in Portugal is mainly driven by demand forces, with supply being ineffective in counterbalancing these pressures, unlike in Spain.
(JEL: C11, C22, R31)

1. Introduction

Since 2013[1] until the end of 2023, housing prices in Portugal increased by 83% in real terms. This contrasts with a growth of only 28% in Spain during the same period. Are there economic fundamentals that explain such discrepancy? In particular, have the macroeconomic dynamics in the two countries been so distinct as to justify this difference?

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1. The first quarter of 2013 represents the trough of the Portuguese economic cycle following the euro area sovereign debt crisis. Aguiar-Conraria *et al.* (2024) classify this cycle as having 10 quarters, with a peak in the third quarter of 2010 and a trough in the first quarter of 2013.

In recent years, Portugal and Spain have faced similar adjustment processes in their economies, particularly following the financial and European sovereign debt crises. Following these two crises, housing prices in both countries contracted — although by different magnitudes. Between the 2008 financial crisis and the start of the economic recovery in 2013, prices (in real terms) decreased by an annual average of 4% in Portugal and more than 8% in Spain. In the period between 2014 and 2023, after a period of economic recovery, the Covid-19 pandemic crisis was followed by an inflationary shock in 2022 and a subsequent increase in key interest rates by the European Central Bank (ECB), in an unusual context of war in Ukraine. During this period, housing prices recovered, reaching an average annual growth of 6% in Portugal and less than 3% in Spain (Figure 1).

Given this price behaviour, the goal of this study is, firstly, to describe the macroeconomic dynamics underlying the evolution of the housing markets in both countries in recent years. Beyond this characterization, which helps to better understand whether such price behaviour can be rationalized by economic fundamentals, the second part formally tests this hypothesis —– using a test that detects overvaluation and quantile regressions. Additionally, using a structural Bayesian vector autoregressive (BVAR) model, the contribution that demand and supply forces have had on market equilibrium during each period is estimated.

The use of the methodology developed by Phillips and Shi (2020) allows testing for price overvaluation in the housing markets of Portugal and Spain. Similarly, quantile regressions help identify periods during which housing prices are possibly misaligned with macroeconomic determinants. Specifically, it is considered that misalignment occurs when price growth exceeds what is expected for the right tail of the conditional distribution — i.e., periods during which prices grew more rapidly than expected

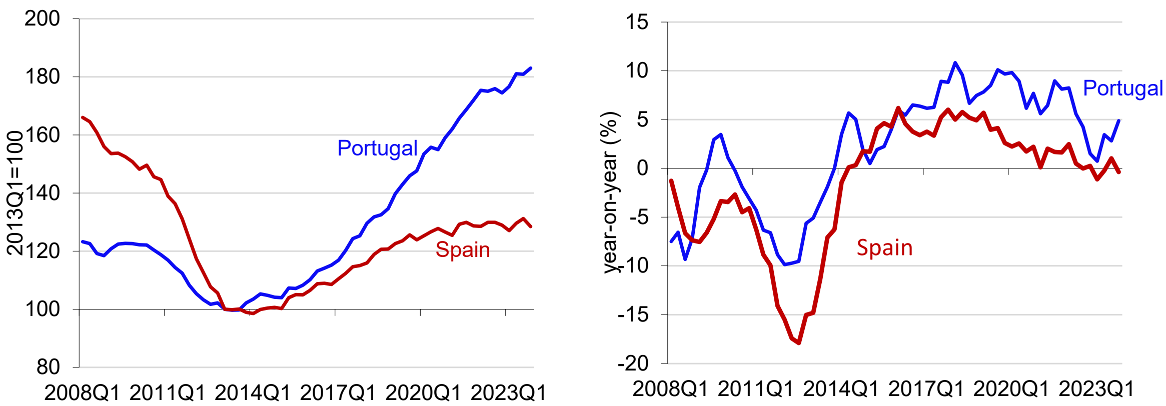


FIGURE 1: Evolution of house prices (left) and the respective year-on-year growth rate in Portugal and Spain in real terms

Note: House prices correspond to a hedonic price index (i.e., adjusted for house quality: price per square meter, size, and location) for newly constructed and existing houses acquired in the residential market. In the case of Portugal, the aggregate house price index has been calculated by the Instituto Nacional de Estatística (INE) since 2009 and, before that, by *Confidencial Imobiliário*.
Sources: INE, *Confidencial Imobiliário*, ECB, and authors' calculations.

based on a conditional quantile on the right side of the distribution. The conclusion of these two exercises points in the same direction: in Portugal, prices exhibited signs of overvaluation by the end of 2023, whereas this was not observed in Spain.[2] Note that signs of housing price overvaluation in Portugal has persisted since early 2017, according to the results of the Phillips and Shi (2020) test, consistent with what was observed by Rodrigues *et al.* (2022). The same test does, however, not detect overvaluation in the price behaviour of the Spanish market.

Another contribution of the study is to estimate a structural bayesian vector autoregressive (BVAR) model that characterizes the housing market along a demand and a supply curve. By imposing prior distributions on the elasticities of each curve, which combine sign restrictions with the possibility of guiding model estimation using elasticity estimates from existing literature, specific structural shocks are identified for each of the curves, for each period. This analysis suggests that house price growth in Portugal, for most of the period considered, has been driven by demand forces, with supply being unable to counterbalance such effect. In Spain, however, this demand pressure is mitigated by supply contributions, particularly in the pre-pandemic period.

Overall, there are signs of overvaluation in price growth in Portugal but not in Spain. Additionally, in the case of Portugal, housing prices can also be said to be misaligned with the macroeconomic fundamentals considered in the analysis, thereby confirming the more atypical behaviour of this market in Portugal in recent years. Moreover, by decomposing the market forces driving prices, the study can also assist in the design of correctly targeted public policies.

However, some caveats of the analysis need to be highlighted. The complexity of markets requires that all exercises performed necessarily simplify reality. For example, there is geographical heterogeneity within each country that impacts the dynamics of each city; and the rental market also plays an important role in the dynamics of the housing market. However, due to data constraints, these dimensions are abstracted from in this study. It is also important to note that when comparing Portugal and Spain, that the Spanish economy is significantly larger than the Portuguese. Nevertheless, as presented in the following sections, both economies have a significant weight of the tourism sector, considerable cultural proximity, and similar demographic changes. Additionally, the construction sector in each country has a similar weight in their GDPs.

The remainder of the article is organized as follows. Section 2 discusses the evolution of some macroeconomic variables that may underlie the dynamics observed in the housing markets in Portugal and Spain; Section 3 presents empirical results that identify the existence of overvaluation in price behaviour over the period of analysis and determine whether prices are growing in an "extreme" manner; Section 4 identifies the contribution that demand and supply shocks have had on the dynamics observed in

2. "Conditional quantile" refers to the predicted price movements based on the behaviour observed from a set of explanatory variables at a specific quantile of the conditional distribution. In the analysis conducted, due to the number of available observations, the 80th percentile is defined as the threshold above which price movements are considered "misaligned" with fundamental behaviour. Section 3.2 provides a detailed explanation of the quantile regression model used.

these markets; finally, Section 5 concludes. An appendix provides a brief description of the overvaluation test proposed by Phillips and Shi (2020) - Appendix A; a brief description of a quantile co-integration test - Appendix B; and an analysis of the robustness of the results of the historical decomposition of demand and supply shocks based on the number of transactions - Appendix C.

2. Overview of recent macroeconomic dynamics in both countries

In this section, the macroeconomic dynamics of both countries is characterized, providing better context for understanding the behaviour of the housing market, followed by a description of changes in this market. However, before proceeding, it is important to briefly describe the two main variables that are used in this article to characterize the behaviour of the housing markets in both countries: house prices and residential investment (residential gross fixed capital formation).

The house price indices for both countries follow the hedonic pricing methodology, which aims to control for potential biases arising from differences in the quality of the houses (price per square meter, size, and location) sold between periods. These indices aggregate the price trends of both newly constructed houses and existing ones acquired in the residential market. The indices are compiled by the respective national statistics institutes and, in the case of Portugal, by *Confidencial Imobiliário* for the period before 2009. In both cases, the indices are deflated using the respective private consumption deflators.[3]

Regarding the residential gross fixed capital formation, the series refers to real investment in residential constructions (apartments or houses) and is compiled by the respective national statistics institutes in accordance with the European System of Accounts (ESA).

2.1. Macroeconomic dynamics

Between 2008 and 2023, the evolution of GDP, residential investment (residential GFCF), and disposable income per capita was globally similar in Portugal and Spain, as shown in Figure 4. Unemployment, housing credit stock, and short-term real interest rates also showed similar trends.[4]

In the five years following the financial crisis, up to the recovery in 2013, both economies experienced an average annual GDP contraction of 1% and a more significant decline in housing investment, around 12% in both countries (Figure 4). Regarding labour market conditions, it is observed that after the crisis, the labour force registered a significant reduction, partly due to increased emigration flows and population aging,

3. The methodology for several EU countries can be found in `ec.europa.eu/eurostat/cache/metadata/en/prc_hpi_inx_esms.htm` and in the case of *Confidencial Imobiliário*, an independent portuguese databank, in https://www.confidencialimobiliario.com/.

4. The unemployment rate in Spain is markedly higher than in Portugal for most of the period shown in Figure 3. Despite the difference in the level of the rates, their trends have exhibited similar dynamics.

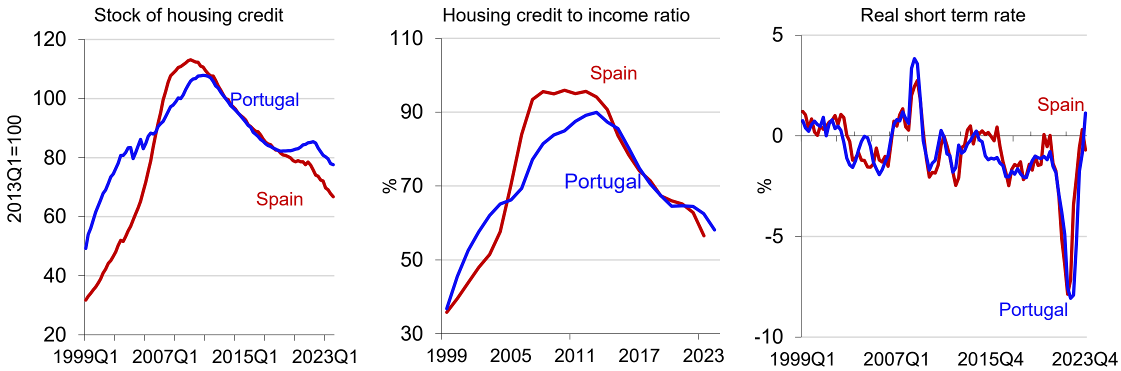


FIGURE 2: Credit market.

Note: The real interest rate is given by the 3 month EURIBOR and deflated by the private consumption deflator of each country.
Sources: ECB, INE and authors' calculations.

and that the unemployment rate rose sharply, peaking in 2013 (Figure 3). However, despite the relatively similar evolution of determinants in both countries during this period, the decline in housing prices in Portugal was half the value observed in Spain — an annual average of 4% compared to 8%, respectively.

The following years, from 2014 to 2023, were particularly challenging for both economies. After a period of economic recovery, there was the Covid-19 pandemic, followed by an inflationary shock in 2022 that led to an increase in the ECB policy interest rates after a long period of very low rates. In these 10 years, activity grew by 2% per year on average in both countries, and residential investment also grew but at a slightly faster pace in Spain than in Portugal (4% and 3%, respectively). The unemployment rate decreased in both countries, excluding the pandemic period, and later "stabilized".

In the period 2014-2023, as already mentioned, housing prices rose by an annual average of less than 3% in Spain and more than two times that in Portugal. It is

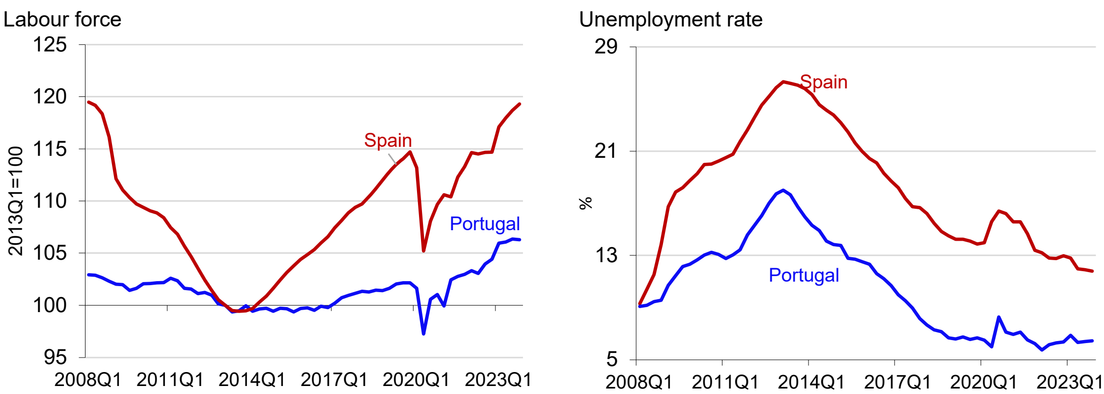


FIGURE 3: Labour market.

Sources: Banco de Portugal and ECB.

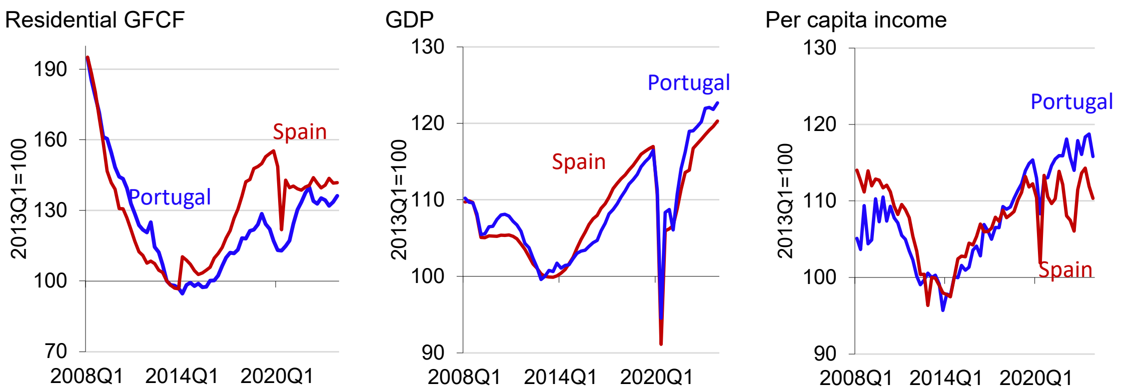


FIGURE 4: Residential GFCF, GDP and per capita disposable income.

Note: Data in real terms (disposable income is deflated by the private consumption deflator of each country).
Sources: Banco de Portugal, ECB and authors' calculations.

important to note that the increase in housing prices in Portugal, especially since 2017, has contributed to the deterioration of accessibility to the housing market, both for acquisition and rental, especially in the metropolitan areas of Lisbon and Porto; see (Rodrigues *et al.* 2023).

Finally, given its relevance for the housing sector, it is important to examine the evolution of credit in more detail. During the transition to the single currency and up until the financial and sovereign debt crises, Portugal and Spain experienced episodes of very high growth in mortgage credit. This occurred in both economies within a framework of reduced banking loan costs and strong, sustained growth in household disposable income, leading to increased household indebtedness. The ratio of housing loans to disposable income rose from about 30% in 1999 to around 90% in 2013 in both countries.

In contrast, after the financial crisis, there was a significant slowdown in housing credit (Figure 2). The crisis had negative effects on both supply, with a considerable tightening of banking conditions and requirements for credit access, and on demand for housing credit. By the end of 2023, the ratio of housing loans to disposable income was below 60% in both countries.

2.2. *Housing markets reconfiguration*

In recent years, there have been significant changes in the housing markets of both countries. These include demographic changes, as well as other changes following the financial crisis. According to the Census, the percentage of younger families owning houses has substantially decreased between 2011 and 2021 — from 70% to around 35% in Spain and from 60% to 40% in Portugal.[5] Loan applications from these younger households, likely with higher risk profiles (for example, due to greater job instability),

5. Families where the age of the household representative is below 35 years.

have declined. Credit conditions have become more stringent in terms of loan amounts and terms (Costa 2023; Gavilán 2022; Rodrigues *et al.* 2023).[6]

Another demographic change that has been observed is an increase in the number of households, combined with a decrease in household size. Currently, there is a larger number of single-person households, couples without children, and single-parent families (Figure 5).

Regarding the resident population, although Census data shows a decrease in the resident population in Portugal of about 1% between 2011 and 2021, the situation varies depending on the region considered: while the Porto metropolitan area also registered a reduction of 1%, the population of the Lisbon metropolitan area, on the contrary, increased by 2% (Rodrigues *et al.* 2023). In the case of Spain, the data show an increase of less than 1% in the population, but increases of 4% and 3% in the Community of Madrid and Catalonia, respectively, which, according to Álvarez-Román and Garcia-Posada (2021), had a positive effect on price growth.

There has also been a diversification in the use of residential buildings for tourism, and the growing demand from foreigners and immigrants in Portugal and Spain contribute to an upward price pressure. Online platforms that facilitate customer access and short-term rental management have made housing investments to accommodate tourists more attractive to a wide range of investors. This reality not only increases demand in the real estate market but also enhances the return on investment in tourist accommodations, as short-term rentals for tourists (if occupancy rates are adequate) offer substantially higher returns than permanent rentals to the local population. This argument is somewhat supported by the rapid growth in the number of businesses associated with local accommodation in a short period of time — for instance, in Lisbon, the number of properties registered for short-term rentals increased from twelve thousand in 2013 to over ninety-four thousand in 2019 (Gonçalves *et al.* 2023). Barcelona and Madrid are among the cities with more local accommodations listings.

For foreigners choosing to live or invest in Portugal and Spain, there has been significant growth in real estate investment in recent years. In Portugal, the stock of real estate investment held by non-residents represented 12% of GDP in 2023, compared to 4% in 2008.[7] In Spain, foreigners bought 125 thousand homes in 2023, mainly in the most touristic areas, representing 19% of the total transactions, up from 7% in 2007 (Gavilán 2024). Overall, the pressure from foreigners on housing prices is greater in the metropolitan areas of Lisbon and Porto, but the impact on the median house value seems to be globally limited, the existence of some spillover effects cannot be ruled out (Figure 6).

On the other hand, there has been a contraction of supply, which also contributes to an upward price pressure, which was observed in both countries over the past decade.

6. In July 2018 the Bank of Portugal, as the national macroprudential authority, implemented a measure targeting new credit contracts with consumers that introduced limits on the Loan-to-Value (LTV) ratio, the Debt Service-to-Income (DSTI) ratio, and loan maturities. In Spain, the Loan-to-Price ratio (LTP) has significantly decreased in recent years.

7. According to the external statistical data from Banco de Portugal.

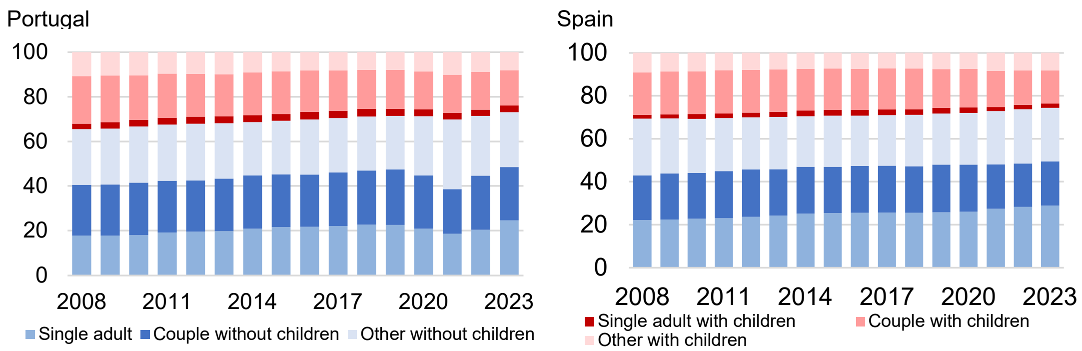


FIGURE 5: Household composition
Sources: Eurostat and authors' calculations.

According to Spanish government statistics, there was a substantial reduction in housing construction in Spain between 2012 and 2022, compared to the period between 2001 and 2011 — a reduction from 5 million to 800 thousand housing units. The same occurred in Portugal, where there was a decrease from 700 thousand to about 150 thousand housing units (Figure 7).

However, despite this phenomenon being common to both countries, construction dynamics over the past two decades are not exactly identical. Note that the slowdown in construction in Portugal appears to have begun in the early 2000s, whereas this decline is observed in Spain only later in that decade. Similarly, when the decline in construction occurs, it is much more abrupt in Spain, whereas in Portugal it is more gradual. In both cases, however, the lowest annual values are seen between the financial crisis and the sovereign debt crisis, with only modest recoveries following the latter.

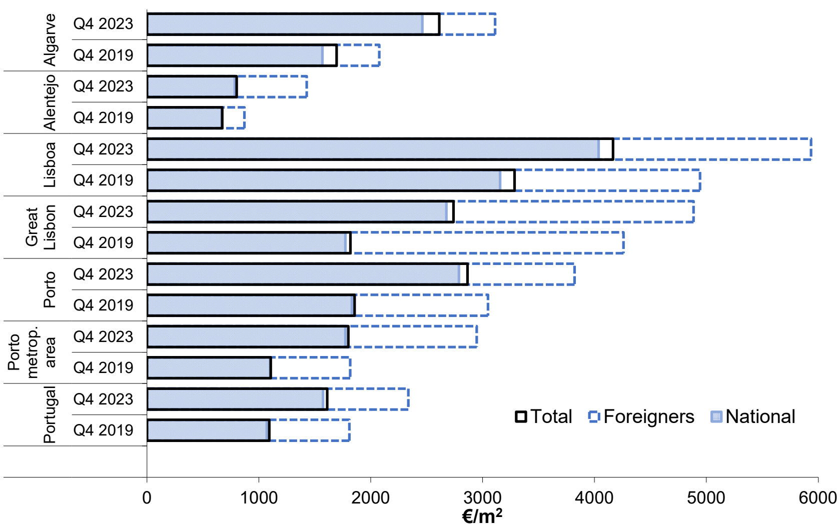


FIGURE 6: Median sales prices of dwellings by tax residence of the purchaser: Portugal
Source: INE

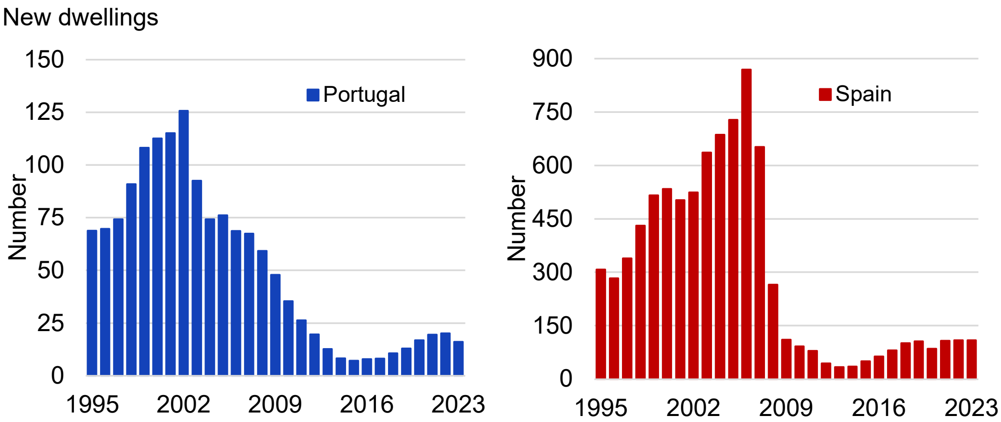


FIGURE 7: Construction of residential dwellings

Sources: INE, London Stock Exchange Group and authors' calculations.

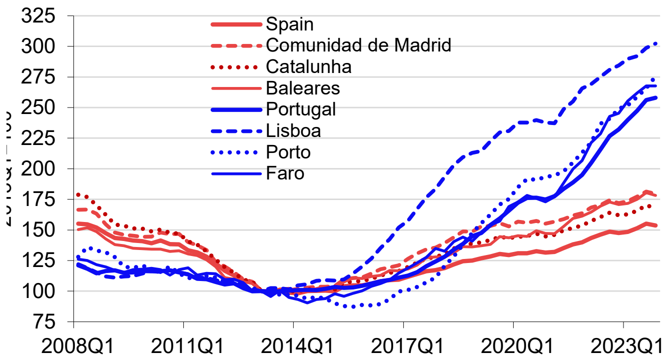


FIGURE 8: Evolution of house prices in selected regions

Note: The median prices in euros per m² at the local level, compiled by INE, are only available since 2019. Therefore, in this figure, and to compare the evolution of housing prices in various regions of Spain and Portugal since 2008, we used the price index series by municipality from *Confidencial Imobiliário*. Sources: *Confidencial Imobiliário* and Instituto Nacional de Estadística (Spain).

The economic impact of the international financial crisis and the sovereign debt crisis led to financial restrictions in the construction sector, resulting in a loss of the sector's installed capacity. The construction sector in Spain has accounted for 6.5% of total employment since 2020, almost half of what it was during the boom years of the 2000s. In Portugal, the construction sector represents 7% of total employment in 2023, down about 3 percentage points from the mid-2000s. The slowdown in construction is also partly due to the slower, more complex but necessary urban rehabilitation process across all regions. The housing stock shows some aging dynamics, with more rehabilitation and less new construction (Rodrigues *et al.* 2023).

Together, these factors contribute to an increase in market frictions due to the recomposition of existing demand, which may help explain the evolution of prices at both regional and national levels (Figure 8).

3. Analysing housing price dynamics: two complementary methodologies

In the previous section, it was concluded that despite the relatively similar evolution of the described macroeconomic variables in both countries, housing prices have exhibited distinct dynamics in the two cases — more pronounced in upward cycles but more contained in downward cycles in Portugal. In this section, we formally test whether prices have deviated from the values that would be "expected" based on what the macroeconomic variables considered would indicate for each period.

To this end, we use two methodologies. The first is based on the approach proposed by Phillips and Shi (2020), which allows for the detection of periods that may be associated with price overvaluation.[8] The second allows, with a quantile regression approach, for the detection of housing prices misalignments with the considered macroeconomic determinants.[9] These two methodologies are seen as complementary in the analysis conducted: the first test has a purely statistical aspect, capturing periods of sharp growth (or decline) that deviate from the "normal" behaviour of prices; the second exercise has a more explanatory nature, comparing the observed behaviour of prices against what would be predicted based on the behaviour of a set of explanatory variables.

3.1. *Results of the Phillips and Shi econometric test*

This methodology is based on the fact that asset prices can be explained by two components: the market fundamental and the non-fundamental component. The latter, when it exists, typically causes explosive price behaviour that temporarily dominates the time series dynamics. It is precisely this explosive behaviour that the approach aims to detect.

The procedure by Phillips and Shi (2020) begins with the application of a test (GSADF) that identifies multiple episodes of overvaluation over the time series, considering different start and end points of the time window. It then uses another test (BSADF) to monitor in real time the formation and collapse of overvaluation episodes (the blue line in Figure 9 shows the results of the BSADF for the considered period). The results from the GSADF and BSADF tests are compared with critical values, which are determined via bootstrap. When the values of the test exceed the critical values, it indicates the presence of overvaluation (shaded blue areas in Figure 9).

Figure 9 presents the application of the test for Portugal and Spain for the period between 1988Q1 and 2023Q4. Shaded areas point towards the existence of possible overvaluation episodes.

The application of the test for Portugal suggests the possible start of an overvaluation episode in the first half of 2017 (as previously reported by Rodrigues *et al.* 2022).

8. Appendix A provides a detailed description of the methodology by Phillips and Shi (2020).
9. This methodology was inspired by the work of Machado and Sousa (2006).

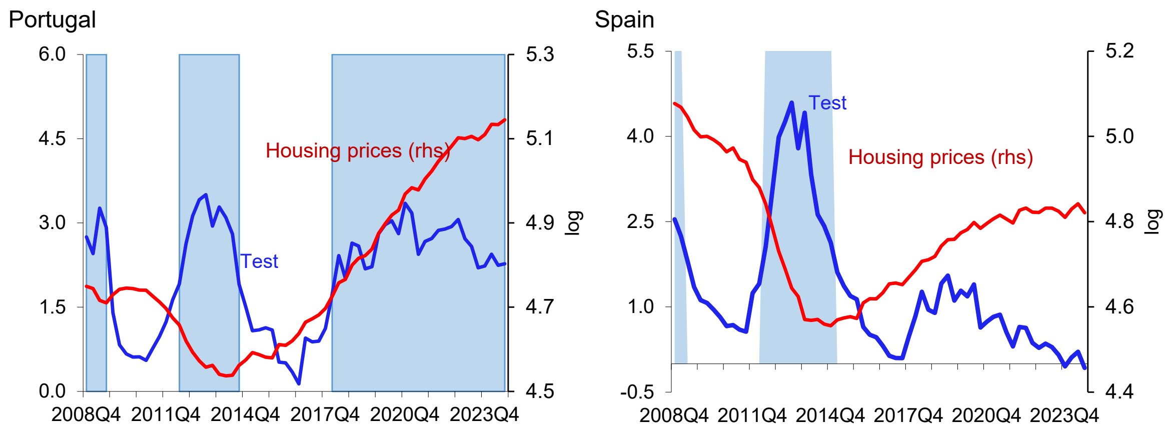


FIGURE 9: Over or undervaluation periods – Phillips and Shi (2020) test results and house prices evolution.

Note: Left-hand side scale —- Value of the Phillips and Shi (2020). Right-hand side scale — House price index in logs. The shaded areas indicate periods during which the series of results from the Phillips and Shi (2020) test (represented by the blue line) rejects the null hypothesis of no signs of overvaluation (or undervaluation) in price behaviour. For more details see appendix A.
Sources: Authors' calculations.

3.2. *Results of the quantile regression*

To complement the previous analysis, which detects overvaluation in prices in Portugal but not in Spain, a quantile analysis is conducted. This approach allows for the examination of different parts of the data distribution (such as the right and left tails of the housing price distribution), rather than just the mean, as is typical with traditional linear regression. This is an important feature because the impact of a variable on housing prices can differ in a context of lower prices compared to higher prices.

The estimated model is,

$$\begin{aligned} Q_{\ln(HP_t)}\left(\tau \mid \mathcal{F}_{\mathrm{t}-1}\right) \quad &= \quad \alpha_0(\tau) + \alpha_1(\tau) rdipcc_t + \alpha_2(\tau) rmmi_t \\ &\quad + \alpha_3(\tau) GFCFresid_t + \alpha_4(\tau) loan_t + \alpha_5(\tau) unemp_t \end{aligned} \tag{1}$$

where τ is the quantile of interest, $ln(HP_t)$ corresponds to the natural logarithm of the real house price index (obtained with the private consumption deflator) at time t, $rdipc_t$ is the natural logarithm of real per capita disposable income at time t, $rmmi_t$ is the short-term real risk-free interest rate at time t, $GFCFresid_t$ is the natural logarithm of residential gross fixed capital formation at time t, $loan_t$ is the natural logarithm of real loans for housing purchase at time t, and $unemp_t$ is the unemployment rate at time t.[10] The empirical analysis covers the period from the first quarter of 1988 to

10. Including foreign direct investment in real estate as a determinant in the quantile regression for Portugal does not qualitatively alter the conclusions.

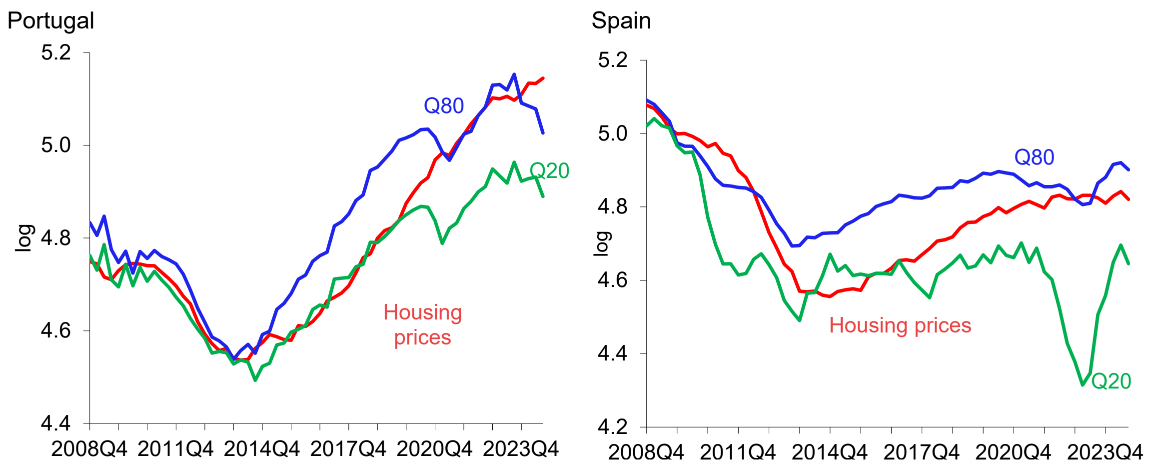


FIGURE 10: Results of the quantile regressions.
Sources: Authors' calculations.

the fourth quarter of 2023.[11] Since the variables used in equation 1 are non-stationary (confirmed through unit root tests), it is necessary to test for quantile cointegration. Following Xiao (2009), a quantile cointegration test is conducted by applying a CUSUM test to the residuals of equation 1. Based on the results of this test, the null hypothesis of cointegration cannot be rejected.[12] Thus, equation 1 can be seen as a long-term equilibrium specific to each quantile τ.

Figure 10 presents the results of the model estimates for each country, for the 0.2 and 0.8 quantiles, and the natural logarithm of the observed real housing price index over the period (the 0.2 and 0.8 quantiles are chosen as limits due to the length of the series). The estimated conditional quantiles suggest signs of overvaluation from the end of 2020 onwards.[13] In Spain, on the other hand, housing prices are consistent with the determinants, i.e., there does not appear to be overvaluation.

Overall, the results suggest signs of overvaluation in Portugal, as both approaches point to housing prices being misaligned with their fundamentals. In Spain, this is not the case, which is consistent with Álvarez-Román and Garcia-Posada (2021).

11. Given that the number of observations is relatively small, particularly when analyzing price behaviour in the tails of the distribution, the quantile regression analysis was conducted at the 0.2 (left tail) and 0.8 (right tail) quantiles to ensure a reasonable number of observations for model estimation.

12. For Portugal the test results are 0.4530 for $\tau = 0.2$, and 0.5137 for $\tau = 0.8$, and for Spain 0.7131 $\tau = 0.2$, and 0.8228 for $\tau = 0.8$. The critical values for the CUSUM test for significance levels of 90%, 95%, and 99% are for τ=0.2, 1.1448, 1.2468, and 1.4102, respectively, and for τ=0.8, 1.1510, 1.2452, and 1.4233, respectively.

13. Given that the estimated quantiles are conditional on the data available at the time of their estimation (i.e. reflecting the specific economic situation at the time), an exercise that recursively calculates the conditional quantiles makes it possible to detect signs of overvaluation since 2017 (in line with the results presented in the 3.1 section) — see Rodrigues *et al.* (2022).

4. Decomposing market dynamics into supply and demand shocks

After concluding in the previous sections that in the recent period there is overvaluation in the behaviour of prices in the Portuguese market (which is not observed in the Spanish case), this section quantifies the market forces that have influenced such behaviours. To do this, a structural BVAR model is estimated through which the forces that have had the greatest impact on market dynamics are formally quantified.

It is important to mention how this exercise should be reconciled with the results obtained in section 3.2. In that section, we saw that prices are evolving above what is predicted by a series of explanatory variables for the 0.8 quantile of the distribution. This means that the historical behaviour and consequent impact on prices of these variables do not seem to be compatible with the most recent evolution of the market. It may be the case that this is justified by the existence of other variables, not so commonly used in the literature, that are influencing market dynamics.

The goal of the BVAR estimated in this section is precisely to capture, in a reduced form, any force impacting the market (and not just a set of pre-selected variables), as long as such a force impacts either the demand (curve) or the supply (curve) in the market. Similarly, section 3.1 only identifies periods of price overvaluation, while this section identifies the forces that drive this behavior (both in periods of overvaluation as well as in periods of more stable behavior).

The model only identifies, in a reduced form, historical demand and supply shocks in each market. The methodology does not allow to distinguish the exact origin of demand or supply shocks — for example, a demand shock could have its root in a demographic phenomenon or instead a change in interest rates, yet the model classifies both as demand shocks only. This limitation of the model can also be considered useful: this methodology is able to capture any shock that has occurred, without this being explicitly dependent on the inclusion of certain variables in the model, which would always make the model's results dependent on the variables included.

This exercise is important since the implementation of public policies that have an effective impact on the housing market depends on several factors, but largely on being correctly targeted. Understanding which forces have historically put the most pressure on the housing market equilibrium — that is, from which side: demand or supply — becomes crucial in designing measures that alleviate such pressures.

4.1. Methodology and data

This section identifies the supply and demand shocks that have influenced prices and quantities in the housing market in both Portugal and Spain. To this end, we followed the methodology developed by Baumeister and Hamilton (2015) and estimated a structural BVAR model to describe the dynamics of this market in each country. The estimation of this model allows us to historically decompose the contribution that supply and demand shocks have had on the dynamics observed at each moment in the Portuguese and Spanish markets. [14]

The VAR model considered in the analysis for each country, in its structural form, can be represented as,

$$\boldsymbol{A}^c\boldsymbol{y}_t^c = \boldsymbol{B}_0^c + \boldsymbol{B}^c(L)\boldsymbol{y}_{t-1}^c + \boldsymbol{\varepsilon}_t^c, \tag{2}$$

where $\boldsymbol{y}_t^c = (\Delta p_t^c, \Delta q_t^c)'$ is a 2×1, $c = \{Portugal, Spain\}$, p_t^c is the price level at time t, and q_t^c is the quantities built at time t. $\boldsymbol{B}_0^c$ is a vector of constants and $\boldsymbol{B}^c(L)$ is a polynomial matrix in L associated with the lags of $\boldsymbol{y}_t^c$. Additionally, $\boldsymbol{\varepsilon}_t^c$ represents a 2×1 vector of structural shocks i.i.d $N(0, \boldsymbol{D})$, where $\boldsymbol{D}$, the variance-covariance matrix, is diagonal.

Defining $\boldsymbol{\varepsilon} t^c = (\varepsilon d, t^c, \varepsilon_{s,t}^c)'$, the first equation of the system corresponds to a demand curve in the market, and the second to a supply curve. Thus, assuming that the matrix of contemporaneous relations $\boldsymbol{A}^c$ is,

$$\boldsymbol{A}^c = \begin{bmatrix} -\beta^c & 1 \\ -\alpha^c & 1 \end{bmatrix}, \tag{3}$$

the model can be represented by the following demand and supply equations for housing in the market, respectively:

$$\Delta q_t^c = b_{10}^{d,c} + \beta^c \Delta p_t^c + \sum_{i=1}^{l} b_{11}^{i,d,c} \Delta p_{t-i}^c + \sum_{i=1}^{l} b_{12}^{i,d,c} \Delta q_{t-i}^c + \varepsilon_{d,t}^c \tag{4}$$

$$\Delta q_t^c = b_{20}^{s,c} + \alpha^c \Delta p_t^c + \sum_{i=1}^{l} b_{21}^{i,s,c} \Delta p_{t-i}^c + \sum_{i=1}^{l} b_{22}^{i,s,c} \Delta q_{t-i}^c + \varepsilon_{s,t}^c. \tag{5}$$

Thus, β^c can be interpreted as the demand elasticity, while α^c as the supply elasticity [15]. To identify the demand and supply shocks in this system, sign restrictions were used on these elasticities so that the assumed premise is that the demand curve has a negative slope ($\beta^c < 0$) and the supply curve a positive slope ($\alpha^c > 0$). [16]

In addition to sign restrictions on the elasticities, prior distributions were also used to guide the possible values of β^c and α^c, so that the probability is not uniform for all values that respect the sign restrictions. To this end, a truncated *Student-t* distribution

14. This methodology, with slight adaptations, has already been applied by the authors to various markets. For instance, Baumeister and Hamilton (2015) apply it to the U.S. labour market; Baumeister and Hamilton (2018) analyze the impact of monetary policy decisions on economic fluctuations; and Baumeister and Hamilton (2019) study the behaviour of supply and demand shocks in the oil market and their impact on the global economy. A more detailed explanation of the methodology and the model estimation process can be found in these studies.

15. Since both elasticities are associated with price changes and the corresponding response of quantities in period t, they can be interpreted as contemporaneous or short-term elasticities

16. That is, a positive demand shock increases, *ceteris paribus*, the quantities and equilibrium prices, while a positive supply shock increases, *ceteris paribus*, the quantities, but decreases the equilibrium prices. The magnitude of the impact that each shock has on the respective market equilibrium depends on the ratio of elasticities, $\frac{\beta^c}{\alpha^c}$. A more detailed explanation can be found in Brinca *et al.* (2021), where the authors apply a similar methodology to the dynamics of the U.S. labour market during the Covid-19 period.

was assumed for both demand and supply, with the following values: (i) for housing demand elasticity, β^c, both in the Portuguese and Spanish cases, a conservative approach encompassing a broad range was chosen. In this sense, a location parameter of -0.6, a scale parameter of 0.6, and 3 degrees of freedom were chosen. Since this elasticity is truncated at negative values, it means that the prior distribution places a 90% probability of being included in the range [-2.16; -0.11] for both countries; (ii) for supply elasticity, the existence of more studies attempting to quantify this elasticity allows for more precise guidance. Thus, the results of Cavalleri *et al.* (2019) were used, defining the location parameter for Portugal at 0.84 and for Spain at 1.17. [17] [18] The scale parameter and degrees of freedom are identical to those chosen for demand (0.6 and 3, respectively), meaning that a 90% probability is assigned to the supply elasticity in Portugal being between [0.17; 2.34] and in Spain between [0.29; 2.63].

Regarding the data used in this exercise, and given that the correct estimation of the model requires a relatively long time series, residential investment was used for quantities Δq_t^c, as it presents a longer time series than housing transactions in both the Portuguese and Spanish cases. For prices Δp_t^c, the (real) housing price index was used. Both variables are quarterly and enter the model in year-on-year variations. The time period included starts in the first quarter of 2000 and ends in the fourth quarter of 2023. The model includes 8 lags of the variables ($l = 8$).

It is important to clarify some points regarding the use of residential investment as a proxy for equilibrium quantities in each country's market. Residential investment is, in many studies, used directly as a representative variable of the market supply. However, in this exercise, the use of residential investment should be interpreted differently. In each period, supply and demand forces interact such that from this interaction arises the decision to increase or decrease residential investment, with the respective consequences on the equilibrium price. In other words, residential investment is seen in this exercise as a result of the market equilibrium, not as an independent supply force. Nevertheless, despite the data limitation that the number of transactions presents for both countries, a robustness analysis conducted in Appendix C shows that the historical decompositions, in the case of using transactions instead of residential investment, do not differ substantially from those presented in the next section 4.2.

4.2. Results

The identification of demand and supply shocks, through sign restrictions and prior distributions guiding the values of the elasticities, allows for an analysis of how each

17. The use of results obtained by Cavalleri *et al.* (2019) is due to the fact that this is a study that calculates long-term housing supply elasticities using an error correction model for OECD countries, with 0.84 for Portugal and 1.17 for Spain. The standard errors associated with these coefficients in that study indicate upper limits for the 95% confidence intervals of these estimates of 1.46 and 1.49, respectively.

18. Cavalleri *et al.* (2019) find a long-term housing supply elasticity using an error correction model for OECD countries, with values of 0.84 for Portugal and 1.17 for Spain. The standard errors associated with these coefficients in the study suggest upper limits for the 95% confidence intervals of 1.46 and 1.49, respectively.

of these market components has contributed to its equilibrium — an analysis entitled historical decomposition. In addition, the estimation of the model also allows for the estimation of impulse-response functions (IRFs), which answer a different question to that of the historical contribution of each shock. Impulse-response functions show how prices and quantities respond, on average, to demand and supply shocks.

Figure 11 shows IRFs for Portugal and Spain. This first analysis allows us to identify similarities between the two countries: the response of prices and quantities seems more pronounced to demand shocks than to supply shocks. It should be noted that the effects on both prices and quantities quickly become statistically insignificant following supply shocks, which is not the case with demand shocks, which seem to have long-lasting effects. Also noteworthy is the less pronounced percentage effect on prices than on quantities, in this case for both types of shocks.

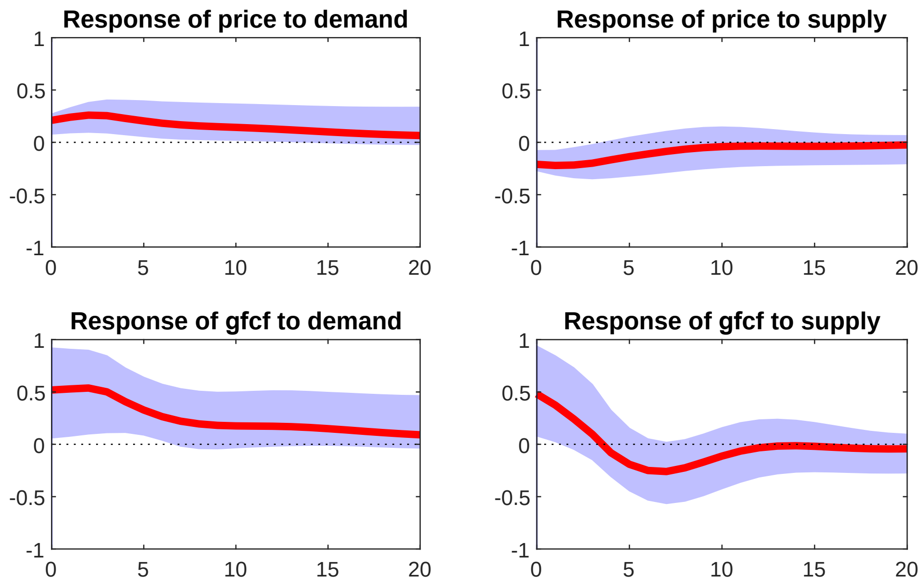
However, for a characterization of the evolution of prices and quantities, historical decompositions are a more informative exercise. Figure 12 shows the historical breakdowns of price growth and housing investment in each country, showing the respective contributions for price and quantity developments that can be attributed to either demand or supply shocks in each market. Several conclusions can be drawn from these graphs.

Between 2008 and 2013, the forces in both markets generally seem to have similar behaviours: demand markedly pulling residential investment growth to negative values, while supply oscillates between negative and positive contributions. Consequently, in both cases, the contribution of demand to price growth is clearly negative, while the contribution of supply oscillates between positive and negative values.

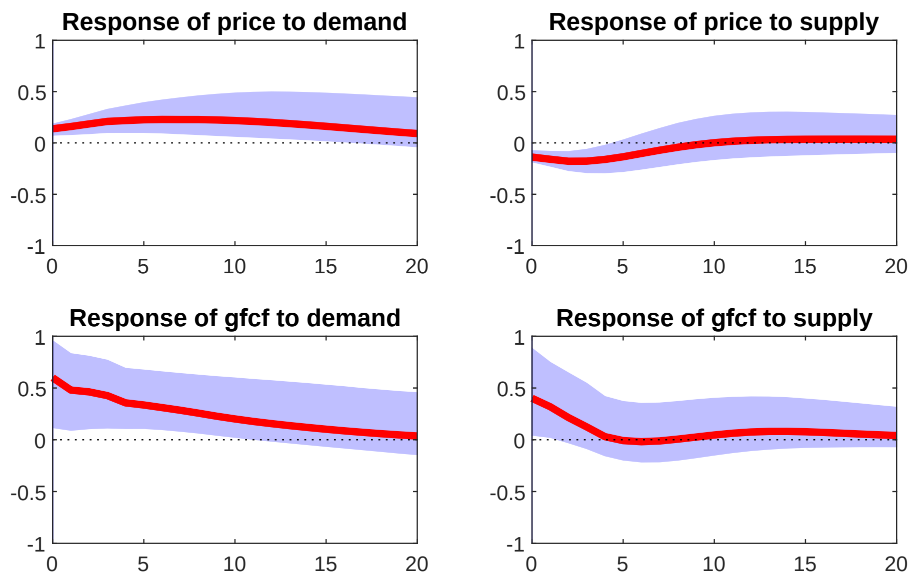
From 2014 until the beginning of the Covid-19 pandemic in 2020, residential investment in Portugal enters a period of continuous growth above the historical average growth. The decomposition indicates that this growth is mainly driven by demand forces. The contribution of supply oscillates between negative and positive values, being statistically insignificant for most of the period. Similarly, price growth is markedly driven by demand forces. Supply is unable to counterbalance this effect, also contributing, in some periods, albeit slightly, to price growth.

This narrative contrasts with the decompositions calculated for the Spanish market. After some fluctuations in the 2014-2015 period, residential investment growth also showed continuous growth above the historical average in the country. However, in this case, although most of the contribution comes from the demand side, the supply also continuously contributes positively to this growth. This explains that while demand is markedly pushing prices upwards, the supply is somewhat counterbalancing this pressure (unlike the Portuguese case). Note how, between 2016 and early 2020, price growth in Spain would have been more pronounced if only demand shocks influenced market equilibrium. This contrast led to a more pronounced price growth, compared to its historical average, in Portugal than in Spain during this period.

From early 2020 to the end of 2023, the model indicates that in the Portuguese case, there continues to be considerable pressure on prices from the demand side, without the supply being sufficiently effective to counterbalance this trend. There was a slowdown



(A) Portugal



(B) Spain

FIGURE 11: Impulse-response functions of prices and housing investment to a demand (left column) and a supply (right column) shock.

Note: The size of the simulated shock is one standard-deviation. In blue, credible intervals of 95%.
Source: Authors' calculations.

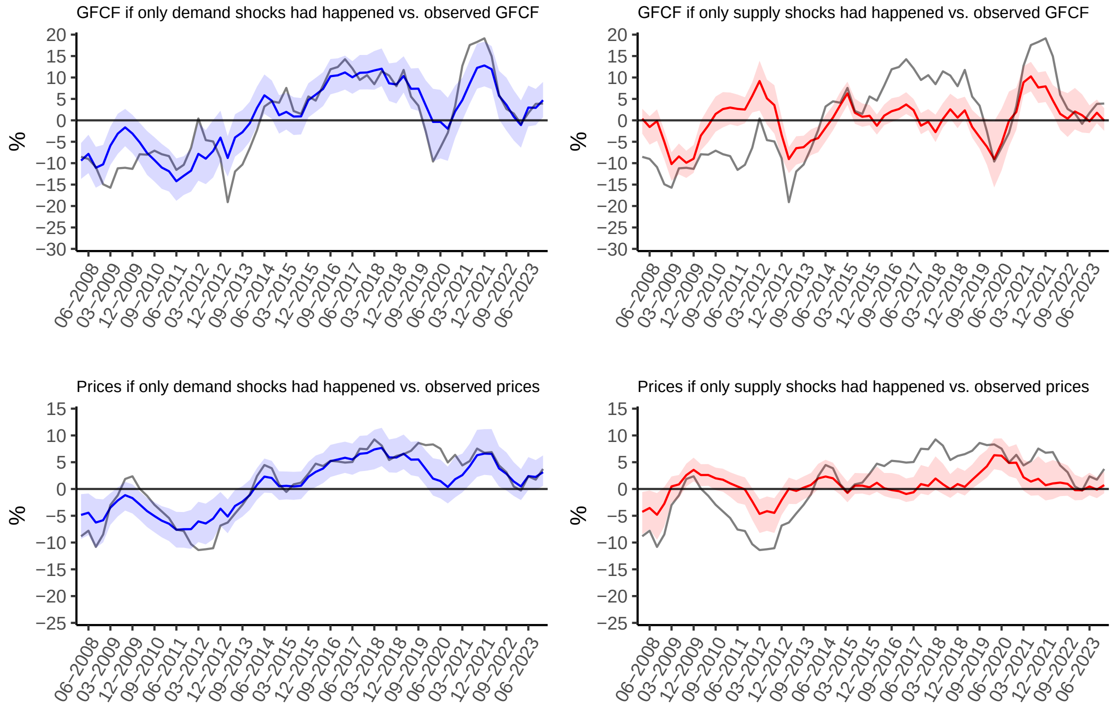
in residential investment during the Covid-related quarters, followed by a strong recovery (again, mostly driven by demand) in 2021. Since mid-2022, the restrictive monetary policy cycle initiated by the ECB led to a slowdown in both residential investment and prices, although by the end of 2023, the latter were already resuming an accelerating trajectory, once again driven by demand pressure. In Spain, on the other hand, since the pandemic, prices have grown below or in line with its historical average (i.e. around zero on the graphs). Initially, supply constraints put slight pressure on prices to accelerate, but weak demand counterbalanced this trend. In the most recent period, neither demand nor supply has been creating considerable pressure on prices.

Summing up, the historical decompositions indicate that, both in Portugal and Spain, house price growth has been driven mainly by demand forces. However, results highlight how supply has not been able to counterbalance such pressure in the Portuguese case. On the other hand, in Spain, especially in the pre-pandemic years, the positive effect of supply on GFCF had a negative impact on prices.

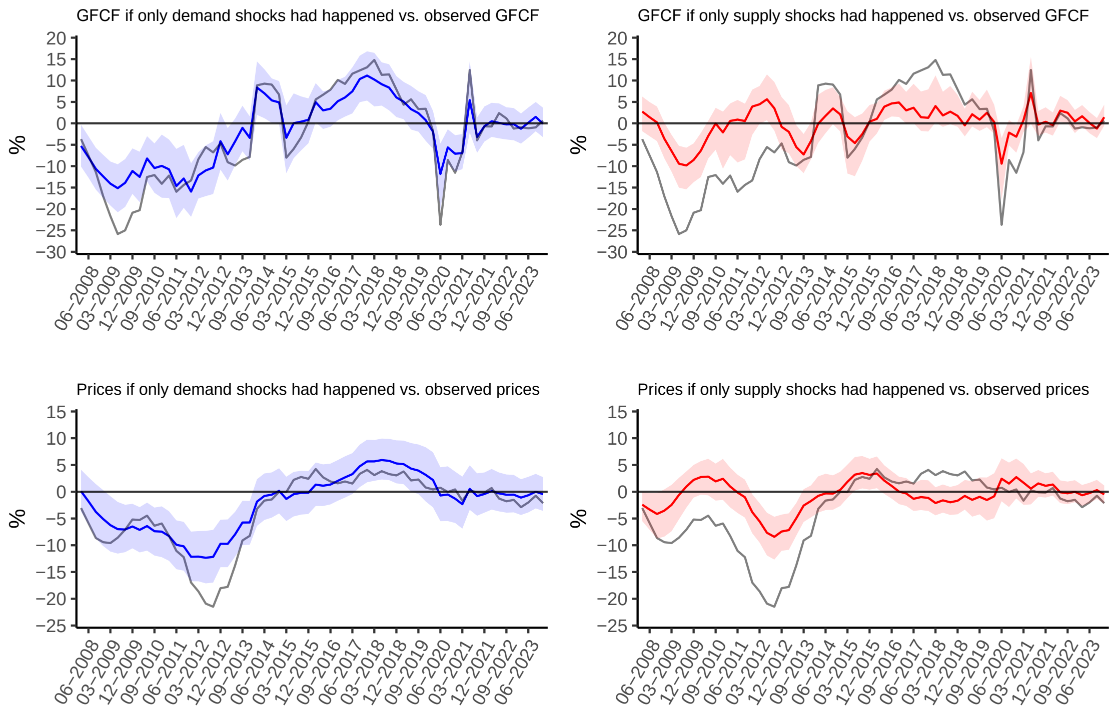
5. Conclusion

The Portuguese and Spanish economies have been marked by common macroeconomic dynamics between 2008 and 2023: the financial and sovereign debt crises in the euro area, followed by the pandemic crisis and, more recently, rising inflation. It was also observed that the relevant determinants for the housing market evolved similarly in both countries. Despite this, using the test by Phillips and Shi (2020), it was found that since 2017 there has been signs of overvaluation in prices in Portugal. A complementary analysis using quantile regressions allows us to conclude that housing prices are misaligned compared to what is predicted by macroeconomic determinants. In contrast, both approaches indicate that there is no overvaluation of prices in Spain.

Finally, the contribution of supply and demand forces to market equilibrium in each country was described and quantified. This analysis reveals that, in general, unlike in Spain, the growth of housing prices in Portugal is mainly driven by demand forces, with supply not fully counterbalancing this pressure. In this context, the type of analysis conducted in this article is considered an important prerequisite for designing effective public policies.



(A) Portugal



(B) Spain

FIGURE 12: Historical decompositions of the growth rate of residential GFCF and house prices.

Note: The grey lines represent the observed growth rates of GFCF and prices, subtracted from their historical averages, respectively. The blue and red lines represent the contribution of demand and supply shocks to each of the growth rates of the variables. The shaded areas represent the corresponding one standard deviation credible intervals.
Source: Authors' calculations.

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Appendix A: Description of Phillips and Shi (2020)

A.1. *The Phillips, Shu and Yu test*

The test procedure introduced by Phillips, Shi and Yu [PSY] (2015) is implemented in three steps:

1. test the null hypothesis that there are no mildly explosive periods in the sample against the alternative that there is at least one such period;
2. if the test rejects, then date-stamping the mildly explosive period(s) in the sample follows;
3. setting the results in the context of a rational asset pricing model and using fundamentals proxy variables to assess whether or not the detected periods of mild explosivity are consistent with departures from house price fundamentals.

A.2. *Methodology of the PSY procedure*

To implement the procedure we consider, as suggested by PSY, a starting fraction r_1 and an ending fraction r_2 of the total sample, with window size $r_w = r_2 - r_1$, and fit the augmented Dickey-Fuller (ADF) test regression,

$$\Delta y_t = \alpha_{r_1,r_2} + \varphi_{r_1,r_2} y_{t-1} + \sum_{i=1}^{p} \vartheta^i_{r_1,r_2} \Delta y_{t-i} + \varepsilon_t \tag{A.1}$$

where p is the lag order chosen on sub-samples using some information criteria (e.g. BIC or AIC) and $\varepsilon_t \sim i.i.d.(0, \sigma^2_{r_1,r_2})$. The number of observations used to run the regression is $T_w = [r_w T]$ and we denote the unit root t-statistics, i.e., the t-statistics that tests the null hypothesis $H_0 : \varphi = 0$, computed from (A.1) as $ADF^{r_2}_{r_1}$.

PSY (2015) introduce two statistics to detect overvaluation episodes, namely the backward $\sup ADF$ (BSADF) and the generalised $\sup ADF$ (GSADF), which are defined as,

$$BSADF_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \left\{ ADF^{r_2}_{r_1} \right\}$$

and

$$GSADF(r_0) = \sup_{r_2 \in [r_0, 1]} \left\{ BSADF_{r_2}(r_0) \right\}$$

where the endpoint of the sample is fixed at r_2 and the window size is allowed to expand from an initial fraction r_0 of the total sample r_2. PSY suggest that r_0 is chosen to minimise size distortions, according to the rule $r_0 = 0.01 + 1.8/\sqrt{T}$, where T is the sample size. This procedure defines a particular BSADF statistic and the GSADF statistic is computed through the repeated implementation of the BSADF test for $r_2 \in [r_0, 1]$. Critical values are obtained by simulation (in Table B.1 we provide the critical values used in our empirical application). Limit theory of the procedure and small sample performance have been provided by PSY.

The null hypothesis of no mildly explosive periods is based on the GSADF statistic and date-stamping of the periods is accomplished through the BSADF statistic: the start and end points of a bubble, $r_{1,s}$ and $r_{1,f}$ are estimated subject the minimum duration conditions,

$$\widehat{r}_{1,s} = \inf_{r_2 \in [r_0,1]} \left\{ r_2 : BSADF_{r_2}(r_0) > scv_{r_2}^{\beta_r} \right\}$$

and

$$\widehat{r}_{1,f} = \inf_{r_2 \in [\widehat{r}_{1,s}+\delta \log(T)/T,1]} \left\{ r_2 : BSADF_{r_2}(r_0) > scv_{r_2}^{\beta_r} \right\}$$

where $scv_{r_2}^{\beta_r}$ is the 100(1-β_T)% right-sided critical value of the BSADF statistic based on $[r_2 T]$ observations and δ is a tuning parameter that can be chosen based on the sampling frequency. A tuning parameter of 1 implies a minimum duration condition of $\log(T)$ observations. A mildly explosive period is declared if and when the BSADF test has been above its critical value for at least $[\widehat{r}_{1,s}T]$+$[\log(T)]$ observations. Conditional on a first mildly explosive period having been found and estimated to have terminated at $\widehat{r}_{1,f}$ the procedure is then repeated in search of a second and possibly more such periods. PSY show that subject to rate conditions, the sequential procedure provides consistent estimates of the origination and termination dates of one or more bubbles (see also Homm and Breitung, 2012).

The final element of the PSY procedure assesses whether the mildly explosive periods detected are bubbles.

A.3. Philips and Shi test

Phillips and Shi (2020) propose a bootstrap procedure that combines the procedures of Harvey et al. (2016) and Shi et al. (2018). It is designed to mitigate the potential influence of unconditional heteroskedasticity and to address the multiplicity issue in recursive testing. Let $\tau_0 = \lfloor Tr_0 \rfloor$ and τ_b be the number of observations in the window over which size is to be controlled.

Step 1: Using the full sample period, estimate the regression model (2) under the imposition of the null hypothesis $H_0 : \rho = 0$ and obtain the estimated residual, say e_t.

Step 2: For a sample size $\tau_0 + \tau_b - 1$, generate a bootstrap sample given by,

$$\Delta y_t^b = \sum_{j=1}^{p} \hat{\varphi}_j \Delta y_{t-j}^b + e_t^b \tag{A.2}$$

with initial values $y_i^b = y_i$ with $i = 1, ..., j+1$, and where the $\hat{\varphi}_j$ are the OLS estimates obtained in the fitted regression from Step 1. The residuals $e_t^b = w_t e_l$ where w_t is randomly drawn from the standard normal distribution and e_l is randomly drawn with replacement from the estimated residuals e_t.

Step 3: Using the bootstrapped series, compute the PSY test statistic sequence $PSY_t^{b}{}_{t=\tau_0}^{\tau_0+\tau_b-1}$ and the maximum value of this test statistic sequence,

$$\mathcal{M}_t^b = \underset{t \in [\tau_0, \tau_0+\tau_b-1]}{max} (PSY_t^b) \tag{A.3}$$

where $t \in [\tau_0, \tau_0 + \tau_b - 1]$.

Step 4: Repeat Steps 2-3 B times.

Step 5: The critical value of the PSY procedure is now given by the 95% percentiles of the $\mathcal{M}_t^b$ sequence.

Step 2 implements a Wild bootstrap to address heteroskedasticity; and Steps 3-5 replicate the PSY recursive test sequence and create critical values that account for multiplicity in the test sequence recursion.

Appendix B: Testing for Quantile Cointegration

Following Xiao (2009), considering $\psi_\tau(u) = \tau - I(u < 0)$ and the quantile regression residual

$$\varepsilon_{t\tau} = y_t - Q_{y_t}(\tau|\mathcal{F}_{t-1}) = y_t - \Theta(\tau)' Z_t = \varepsilon_t - F_\varepsilon^{-1}(\tau),$$

it follows that $Q_{\varepsilon_{t\tau}}(\tau) = 0$, where $Q_{\varepsilon_{t\tau}}(\tau)$ is the $\tau - th$ quantile of $\varepsilon_{t\tau}$ and $E\psi_\tau(\varepsilon_{t\tau}) = 0$.

Hence, the cointegration relationship may be tested by directly looking at the fluctuation in the residual process $\varepsilon_{t\tau}$ from the quantile cointegration regression. In the case of cointegration the residual process should be stable and the fluctuations in the residuals should reflect only equilibrium errors. Otherwise, the fluctuations in the residuals can be expected to be of a larger order of magnitude. Thus, cointegration can be tested based on $\varepsilon_{t\tau}$. If the following partial sum process is considered,

$$Y_T(r) = \frac{1}{\omega_\psi^* \sqrt{T}} \sum_{j=1}^{[rT]} \psi_\tau(\varepsilon_{j\tau})$$

where ω_ψ^{*2} is the long-run variance of $\psi_\tau(\varepsilon_{j\tau})$, under appropriate assumptions, the partial sum process follows an invariance principle and converges weakly to a standard Brownian motion $W(r)$. Choosing a continuous functional $h(.)$ that measures the fluctuation of $Y_T(r)$ (notice that $\psi_\tau(\varepsilon_{j\tau})$ is indicator based), a robust test for cointegration can be constructed based on $h(Y_T(r))$. By the continuous mapping theorem under regularity conditions and the null of cointegration,

$$h(Y_T(r)) \Rightarrow h(W(r)),$$

see Xiao (2009) for details.

In this context the classical Kolmogorov-Smirnoff and the Cramer-von Mises type measures are of particular interest. Under the alternative of no cointegration these statistics diverge to ∞. In Table A.1, we report results for the application of this approach using the Kolmogorov-Smirnoff metric, thus the test is $\sup |Y_T(r)|$.

Appendix C: Historical decomposition of demand and supply shocks with number of transactions

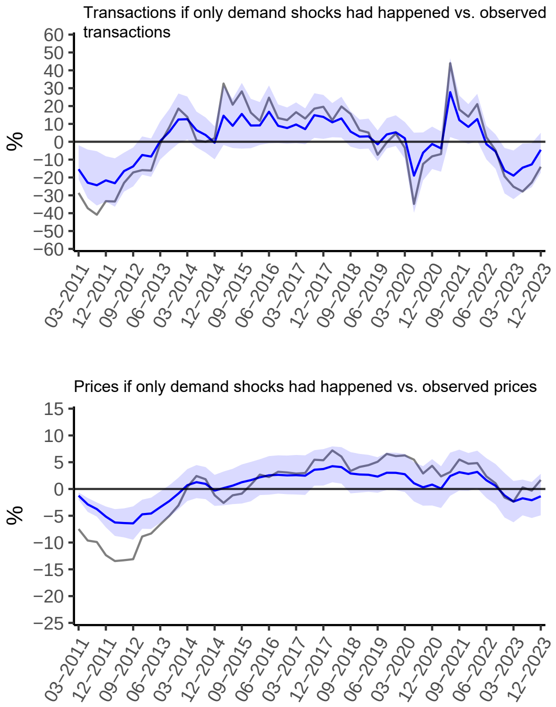
This section presents a robustness analysis in which, in the structural BVAR model presented in section 4, GFCF is replaced by the number of housing transactions.

As previously mentioned, the number of transactions would be the most appropriate variable to use as a *proxy* for the equilibrium quantities transacted on the market. In practice, however, for both countries, the number of transactions is a series that covers a short period of time, which makes the model's estimation less robust. For example, for the same number of *burn-ins* used in the model in section 4, Geweke's diagnosis fails in the Portuguese case when using the number of transactions, which means that the algorithm that simulates the *a posteriori* distribution of elasticities did not converge to the objective within the *burn-in* period.

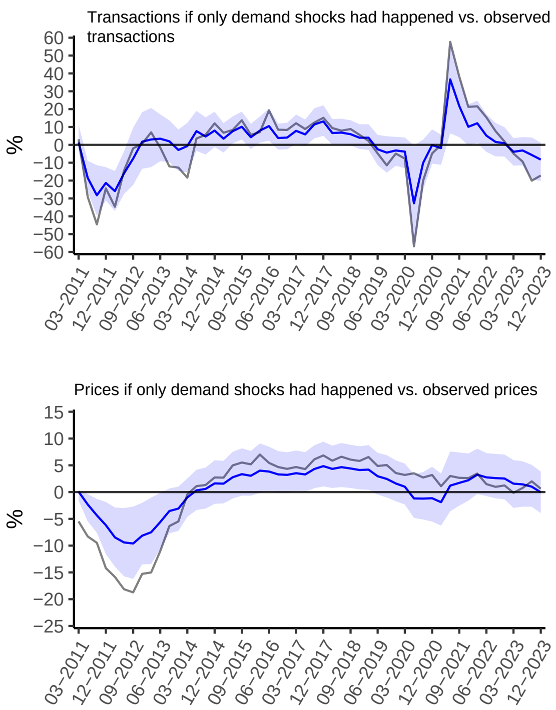
Even so, and just as a robustness exercise, Figure C.1 shows the historical breakdowns between demand and supply contributions to the Portuguese and Spanish market equilibrium, using the number of transactions and the price index. The model uses quarterly data from the first quarter of 2009 until the end of 2023.[19]

The main conclusions remain unchanged. Prices in both countries between 2014 and the beginning of 2020 were markedly pressured by demand, with supply not being effective in counterbalancing this pressure. In the most recent period, after a substantial drop in transactions driven by falling demand following the ECB interest rate hikes, Portugal is already showing a recovery in transactions, again driven by a recovery in demand, while transactions in the Spanish market continue to slow down, with demand still contracting.

19. Unlike the model presented in section 4, in this case we used 4 quarters of lags for the endogenous variables, instead of 8 quarters, in order to avoid losing an additional year in the model's estimation.



(A) Portugal



(B) Spain

FIGURE C.1: Historical decompositions of the growth rate in the number of transactions and house prices.

Notes: The gray lines represent the growth rates of transactions and prices, subtracted from their historical averages, respectively. The blue and red lines represent the contribution of demand and supply shocks to each of the variables' growths. The shaded areas represent the respective credible intervals of one standard deviation.
Source: Authors' calculations.