Lisbon School of Economics & Management
Universidade de Lisboa

MASTERS IN MANAGEMENT (MIM)

MASTERS FINAL WORK

DISSERTATION

BUBBLE OR FUNDAMENTALS? EVIDENCE FROM THE PORTUGUESE HOUSING MARKET

BEATRIZ PACHECO MOTA

APRIL - 2026

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ABSTRACT

Is the Portuguese housing market experiencing a speculative housing bubble, or can recent house price dynamics be explained by macroeconomic fundamentals? This question has become prominent in public debate, especially considering the strong and sustained increase in housing prices over the past decade. As concerns about overheating have grown, it is important to determine whether price increases reflect speculation or economic fundamentals.

This study examines the presence of potential bubbles in the Portuguese housing market using the PSY-IVX framework proposed by Shi and Phillips (2023). This approach allows real house prices to be separated into fundamental and non-fundamental components and tests whether the latter display explosive behaviour. By gradually expanding the model to include demand, financial and supply-side factors, the analysis examines whether price deviations persist once broader economic conditions are considered.

The results show that conclusions about exuberance are highly sensitive to the model specification. When only a limited set of variables is considered, an episode of explosive behaviour emerges between 2017 and 2020. However, once a broader set of macroeconomic and structural factors are incorporated, including income growth, labour market conditions, credit dynamics, construction costs and foreign demand, this pattern no longer persists. Under the preferred specification, no sustained explosive process is identified between 2009 and 2025.

Overall, the findings do not support the hypothesis of a persistent speculative bubble in the Portuguese housing market during the analysed period. Although housing affordability pressures and supply constraints remain significant, recent price growth appears to be largely supported by economic fundamentals rather than speculation.

Keywords: Housing Bubbles, Portugal Housing Market, Real Estate Prices, Macroeconomic Drivers, Fundamentals, HPI, PSY, IVX.

JEL CODES: R21, R31, C12, C58

RESUMO

Será que o mercado imobiliário português está atualmente a atravessar uma bolha especulativa, ou poderá a recente dinâmica dos preços da habitação ser explicada por fundamentos macroeconómicos? Esta questão tem ganho particular relevância no debate público, sobretudo face ao aumento acentuado e persistente dos preços das casas ao longo da última década. Neste contexto, torna-se fundamental avaliar se a evolução observada reflete comportamentos especulativos ou, pelo contrário, alterações sustentadas nas condições económicas subjacentes.

Este estudo analisa a existência de potenciais bolhas no mercado imobiliário português através da metodologia PSY-IVX proposta por Shi and Phillips (2023). Esta abordagem permite decompor os preços reais da habitação em componentes fundamentais e não fundamentais, testando se estes últimos exibem comportamentos explosivos. Através da expansão gradual do modelo, incorporando fatores de procura, condições financeiras e determinantes do lado da oferta, a análise procura avaliar se os desvios nos preços persistem após o controlo por um conjunto mais abrangente de fundamentos económicos.

Os resultados indicam que as conclusões relativas à eventual exuberância do mercado são sensíveis à especificação do modelo. Quando se considera apenas um conjunto restrito de variáveis, identifica-se um episódio de comportamento explosivo entre 2017 e 2020. Contudo, após a inclusão de um conjunto mais alargado de fatores macroeconómicos e estruturais, nomeadamente o crescimento do rendimento, as condições do mercado de trabalho, a dinâmica do crédito, os custos de construção e a procura externa, esse padrão deixa de se verificar. Na especificação considerada preferencial, não é detetado qualquer processo explosivo sustentado no período entre 2009 e 2025.

De forma geral, os resultados não corroboram a hipótese da existência de uma bolha especulativa persistente no mercado imobiliário português durante o período analisado. Embora subsistam pressões relevantes sobre a acessibilidade à habitação e limitações do lado da oferta, a recente valorização dos preços parece ser, em larga medida, consistente com a evolução dos fundamentos económicos, e não predominantemente explicada por dinâmica especulativa.

DECLARATION OF INDEPENDENCE AND USE OF AI

I certify that this work was completed entirely on my own and independently, using only the sources and materials explicitly referenced in the document.

Generative AI applications, namely ChatGPT and Gemini, were used only as assisted editing tools, to improve spelling, grammar, clarity and readability during manuscript preparation. After using these tools, I have carefully reviewed and edited the text , taking full responsibility for the final content. Furthermore, sections of this manuscript were translated from Portuguese (native language) into English using the same tools. All translations were subsequently review and revised to ensure accuracy, namely concerning terminology.

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ABBREVIATIONS

GFC – Global Financial Crises

HPI – House Price Index

REM – Real Estate Market

ECB – European Central Bank

GDP – Gross Domestic Product

SIP – Special Inspections Program

NPL – Non-Performing Loan

LTV – Loan to Value

PR-ratio – Price to rent ratio

PIR – Price to income ratio

OLS – Ordinary Least Squares

ADF – Augmented Dickey-Fuller

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1. INTRODUCTION

1.1. Relevance of the Study

In the period preceding the subprime mortgage crisis, lending to borrowers with poor credit histories, termed subprime loans, expanded significantly, resulting in a pronounced increase in house prices (Tudor, 2009). This growth, described as a housing boom, was interpreted as both an indicator of economic development and a lucrative investment prospect (Case and Shiller, 2003). Subsequent increases in interest rates and the resetting of adjustable-rate mortgages rendered many subprime borrowers unable to fulfil repayment obligations. The proceeding defaults and foreclosures precipitated a rapid decline in house prices, exposing the fragility of the market and the unsustainable nature of elevated price levels (Case and Shiller, 2003).

The collapse of the housing market had long-term consequences, severely impacting major financial institutions worldwide. The failure of several Global Systemically Important Financial Institutions (G-SIFIs) triggered a broader financial crisis, culminating in the Global Financial Crisis (GFC) of 2007-2008 (Tudor, 2009; Reinhart and Rogoff, 2008). This GFC worldwide had an impact, contributing to the instability that led to Portugal's the first recession, starting in early 2008, followed by a second recession associated with the European sovereign debt crisis. By 2010, Portugal was facing unforeseen increases in deficits and public debt, amid growing concerns reflected in a sovereign rating downgrade by Moody's during that summer. A year later, confronted with rising risk premia on its public debt and increasing fears of sovereign default, the Portuguese government formally requested financial assistance from the International Monetary Fund (IMF), the European Commission (EC), and the European Central Bank (ECB) (Oliveira and Queiró, 2023).

This crisis illustrated the interconnectedness of the housing and financial sectors and highlighted the profound impact that financial sector practices can have on the global economy. In the aftermath, concerns about the potential formation of housing bubbles have become a central issue for policymakers and regulators worldwide. To counter systemic risks and episodes of excessive credit growth, European authorities strengthened prudential regulation. Following the GFC, EU frameworks were reinforced through Basel III, developed by the Basel Committee on Baking Supervision (CBSB) (European Council, 2024). In the European Union, Basel III was implemented through the Capital

Requirements Regulation (CRR), which included enhanced capital requirements and risk weights, and complemented by macroprudential tools such as limits on leverage and liquidity ratios (BCBS, 2011; Regulation (EU) No 575/2013).

Portugal experienced a particularly pronounced decline in housing prices. From 2007 to 2013, real house prices fell by 30% relative to their historical average, coinciding with increased unemployment, reduced credit availability, and higher mortgage default rates. Elevated household debt aggravated these challenges, necessitating substantial public support and recapitalisation of the banking sector, partly in response to stricter capital requirements introduced by the European Banking Authority (EBA) in 2011.

Following economic stabilisation, new risks emerged. After 2015, the flow of new mortgages accelerated and real house prices reached historical peaks, while the stock of bank housing loans remained high by international standards. In response, Banco de Portugal issued a macroprudential recommendation about mortgage borrowing caps in 2018 to limit household leverage and debt service to income, aiming to preserve financial stability amid renewed housing market pressures. Although being a recommendation and consequently not legally mandatory, financial institutions that did not comply with the established limits were required to justify their decisions to the central bank. (Oliveira and Queiró, 2023). These recommendations introduced limits to some of the criteria used to assess creditworthiness at loan origination and, although not being mandatory, in case of not being followed, banks should justify it to the central bank. The caps were employed on loan-to-value (LTV), debt-to-income, maturity and a regular payments requirement Oliveira and Queiró (2023).

Table 1 – 2018's Macroprudential borrowing caps

Regulation	Scope	Cap
LTV cap	*Household permanent residence*	*≤ 90%*
	Other purposes	*≤ 80%*
	Property owned by the financial institution	*≤ 100%*
PTI cap	*Loans (except credit cards)*	*≤ 50%*
Maturity cap	*Housing*	*≤ 40 years*
	Auto loans, education, renewable energy	*≤ 10 years*
	Other consumer credit	*≤ 7 years*

Source: Oliveira and Queiró (2023).

Over the last few years, Europe has experienced a sustained increase in real house prices, recovering from the sharp decline that followed the global financial crisis. Since

2013, house prices in the euro area have steadily increased and by 2023, average house prices in the EU had risen by 48% since 2015 (*Rising Housing Costs in the EU: The Facts (Infographics) | Topics | European Parliament*, 2024), with Portugal among the countries experiencing the highest growth. In fact, Portugal's house price index reached a level in 2023 comparable to Spain's and Ireland's before the Global Financial Crisis, when their housing market was at the centre of a significant bubble (Daly and Zarco, 2015; McQuinn, 2014). While other euro area countries have seen a slowdown in price growth, Portugal shows no signs of deceleration.

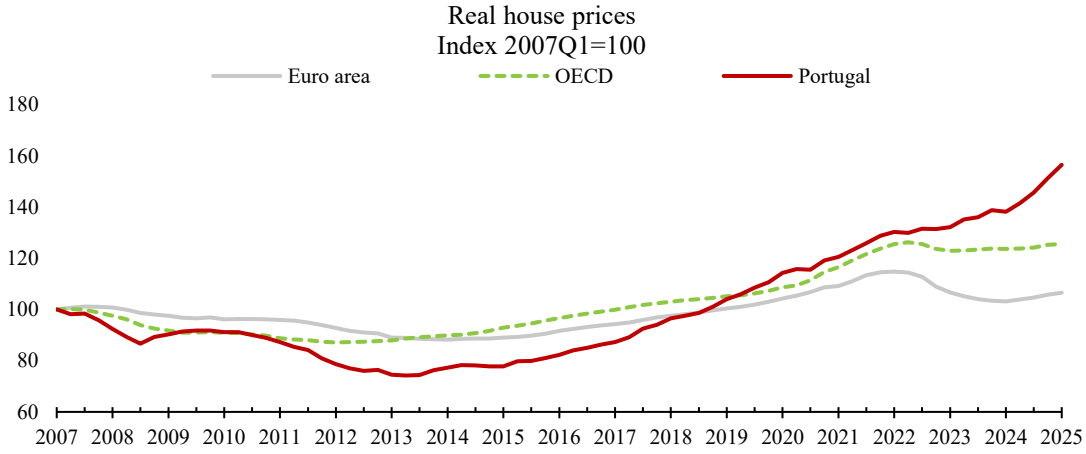

Figure 1 – House Price Index (2007 – 2025)

Source: OECD

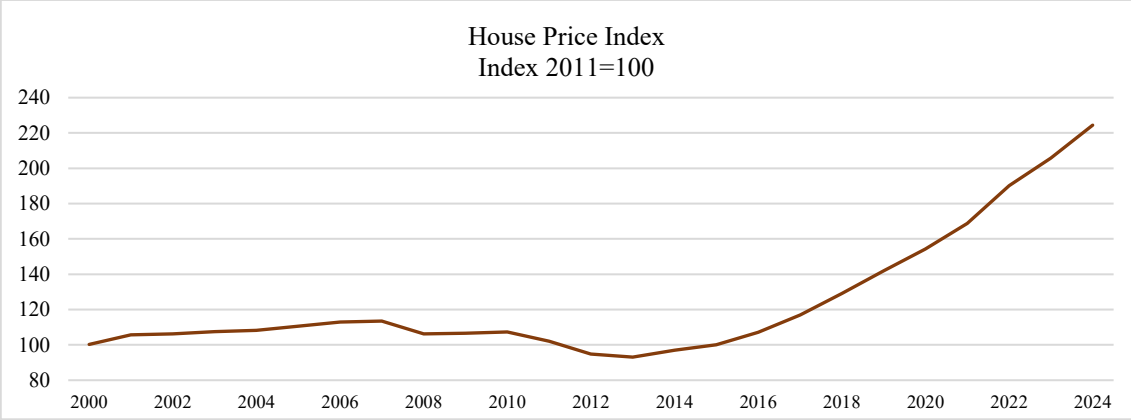

Figure 2 – Portugal House Price Index – nominal (2000 – 2024)

Source: OECD

Beyond the strong increase in house prices observed since 2013, affordability conditions in Portugal have deteriorated markedly. As shown in OECD data, the price-to-income ratio has risen significantly over the past decade, diverging from both the euro

area and OECD averages (OECD, 2024). By 2023, the ratio in Portugal had increased by roughly 50% relative to its 2015 level, indicating that housing prices have grown substantially faster than household incomes.

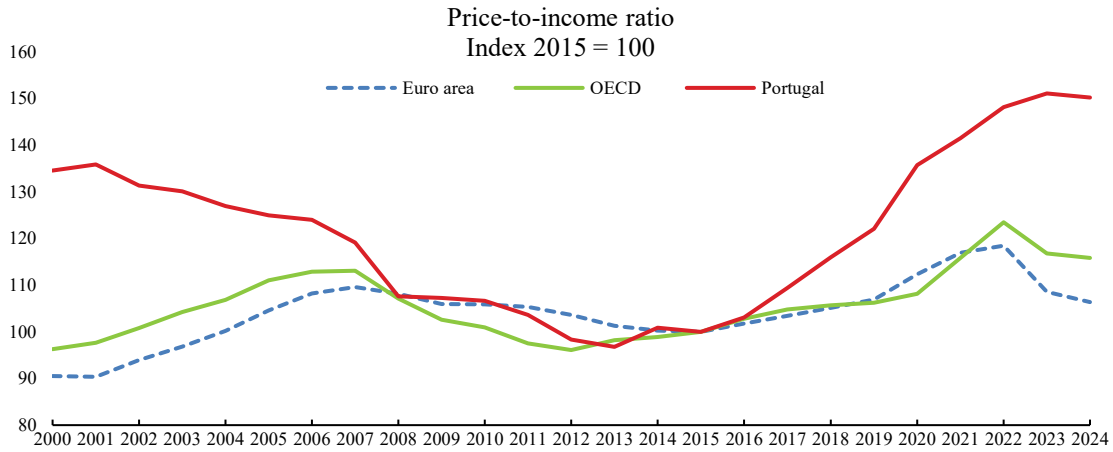

Figure 3 – Price-to-income Ratio (2000 – 2024)

Source: OECD

Despite the regulatory advancements, the early detection of housing bubbles remains an ongoing challenge. The identification and prediction of bubbles are complicated by the interplay of macroeconomic factors, financial innovation, and behavioural dynamics, often leading to divergent views among experts (J. Shiller, 2007). As such, the question of how best to monitor and mitigate the risks associated with housing market cycles continues to be a subject of intense debate and research.

In response to concerns regarding potential overheating in the real estate market, this study seeks to assess the existence of a speculative bubble in Portugal's housing market. Additionally, the analysis aims to provide an evidence-based foundation for expert and policymaker discussions concerning the drivers of recent housing price increases in the country.

1.2. Methodology

To assess the potential presence of housing bubbles, this study will utilise the PSY-IVX econometric procedure, developed by Shi and C.B. Phillips (2023). This approach combines the recursive evolving test (PSY), as introduced by Phillips et al. (2015), with the IVX method (Kostakis *et al*., 2015; Phillips and Magdalinos, 2009; Yang *et al*., 2020). The PSY-IVX method decomposes the real house prices into fundamental and non-

fundamental components and employs a reduced-form model to estimate housing market fundamentals, thereby enhancing estimation accuracy.

1.3. Structure of the work

The present study will be organised as follows: Chapter 2 reviews the literature on housing bubbles, beginning with conceptual definitions, followed by an analysis of their origins and consequences in international contexts. A dedicated section examines the Portuguese case, and the chapter concludes with a discussion of the main economic fundamentals driving housing prices and the econometric approaches used to detect bubbles.

Chapter 3 outlines the methodology applied in this study. It introduces the PSY-IVX econometric framework, describing both the theoretical foundations and the data employed. The chapter also details the selection of Portuguese housing market fundamentals and explains the econometric procedures used to separate fundamental and speculative price components.

Chapter 4 presents the empirical findings. It reports the results of the PSY-IVX tests applied to Portuguese housing data, identifying potential bubble episodes and assessing the extent to which recent price dynamics reflect fundamentals or speculative pressures.

Finally, Chapter 5 provides the conclusion. It summarises the main findings, discusses their implications for policymakers and regulators, and outlines the limitations of the present study as well as avenues for future research.

2. LITERATURE REVIEW

2.1. Defining Housing Bubbles

The concept of a "housing bubble" is widely discussed in economic literature, generally referring to a sustained, but temporary period of overvalued housing prices, driven largely by demand, speculation, and exuberant expectations rather than fundamental economic indicators (Teng *et al*., 2013). Stiglitz (1990) famously defined a bubble as a situation where the increase in housing prices is purely justified by buyers' expectations of higher housing prices in the future and not by fundamental factors. Thereby, when housing bubbles occur, land used for housing production is traded at competitive prices that often exceed the value justified by its expected future economic returns, as housing entrepreneurs expect to resell it at a high price later (Martín *et al*., 2019).

However, Stiglitz's definition has been subject to debate, causing a lot of controversy through the years due to its different interpretations. Lind (2009) has even developed an Anti-Stiglitz definition of price bubbles. The author criticised this approach for conflating descriptive aspects (price increases) with a vague explanatory component (not caused by fundamentals), arguing that the term "fundamentals" itself is difficult to delineate, that is, it is difficult to define what should be considered in the fundamentals range, namely whether it should include real or nominal interest rates, or both current and expected rates.

To address the interpretation issue, Lind (2009) draws on a concept introduced by Mackie (1977): the INUS condition (Insufficient but Necessary part of an Unnecessary but Sufficient condition). This framework suggests that complex phenomena like real estate bubbles arise from multiple factors that collectively fulfil the sufficient conditions for a bubble to form.

What emerges from the literature is that bubbles cannot be defined by prices alone. They are best understood as periods in which asset values become dissociated from economic fundamentals, supported by investor psychology, credit expansion, and speculative incentives.

Following this conclusion, Lind (2009) suggested a set of dimensions from which sufficient conditions for the emergence of a bubble could be extracted:

1. The macroeconomic environment and policies

2. Structural shifts in the economy
3. Capital and Credit Markets
4. Beliefs, expectations and strategies of the actors
5. The incentives of individuals

Given the complexity of the definition and detection of bubbles, recent research emphasises the need for quantitative frameworks that separate fundamental and speculative components of house prices. Shi and Phillips (2023) and Tomal (2021) suggested using a popular concept that distinguishes between economic fundamentals and speculative factors responsible for bubbles, leading to a model that separates these components.

Let $p_t = log\ (P_t)$, where P_t constitutes real housing prices, and $r_t = log\ (R_t)$, with R_t representing real housing rents. By using recursive substitution, the log price-to-rent (PR) ratio of housing $(p_t - r_t)$ is decomposed into fundamental (F_t) and bubble components (B_t), such that:

$$p_t - r_t = F_t + B_t \quad (1)$$

2.2. Origins and Consequences of Housing Bubbles

The consequences of housing bubbles were profound, as illustrated by the 2007-2008 Global Financial Crisis. In the United States, house prices rose sharply during the decade preceding the GFC, fuelled by an unprecedented expansion of mortgage credit. The increase of subprime lending (mortgages extended to borrowers with weak credit histories) and the widespread use of adjustable-rate mortgages created large pools of vulnerable households (Tudor, 2009).

This boom translated into a sharp rise in household debt, largely driven by homeowners borrowing against increasing home equity (Mian and Sufi, 2011). However, when interest rates rose in the mid-2000s, mortgage delinquencies increased sharply, leading to the collapse of major lenders and originating losses throughout the financial system (Case & Shiller, 2003). By 2007, the housing market downturn had spread into a full-scale banking crisis, culminating in the collapse of Lehman Brothers in September 2008 (Wiggins *et al*., 2019).

Similar dynamics have been observed elsewhere. In Spain and Ireland, these bubbles have proved to have a great impact, not only in the housing sector, but also on the broader economy (Jorda *et al*., 2014).

In Spain, a sharp expansion between 1995 and 2008 was fuelled by a credit boom, especially in mortgage loans, resulting in unsustainable increases in house prices. This credit led to an almost threefold increase in the external debt of Spanish banks (Martín *et al*., 2019).

The availability of cheap credit not only stimulated demand but also financed a vast construction boom, with housing completions exceeding 800,000 units annually at the peak. Much of this construction was speculative, resulting in the phenomenon of "ghost towns" across Spain when demand collapsed (Daley and Minder, 2010).

However, in 2008, this boom gave way to a prolonged bust, as by 2015 house prices had dropped a third since 2008. Construction activity came to a near standstill (Martín *et al*., 2019), and the banking sector incurred substantial losses, particularly among the savings banks (*cajas*), which had been heavily exposed to real estate.

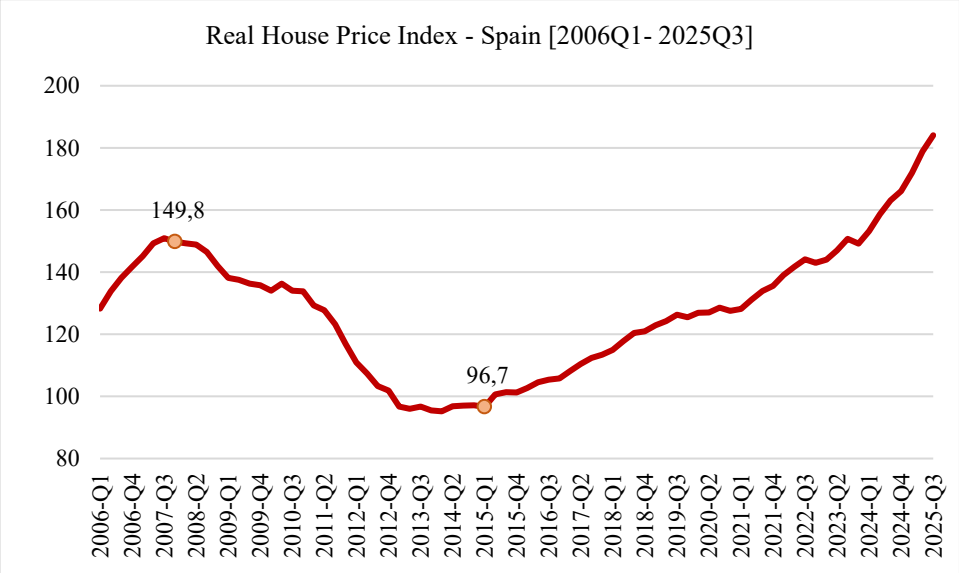

Figure 4 – Real House Price Index – Spain (2006Q1 – 2025Q2)

Source: OECD

In May 2012, Bankia, Spain's fourth-largest bank, collapsed. The institution had been created in December 2010 through the merger of seven savings banks (*cajas*), at a time when the total number of *cajas* had already declined from 45 to seven as part of the restructuring process. Bankia's nationalisation triggered the bailout by the European

Stability Mechanism which came to the rescue in December 2012 with €41 billion, most of it for Bankia (Chislett, 2014). The bursting of the bubble coincided with a long and profound recession (Martín *et al*., 2019), however, following the implementation of the programme's measures, Spain's banking sector was stabilised and recapitalised, improving banks' capital positions and access to funding. This recovery of the financial system supported the country's return to economic growth in 2014, with gains in competitiveness, employment, and the current account balance. This positive trend continued until the COVID-19 pandemic disrupted the European and global economy in 2020 (ESM, 2018).

Ireland's experience illustrates both the scale and consequences of another major housing bubble within the euro area. Between 1995 and 2007, Irish house prices rose by almost 175%, the sharpest increase among advanced economies. This increase was characterised by rapid credit expansion, favourable macroeconomic conditions and construction activity that concentrated an unbalanced share of economic activity in real estate (McQuinn, 2014).

After 2007, a dramatic fall in national prices was registered, the construction sector collapsed and a significant portion of the economy collapsed with it. As the liquidity of the country began to dry up as the foreign investors stopped investing, the Irish government saw it budget deficit rise. The collapse left between 40% to 50% of Irish mortgages in negative equity at the end of 2012 (McQuinn, 2014, International Monetary Fund, 2018). In 2010 the government was forced to seek help from the European Union and to accept international assistance from the "Troika" (composed by the IMF, the European Central Bank, and the European Commission; International Monetary Fund, 2018).

Notably, studies show that the Irish boom initially had strong links to fundamentals (income growth, demographics, interest rates), but after 2003/04, rising prices were increasingly explained by excess mortgage credit and extensive funding of banks, creating a "mutually reinforcing relationship" between house price inflation and lending. (McQuinn, 2014). As banks competed aggressively for market share, lending standards weakened and high-risk mortgage products became widespread, including interest-only loans, tracker mortgages, and loans with LTV ratios exceeding 100%. In parallel, banks became increasingly reliant on cheap foreign wholesale funding to sustain rapid credit expansion. This funding model generated significant maturity mismatches and, for banks

operating in foreign markets, currency mismatches, increasing systemic vulnerability (Baudino et al., 2020). When global wholesale funding markets froze in 2007-2008, the reversal of international capital flows exposed the fragility of a banking system heavily concentrated in property-related lending and dependent on short-term external financing (McQuinn, 2014; Baudino et al., 2020)

China provides another illustrative example of how bubbles can form under specific macroeconomic and institutional conditions. Wang (2023) argued that the country's real estate bubble has been largely driven by excess liquidity, rapid economic expansion, and expectations of both currency and asset appreciation, which attracted large inflows of speculative capital.

China's economic growth model traditionally relies on consumption, exports, and investment. With domestic demand weak and exports constrained by external shocks (U.S. trade restrictions) and the COVID-19 pandemic, policymakers leaned heavily on investment (particularly in infrastructure and housing) to sustain high GDP growth (Wang, 2023).

During the 2008 Global Financial Crisis, massive fiscal stimulus and loose monetary policy helped stabilise the economy, but also created long-term distortions, including industrial overcapacity and abundant liquidity in the housing sector. With limited alternative investment options, much of this capital flowed into real estate, perceived as a safe store of value. This speculative demand reinforced expectations of rising prices, creating a cycle of "false prosperity" that many observers describe as a persistent real estate bubble (Wang, 2023).

Taken together, these cases demonstrate that while the triggers for the bubble surge differ between countries, the consequences converge, emphasising the importance of developing early-warning diagnostic tools to detect speculative dynamics before they translate into systemic crises.

2.3. The Portuguese Case

Over the past forty years, Portugal has undergone significant changes in its housing market, closely linked to financial liberalisation, European integration, and wider macroeconomic cycles. From the 1980s onwards, the liberalisation and privatisation of the Portuguese banking system facilitated the expansion of credit, especially mortgage lending, which became the primary driver of housing provision. Between 1990 and 2007,

loans to households tripled relative to loans to firms, with mortgages constituting the largest share. At the same time, construction and real estate companies increased their indebtedness, reflecting a growing interdependence between finance and housing. By the mid-2000s, homeownership rates had risen from 57% in 1981 to 73% in 2011, placing Portugal among the European countries with the highest ownership levels. This trajectory reflected not only cultural preferences but also state policies, namely, subsidies, tax incentives, and urban expansion strategies, which reinforced a credit-driven model of provision (Santos *et al*., 2015).

In the late 1990s and early 2000s, the Portuguese housing market experienced a construction boom, with annual dwelling completions peaking at over 120,000 units in 2002 (Santos *et al*., 2015). However, from 2002 onwards, this expansion slowed sharply, coinciding with the phasing out of loan subsidies and weaker GDP growth. The 2007-2008 Global Financial Crisis exacerbated these vulnerabilities. From 2007 onwards, non-performing housing loans increased substantially. However, the most pronounced deterioration occurred in the construction sector, where NPL's increased five times between 2006 and 2011, reaching levels not previously observed (Oliveira and Queiró, 2023; Tavares *et al*., 2014). From 2011 onwards, the rise in reported non-performing loans (NPLs) in Portugal was driven not only by the economic recession but also by stricter supervisory intervention under the Economic and Financial Assistance Programme. The Special Inspections Programme (SIP) conducted in 2011 required Portuguese banks to reassess their credit portfolios and recognise additional impairments, identifying €838 million in further provisioning needs (Banco de Portugal, 2011).

The crisis also revealed the fragility of Portugal's household sector, which had reached debt levels equivalent to 130% of disposable income by 2009. Mortgage defaults rose with unemployment, which peaked above 17% in 2012 (Januário and Cruz, 2023). Between 2007 and 2013, real house prices declined by nearly 30 percentage points in terms of deviations relative to the mean (Oliveira and Queiró, 2023).

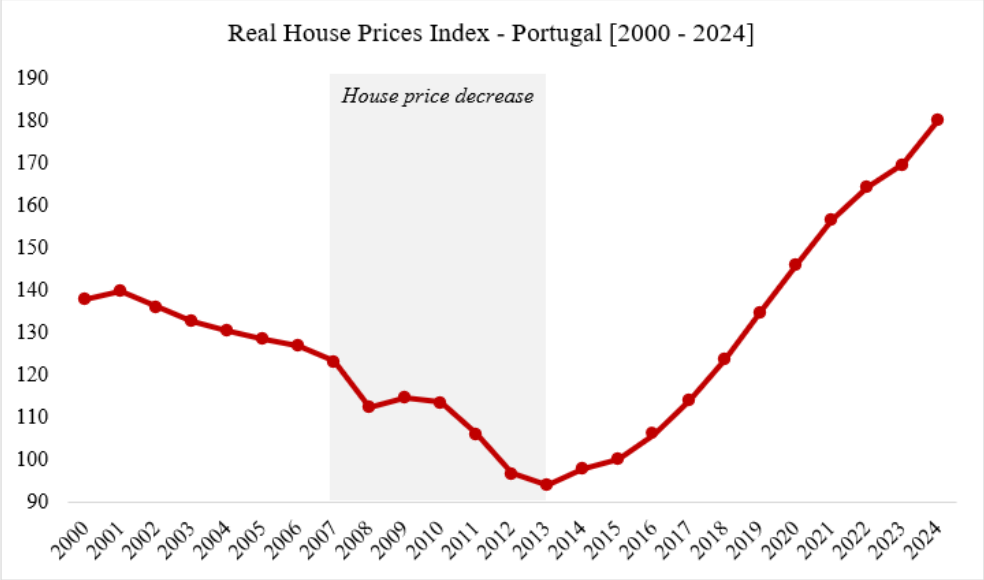

Figure 5 – Real House Price Index - Portugal (2000 – 2024)

Source: OECD

By 2011, the country's economic outlook led to Portugal's request for an international bailout in 2011 (Januário and Cruz, 2023), as the country was facing unforeseen increases in deficits and public debt and was confronted with rising risk premia on its public debt and increasing fears of sovereign default (Oliveira and Queiró, 2023).

From 2014 onwards, house prices began a rapid recovery, particularly in Lisbon and Porto. Between 2014 and 2019, median banking valuations in Lisbon doubled from €1,474 to nearly €3,000 per square metre, continuing to rise even during the COVID-19 pandemic (Januário and Cruz, 2023). Several factors contributed: historically low interest rates, constrained housing supply and significant inflows of foreign capital. The Golden Visa programme, launched in 2012, channelled over €6 billion into Portuguese real estate by 2022, mostly in urban luxury segments, while the rise of short-term rental platforms such as Airbnb further reshaped housing demand (Januário and Cruz, 2023).

However, these dynamics have raised major affordability concerns. While prices surged, real wages stagnated, corroding household purchasing power. Evidence points to a mismatch between available housing stock and household needs, with affordability pressures particularly acute in Lisbon's metropolitan area (Santos *et al*., 2015; Januário and Cruz, 2023). At the same time, housing policy remained fragmented, with limited investment in affordable or social housing, reinforcing reliance on private provision and credit markets (Santos *et al*., 2015).

The Portuguese case does not present conclusive evidence of a speculative bubble equivalent to those in Spain or Ireland, but it does illustrate how financialization and external shocks can generate boom-bust cycles, credit vulnerabilities, and affordability crises. This complex trajectory underscores the importance of rigorous diagnostic tools to assess whether recent price increases are grounded in fundamentals or reflect speculative dynamics (Oliveira and Queiró, 2023; Tavares *et al*., 2014; Santos *et al*., 2015; Januário and Cruz, 2023).

2.4. Fundamentals driving housing markets

When assessing the potential existence of a housing market bubble, there are various factors, indicators and fundamentals that can be analysed to observe their fluctuations and impact on the housing market. The European Central Bank (ECB) regularly publishes research on the housing market and housing prices across Europe, as these developments play a crucial role in the economic and monetary analyses conducted by the institution. In one of its recent articles, *Developments in the Recent Euro Area House Price Cycle*, it is highlighted that although house prices often unfold through cycles of rapid expansion and contraction, their triggers and drivers vary considerably. Examining them exclusively alongside business cycles therefore provides only a limited perspective (Höynck *et al*., 2025).

Complementing this view, Melecky and Paksi (2024), based on a panel of 15 European countries from 2000 to 2020, provide empirical evidence that demand-side and financial factors remain the most influential drivers of housing prices. Their findings indicate that GDP growth, wage growth, demographic change, financial development and household credit availability contribute positively, while unemployment, inflation and higher long-term interest rates tend to dampen price growth. By contrast, supply-side variables generally play a smaller role, except for construction costs, which have partly motivated recent increases in housing prices. Importantly, their results show that the impact of demand and financial factors has been amplified by the period of low interest rates and quantitative easing in Europe.

A salient feature of housing price data is the presence of booms and busts, which may be driven by fundamentals, but can also be intensified by market expectations or speculation. The interlinkages between housing prices, credit, and real economic activity

are well-documented. In advanced European economies, increases in GDP and household income are associated with higher housing prices, while tighter credit conditions reduce them. Evidence also shows that household-credit booms sharply raise the probability of real-estate booms (Melecky and Paksi, 2024). These findings underline how housing bubbles are frequently synchronised with excessive credit creation and often coincide with broader business cycles (Vogiazas and Alexiou, 2017).

Against this backdrop, the accurate measurement of the fundamentals is a central econometric challenge, as asset prices must be assessed relative to fundamentals before diagnosing speculative components. In practice, researchers often work with real house prices or log price-to-rent (PR) ratios, using rents as a proxy for market fundamentals, or price-to-income ratios when rental data are unavailable, and then decompose them into fundamental and non-fundamental components for bubble testing (Shi and Phillips, 2023).

2.4.1. Demand-side fundamentals

Studies consistently identify demand-side drivers as key determinants of housing prices. Melecky and Paksi (2024) show that GDP growth, wage growth and demographic change exert significant positive effects, while unemployment has a negative effect. Vogiazas and Alexiou (2017) similarly highlight GDP, unemployment and other macroeconomic indicators as central determinants.

In Portugal, after the intervention of "*troika"*, the government put tourism and foreign investment as central pillars to the country's economic recovery strategy (Januário and Cruz, 2023). The Golden Visa Program was implemented, offering residency permits to investors in real estate, private equity or entrepreneurship if they spent a minimum ranged from 350.000 euros to 500.000 euros in real estate (OECD, 2026). Between 2012 and 2022, this program generated more than 6 billion euros and, as 90.3% of this investment was channelled into real estate acquisitions, this inflow had a high impact on the Portuguese housing market, especially in Lisbon and Porto. The resulting capital inflows subsequently extended to the broader housing market, driven by demand displacement and equity effects (Januário and Cruz, 2023; Jover and Cocola-Gant, 2022).

2.4.2. Financial fundamentals

Financial determinants are consistently found to be crucial. Melecky and Paksi (2024) demonstrate that financial development and the availability of credit are positively associated with housing price growth. Vogiazas and Alexiou (2017) also identify credit to the private sector and monetary conditions as important drivers of housing market dynamics.

According to Oliveira and Queiró (2023), Portugal entered the late 2000s with one of the highest levels of household indebtedness in Europe, with mortgage defaults peaking at 2.7% in 2016.

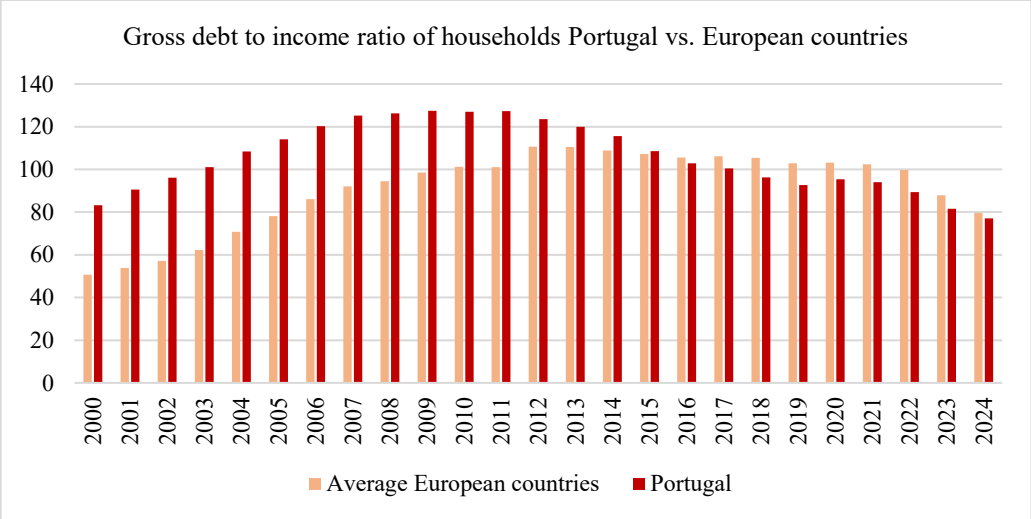

Figure 6 – Gross debt to income ratio of households – PT vs. Europe

Source: EUROSTAT

Note: The average was calculated based on the available date, at the time, of all the European countries available on the database ***nasa_10_ki.***

To reduce these vulnerabilities, Banco de Portugal introduced, as recommendations to all financial institutions granting consumer credit, macroprudential borrowing caps in 2018.

Santos *et al*. (2015) add a longer-run perspective, showing after the creation of a Single Market and the Economic and Monetary Union, Portugal's was allowed to integrate fully into international financial markets, eliminating exchange rate risk and enabling banks to access abundant, low-cost external funding. Privatised Portuguese banks borrowed extensively from core Eurozone institutions, leading to a rapid expansion of external liabilities and a deterioration of the country's net international financial position up to 2008. Rather than supporting productive growth, these capital inflows

primarily financed persistent external deficits and fuelled credit expansion. When international wholesale markets froze after the 2008 crisis, external funding was largely replaced with emergency financing from the Euro system.

Franco and Santos, (2021) further note that, the 2012 rental market liberalization and the introduction of the "Golden Visa" program, increased the exposure of Portuguese housing to global financial flows. By facilitating the entry of foreign and corporate capital into the short-term rental market (e.g. Airbnb), these measures allowed housing units in iconic historic neighbourhoods to be increasingly treated as financial assets for buy-to-let investment. Consequently, while these regulatory shifts promoted urban rehabilitation, they also tightened the link between local housing and international capital, even as credit cycles continued to shape broader patterns of affordability and access.

2.4.3. Supply-side fundamentals

Compared with demand and financial factors, supply-side drivers tend to show weaker effects, though they remain relevant. Melecky and Paksi (2024) find that construction costs were the only supply-side proxy with significant positive effects on housing prices across Europe. Sjöling (2012) stresses that housing market indicators such as price-to-rent and price-to-income ratios are sensitive to imbalances between housing demand and supply, and that stock-flow mismatches contribute to price inflation.

Also, regarding supply-side constraints, in the Portuguese case these were shaped by the structured collapse of the construction industry following the 2011 sovereign debt crisis (Pacheco et al., 2019). Housing construction activity fell sharply between 2007 and 2014, and the subsequent recovery in housing starts was gradual and contained. Between 2015 and 2024, only about half the number of new dwellings were built compared to the eight years preceding the crisis (Banco de Portugal, 2025).

The abrupt slowdown in construction activity and real estate transactions led to a substantial wave of insolvencies within the sector, as many firms lacked the financial capacity to sustain operations under tightened credit conditions (Pacheco et al., 2019). This widespread financial fragility resulted in the exit of many firms from the market, contributing to a structural reduction in productive capacity. Although building permits increased after 2016 and new completions reached approximately 25 thousand dwellings

in 2024, more than tripling from their lowest level, overall construction activity remained well below pre-crisis standards (Banco de Portugal, 2025).

Santos *et al*. (2015) highlight how permissive regulation and speculative land development in Portugal facilitated rapid construction cycles, reinforcing volatility.

2.4.4. Fundamentals versus shocks

Ouazad (2020) argues that while short-run shocks such as crises or disasters can temporarily disrupt housing demand, long-run price dynamics are overwhelmingly shaped by fundamentals, including housing supply elasticity, education, industrial diversification and segregation. In the Portuguese case, Januário and Cruz (2023) find that the global financial crisis had a negative impact on Lisbon's housing market, but that recovery was supported by GDP growth and monetary conditions. At the same time, they observe that housing price growth after 2010 was not fully explained by fundamentals such as wages and income but was fuelled by tourism and foreign capital inflows. Jover and Cocola-Gant (2022) reinforce this finding, showing how international housing demand and investment migration policies intensified speculative pressures in Lisbon and Porto.

From a methodological standpoint, Kishor and Morley (2015) underline the importance of separating fundamentals from speculative components. Their analysis of price-to-rent ratios shows that in addition to fundamentals such as expected rent growth and returns, there exists a non-stationary residual strongly correlated with expected returns. These residual captures speculative behaviour, making it essential for econometric models to distinguish between fundamental and non-fundamental dynamics.

2.5. Methods/ Models Proposed to detect Housing Bubbles

Tomal (2021) emphasises that detecting housing price bubbles in the real estate market (REM) based solely on prices or relational indicators (e.g. price-to-rent or price-to-income ratio) is insufficient, as this approach makes it impossible to determine whether a price increase is driven by market fundamentals. As new methods of analysing and detecting housing market bubbles were developed, this problem has become more widely recognised.

Campbell and Shiller (1987) proposed a methodology that involved testing the stationarity of actual and fundamental prices, concluding that a bubble exists when both series or the actual price is nonstationary and its fundamental counterpart is stationary. Evans (1991), however, later demonstrated that standard unit root and cointegration tests are incapable of reliably detecting explosive bubbles when these bubbles periodically collapse, a finding that has been widely acknowledged in the literature.

Subsequent studies have sought to improve bubble detection. For example, Hui and Yue (2006) examined the housing markets in Beijing and Shanghai, where they used the method of comparing the observed data with those predicted by an econometric model. Although the model considered the predictors explaining housing supply and demand, the authors found it hard to obtain direct estimates of the asset's fundamental value.

To address these limitations, Phillips *et al*. (2015) developed the PSY procedure, which allows for the identification of multiple periods of explosive behaviour in asset prices within a given sample. This recursive right-tail unit root test is more flexible than previous methods, as it enables the detection of both the start and end points of speculative episodes. According to Shi and Phillips (2023), since the method has been developed, it has already been used in several empirical applications. For example, the Federal Reserve Bank of Dallas uses the PSY method to provide quarterly exuberance indicators for 23 international housing markets.

Building on the challenge of bubbles being unobservable until they collapse, Shi and Phillips (2023) highlighted the use of traditional approaches that typically focused on the analysis of raw house prices or log price-to-rent (PR) ratios, using these metrics as proxies for underlying market fundamentals. Nevertheless, while useful, these tests left significant gaps in the analysis, leading to the proposal of a more refined approach that involved decomposing house prices or PR ratios into fundamental and non-fundamental components. Initially, this decomposition was made through the VAR model. Nonetheless, it was later found that this was a problematic approach since both the estimation and calibration errors accumulate in the assembling step. In this way, the decomposition of the fundamentals was then proposed to be based on instrumental variable estimation (IVX).

The IVX method, according to Shi and Phillips (2023) was able "(…) to reduce finite sample bias in estimation, avoid nonstandard limiting distributions of the estimated

coefficients caused by highly persistent regressors and endogeneity, and thereby facilitate valid inference.". Hence, the IVX allowed for the direct estimation of fundamentals, enabling the series to be computed as a residual and the PSY test to be applied to the resulting nonfundamental component. This new approach to bubble testing was called PSY-IVX (Shi and Phillips, 2023).

The PSY-IVX method employs a "reduced form" model, where the growth rate of PR ratios serves as the dependent variable, while the regressors capture housing market demand and supply factors (e.g. rent, interest rates, population, GDP and new housing completions, etc.). The main objective is to distinguish variations driven by fundamental factors from those influenced by other market price drivers (Shi and Phillips, 2023). For these reasons, and after reviewing the various models studied over the past few years, this method will be used to analyse the possible existence of a real estate bubble in the Portuguese market.

3. METHODOLOGY

The PSY-IVX model, developed by Shi and Phillips (2023), offers an econometric approach when diagnosing housing bubbles. As discussed in Section 2.1, housing bubbles are primarily characterised by the explosive behaviour in housing prices. Accordingly, this study employs the PSY-IVX approach to assess fluctuations in house prices relative to their fundamental values, while simultaneously identifying potential episodes of explosive dynamics in the real estate market.

First, an instrumental variables model (IVX-AR) is estimated, allowing real house prices to be decomposed into a fundamental and a non-fundamental component.

Second, a right-tailed recursive Augmented Dickey-Fuller (ADF) unit root test with a rolling window (PSY) is applied to the non-fundamental component, in order to identify whether deviations of prices from their determinants exhibit signs of exuberance and, consequently, macroeconomic vulnerabilities associated with a housing market bubble. Therefore, the non-fundamental component will encompass the bubble process. During speculative episodes, the non-fundamental component comprises both a random error and an explosive bubble process, whereas under normal market conditions it behaves as a purely stochastic disturbance (Shi & Phillips, 2023).

It has become standard practice to apply bubble detection techniques to real house prices, PR ratios, or, when PR data is unavailable, price-to-income ratios (PIR) (Shi & Phillips, 2023). Thus, the starting point for developing the PSY-IVX approach in this study will be to decompose the real house prices into fundamental and non-fundamental components, as this variable is more commonly studied in Portugal and easier to access.

In this framework, the growth of the log house price index is treated as the dependent variable, while fundamental factors are included as regressors.

The identification of the set of fundamental variables x_t is a crucial step in implementing the PSY-IVX methodology, as these variables capture the structural determinants of house price dynamics (Shi & Philips (2023)).

3.1. The IVX Methodology

The estimation of housing market fundamentals is conducted using a reduced-form predictive regression framework in which the real house prices growth is related to a set

of observable economic drivers, the so-called fundamentals. The main goal in this section will be to employ the IVX methodology to this regression in order to decompose it into fundamental and non-fundamental components.

Let p_t denote the logarithm of real house prices ($\log P_t$). The evolution of real house prices is modelled as follows:

$$\Delta p_t = \alpha + \beta x_t + \varepsilon_t \quad (2)$$

$$x_t = \rho_x x_{t-1} + u_{xt}, \quad (3)$$

$$\rho_x = \mathrm{I}_k \frac{C_x}{T^l} \quad (4)$$

Where:

- x_t is the vector of fundamentals;
- β is the coefficient matrix;
- matrix $C_x = \mathrm{diag}(c_{x1}, \dots, c_{xk})$, with $0 \leq \alpha \leq 1$ and $c_{xi} < 0$;
- T corresponds to the sample size;
- ε_t and u_{xt} are error terms.

This linear estimation framework allows the explanatory variables x_t to follow the stochastic process defined in equation (3), with an autoregressive coefficient matrix ρ_x that lies in the neighborhood of the identity matrix I_k of order k. This specification allows the fundamentals to be I(1), near integrated or mildly stationary, providing flexibility to model the dynamic properties of housing price determinants.

Shi and Philips (2023) highlight that, in this context, x_t can exhibit high persistence and that the presence of omitted variables and the joint evolution of y_t and x_t often generate contemporaneous, as well as dynamic dependence between $u_{x,t}$ and ε_t, giving rise to endogeneity in the regressors. In these scenarios, the conventional OLS estimation would be subject to finite-sample bias and invalid inference.

To address these issues, the IVX-AR estimator proposed by Yang *et al*. (2020) will be adopted, which is specifically designed to deliver consistent estimation and valid inference when regressors are near-integrated and potentially endogenous. Rather than relying on external instruments or requiring precise knowledge of the integration properties of the regressors, IVX constructs internal instruments that are mildly persistent transformations of the original explanatory variables. These instruments retain strong

correlation with the regressors, while remaining asymptotically orthogonal to the regression errors, thereby ensuring consistent estimation and valid inference.

The estimation will follow three main steps:

1. Assume an autoregressive structure for the errors and transform the regression accordingly.

2. Construct IVX instruments from filtered differences of the regressors, ensuring reduced persistence.

3. Estimate the transformed equation via instrumental variables and conduct inference using HAC-robust Wald statistics. The fitted values from the regression are given by:

$$\hat{y}_t = \hat{\alpha}_{IVX} + \hat{\beta}_{IVX} x_{t-1} \tag{5}$$

The key advantage of IVX-AR is that it delivers valid asymptotic inference under a wide range of persistence levels for the regressors, including stationary, mildly integrated, and near-unit-root processes, while simultaneously accommodating serial correlation and heteroskedasticity in the disturbances. This makes the method particularly well suited for predictive regressions involving macroeconomic fundamentals, where persistence and time-varying volatility are common empirical features.

In order to control for potential autocorrelation and heteroskedastic behaviour in the model regression errors (ε_t), they are assumed to follow an AR(q)-GARCH(m, n) process, given by:

$$\varepsilon_t = \sum_{i=1}^{q} \phi_i \, \varepsilon_{t-i} + \upsilon_t \tag{6}$$

$$\upsilon_t = \sigma_t \eta_t, \ \eta_t \sim \mathcal{N}(0,1) \tag{7}$$

$$\sigma_t^2 = \omega_0 + \sum_{i=1}^{m} \omega_i \, \upsilon_{t-i}^2 + \sum_{j=1}^{n} \gamma_j \, \sigma_{t-j}^2 \tag{8}$$

The specification collapses to the classical regression framework with serially uncorrelated and homoscedastic errors when $\phi_i = \omega_i = \gamma_j = 0$.

Within this framework, the fundamental component of housing prices is defined as the cumulative sum of the fitted values $\hat{y}_t$, such that:

$$\hat{F}_t = \hat{F}_1 + \sum_{i=2}^{t} \hat{y}_i \tag{9}$$

With $\hat{F}_1 = \log(p_1)$.

3.2. The PSY test

This test was developed by Phillips *et al*. (2015), providing a robust framework for the identification and dating of speculative bubbles in financial and macroeconomic time series, such as housing prices.

To detect speculative episodes, we apply the PSY procedure to the estimated residual component:

$$e_t = P_t - \hat{F}_t \tag{10}$$

Which represent the data after removing the estimated fundamentals. By construction, this residual series has zero mean under the null hypothesis of no explosive behaviour.

To implement the PSY algorithm for bubble detection, $y_t = e_t$.

The PSY methodology is based on recursive right-tailed unit root testing and is designed to identify periods of mildly explosive dynamics. Unlike standard unit root tests that examine the full sample only once, the PSY procedure repeatedly estimates an augmented ADF regression over expanding and rolling subsamples. This recursive structure allows for the dating of bubble origination and collapse episodes.

At its core, the test considers the following regression:

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{i=1}^{k} \psi_i \, \Delta y_{t-i} + \varepsilon_t \tag{11}$$

and evaluates the null hypothesis $H_0: \beta = 0$ (non-explosive) against the right-tailed alternative $H_1: \beta > 0$, which corresponds to explosive behaviour.

In the first step, the ADF regression is estimated under the null hypothesis (assuming a non-explosive behaviour) and the corresponding estimated intercept $\hat{\beta}_0$ and residuals $\hat{\varepsilon}_t$ for this hypothesis.

Next, a bootstrap sample of length $T_0 + T_b - 1$ is generated according to:

$$y_t^b = \hat{\beta}_0 + y_{t-1}^b + \varepsilon_t^b \tag{12}$$

where the initial condition is set to $y_1^b = y_1$.

The bootstrap creates a counterfactual scenario in which no bubble is present. The test then assesses whether the actual data behave in a way that is unusually explosive relative to this non-bubble benchmark.

The bootstrap innovations are constructed as $\varepsilon_t^b = w_t \hat{\varepsilon}_j$, where w_t is an independent draw from the standard normal distribution and $\hat{\varepsilon}_j$ is resampled with replacement from the estimated residuals. This wild bootstrap structure allows for unconditional heteroskedasticity in the error process.

For each bootstrap replication, the full PSY recursive testing procedure is applied to the simulated series y_t^b, producing a sequence of PSY statistics. The maximal statistic over the recursive sequence is then computed as:

$$\mathcal{M}^b = \sup_{r \in [r_0, 1]} (PSY_r^b) \tag{13}$$

This process is repeated $B = 2999$ times, yielding an empirical distribution of $\mathcal{M}^b$under the null hypothesis.

The bootstrap procedure yields an empirical distribution of the maximal PSY test statistic under the null hypothesis of non-explosive behaviour. From this distribution, the critical value is defined as the threshold that is exceeded in only 5% of the bootstrap replications. This critical value is then used to evaluate the PSY statistic computed from the observed data.

By construction, this critical value ensures that the probability of incorrectly identifying at least one bubble episode within a monitoring window of length T_b does not exceed the 5% significance level. In other words, even though the PSY test is applied repeatedly over time using overlapping subsamples, the bootstrap-based critical value controls the overall likelihood of false bubble detection across the entire monitoring period.

Following Phillips and Shi (2020), the monitoring window T_b is set to one year in the empirical application. This choice reflects a trade-off between timely detection of emerging speculative behavior and conservative statistical inference, as longer monitoring windows lead to stricter critical values and a lower incidence of false positives.

The resulting bootstrap critical values are robust to unconditional heteroskedasticity in the error process and explicitly account for the multiple-testing nature of the PSY procedure. As a result, the identification of bubble episodes is more reliable in finite samples than when standard asymptotic critical values are employed.

3.3. Data Collection

3.3.1. Dependent Variable

The central variable of interest in this study is the evolution of real residential property prices in Portugal over the period 2009Q1-2025Q1. Housing prices are measured using the real House Price Index (HPI) obtained from the European Central Bank (ECB), which tracks changes in transaction prices of residential property purchased by households, covering both new and existing dwellings.

Formally,

$$y_t = \Delta \log HPI_t \tag{14}$$

This transformation allows the interpretation of first differences as approximate real growth rates and aligns the analysis with the log-linear present-value framework underlying the PSY-IVX methodology (Shi & Phillips, 2023). The sample begins in 2009Q1 to ensure consistency in data availability across all selected fundamentals.

The subsequent analysis decomposes real house prices into fundamental and non-fundamental components using the IVX estimator and then applies the PSY recursive right-tailed unit root procedure to the residual component.

3.3.2. Fundamental Variables

According to the authors, Shi and Phillips (2023), fundamental variables should have clear theoretical relevance in the context of housing market fundamentals. Thus, based on this principle and the literature review conducted previously, the selection of variables was guided by the most influential drivers of housing prices identified by Melecky and Paksi (2024), as well as the variables used as fundamentals by the authors. Accordingly, the variables were grouped into three core categories:

- Demand-side fundamentals: include real GDP, wage, population and employment, all of which are expected to exert a positive influence on housing prices;
- Financial fundamentals: represented by new mortgage lending (credit), which is expected to represent a positive effect in housing prices, inflation (CPI) and interest rates (real interest rates), which are expected to represent a negative effect in housing prices;
- Supply-side fundamentals: proxied by construction costs (labour and materials), which are expected to positively affect housing prices;

In addition, given the importance attributed to housing supply in the study by Shi and Phillips (2023), and the "construction boom" followed by a subsequent slowdown in Portugal documented by Santos *et al*. (2015), the variable *new dwellings* is included as a key supply-side indicator. The rent index is also incorporated, as rental prices play a central role in the authors' study. Finally, to capture external demand pressures in the housing market, a variable measuring foreign demand is included, proxied by the number of foreign residents in Portugal, as well as a variable capturing the foreign investment in the country (Januário and Cruz, 2023).

These variables are intended to explain the evolution of house prices driven by market fundamentals, while separating movements that may be attributable to speculative behaviour.

Given the large set of fundamentals (twelve variables) and having the goal of keeping the model simple in order to avoid overfitting and multicollinearity between variables, the study considers three different sets.

The first and second sets intend to replicate the approach used in Shi and Phillips (2023). In the first set, the fundamentals will be only two: the real mortgage interest rate (mortgage rate, *real_int*) and the log of real housing rents (*log_real_rent*). In the second set, four more variables will be added to previous one: log employment (*log_emp*), log population (log_*pop*), log real disposable income (*log_gri*) and log housing supply (*log_hs*).

The third set of variables aims to incorporate additional macroeconomic and structural factors that appear to have played a relevant role in the evolution of house prices in Portugal.

First, a group of demand-side fundamentals is included. Real GDP and gross real household income capture overall economic activity and households' purchasing power, particularly during and in the aftermath of the sovereign debt crisis (Oliveira and Queiró, 2023). External demand pressures are proxied by the inflow of foreign residents and foreign direct investment in construction and real estate, especially following the introduction of the Golden Visa programme in the post-Troika period (Januário and Cruz, 2023). Second, financial conditions are incorporated through variables reflecting households' access to credit, capturing borrowing capacity and financing constraints that directly influence housing demand (Santos *et al*., 2015). Finally, supply-side factors include indicators of new construction activity and construction costs, accounting for housing supply and cost pressures within the construction sector (Santos *et al*., 2015; Januário and Cruz, 2023).

Table 2 – Selection on fundamentals for each Set

Data Imported	Set 1	Set 2	Set 3
log_hs	*No*	*Yes*	*Yes*
log_cc	*No*	*No*	*Yes*
log_real_credit	*No*	*No*	*Yes*
log_real_rent	*Yes*	*Yes*	*No*
log_gri	*No*	*Yes*	*Yes*
log_foreign	*No*	*No*	*Yes*
log_pop	*No*	*Yes*	*No*
infl_qoq	*No*	*No*	*No*
core_infl_qoq	*No*	*No*	*No*
real_int	*Yes*	*Yes*	*No*
log_real_gdp	*No*	*No*	*Yes*
log_emp	*No*	*Yes*	*No*
log_real_FI	*No*	*No*	*Yes*

The use of logarithmic transformations allows the coefficients to be interpreted as elasticities, improves comparability across variables and mitigates potential heteroskedasticity arising from trending macroeconomic series.

4. RESULTS

4.1. House Price Index

The Graph 6 below illustrates the historical evolution of house prices in Portugal, measured by the House Price Index, while Graph 7 presents the annual variations in these prices.

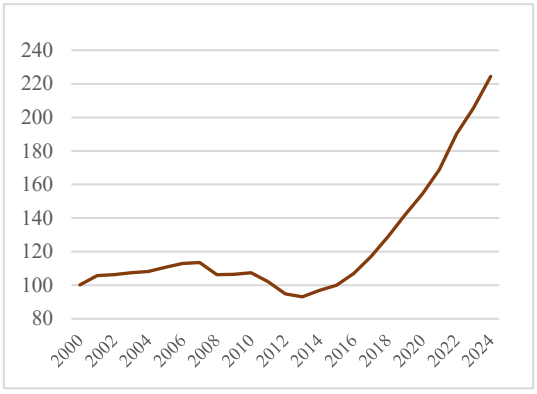

Figure 7 – House Price Index – nominal (2000 – 2024)

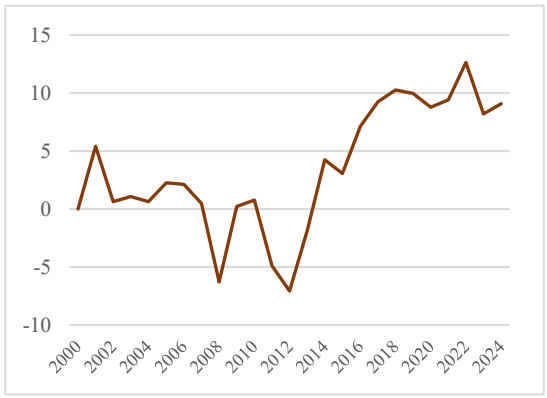

Figure 8 – House Price Index annual variations (2000 – 2024)

Source: OECD

As shown in Graph 6, nominal house prices exhibit a strong upward trend since 2014,[1] after moderate decline between 2010 and 2014, when Portugal experienced a severe economic crisis.

The upward trend observed since 2014 is quantitatively substantial, with cumulative price growth reaching 131,29%, to maximum historical levels. However, the trend followed by housing prices alone is insufficient to diagnose exuberance. The key empirical challenge is therefore to assess whether this trajectory is consistent with structural determinants of housing demand and supply, or whether deviations from fundamentals display explosive characteristics.

4.2. IVX on Fundamental and Non-Fundamental Components

The section displays the results of decomposing the real house prices into the three defined sets.

[1] With a single negative quarterly variation in 2020Q1, following the outbreak of the COVID-19 pandemic.

The Figures 8 to 13 represent the decomposition made by IVX-AR of the dependent variable, real house prices, into fundamental and non-fundamental components, considering the explanatory variables grouped in each set. The figures labelled (F) represent the estimation of the fundamentals and the figures labelled (NF) represent the non-fundamental component.

The first set includes only two core determinants: the real interest rate (mortgage rate, *real_int*) and the logarithm of real housing rents (*log_real_rent*).

The results shown in Figure 8 illustrate a persistent divergence between observed real house prices and both OLS and IVX estimated fundamentals in the first set between 2012 and 2017 (approximately), when real house prices observed were lower than the values suggested by the estimated fundamentals (between 2011 and 2018 when observing the OLS estimation).

According to Figure 9, the non-fundamental component registers pronounced negative values between 2011 and 2014, which may indicate either (i) a bias due to missing relevant fundamentals in the regression or (ii) pessimistic expectations by households regarding future house price developments. Both interpretations are plausible, given that Portugal entered a severe economic crisis in 2008, which lasted until 2014 (Oliveira & Queiró, 2023).

Between 2018 and 2024, real house prices were consistently above the values implied by both OLS and IVX estimations. The magnitude and persistence of this deviation suggest that interest rates and rental dynamics alone are not sufficient to explain the strong post-2015 increase in housing prices (a result that is consistent with the lack of statistical significance of these variables reported in Appendices, Section B, Table 4).

Figure 9 shows that the non-fundamental component shows a marked increase, suggesting that this set does not account for important economic developments in the post-crisis recovery period, such as credit expansion, income recovery, and increasing external demand (that were all reflected on the non-fundamental component). Alternatively, this pattern may also reflect higher price expectations by market participants.

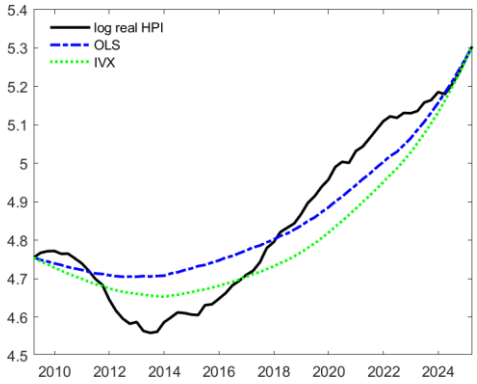

Figure 9 – Set 1 (F)

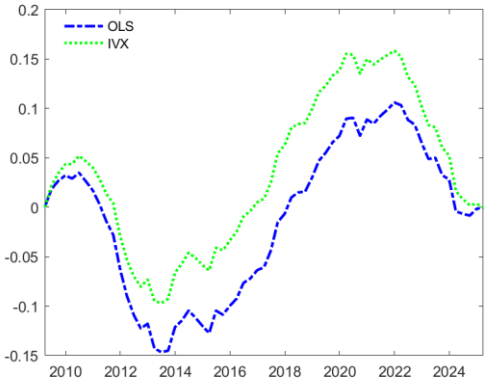

Figure 10 – Set 1 (NF)

Source: Own calculations using the PSY-IVX methodology in MATLAB, with code provided by Shi and Phillips.

To better understand these dynamics, a second set of explanatory variables is considered, extending the baseline specification by including the following explanatory variables: log employment (*log_emp*), log population (*log_pop*), log real disposable income (*log_gri*), and log housing supply (*log_hs*). This extension substantially improves the alignment between observed real house prices and the estimated fundamental component.

As shown in Figure 10, there is still a period in which real house prices remain below the estimated fundamentals. However, this period and the magnitude of the deviation are shorter and mainly concentrated between 2012/13 and 2014, which is consistent with the economic crisis. When analysing the period in which real house prices exceed the estimated fundamentals, the divergence observed under Set 2 is significantly smaller and less persistent than in Set 1, being mainly concentrated between 2016 and 2023. This result suggests that a relevant part of the post-crisis housing price growth can be explained by improvements in labour market conditions, demographic dynamics, and income recovery (Oliveira & Queiró, 2023; Januário & Cruz, 2023).

From an econometric point of view, the inclusion of broader macroeconomic variables absorbs a substantial share of the variation that was previously attributed to non-fundamental factors. The reduction in the volatility of the non-fundamental component, resulting from the comparison between figures 9 and 11, suggests that part of the apparent overvaluation detected under Set 1 until 2021 was likely driven by omitted variable bias. This interpretation is consistent with the joint statistical significance of the additional

variables in Set 2, as reported in Appendices, Section B, Table 5. However, the undervaluation observed afterwards remains when using Set 2.

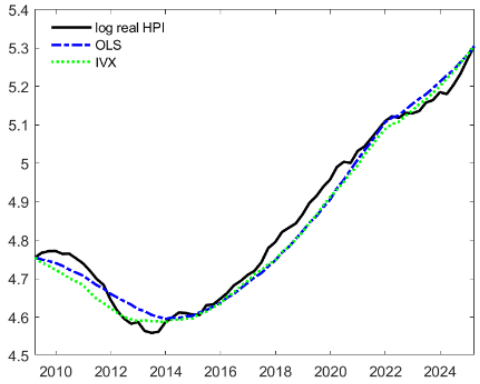

Figure 11 – Set 2 (F)

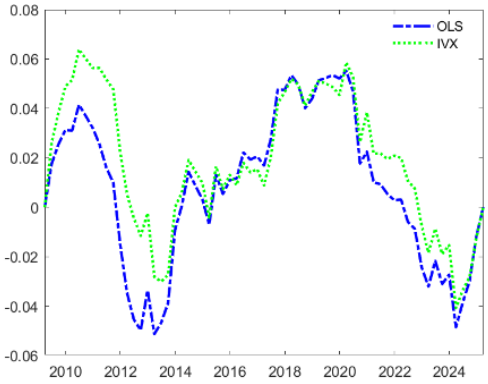

Figure 12 – Set 2 (NF)

Source: Own calculations using the PSY-IVX methodology in MATLAB, with code provided by Shi and Phillips.

The third set includes only variables that appear to have played a relevant role in the evolution of house prices in Portugal. This specification allows the introduction of three additional variables that were not considered in the previous sets, namely construction costs, mortgage credit, foreign demand, real foreign investment and real GDP. Importantly, these variables are jointly statistically significant within the IVX framework, suggesting that they contribute meaningfully to explaining housing price dynamics. (Appendices, Section B, Table 6)

Figure 12 shows that the estimated fundamental component under Set 3 closely tracks the observed evolution of real house prices throughout most of the sample period, although the deviations previously identified under Set 2 remain present. From 2009 to 2012, and again between 2018 and 2022, real house prices were above the levels implied by the IVX estimation, whereas between 2013 and 2014 they fell below the estimated fundamental values. Compared to the previous sets, the deviations between prices and fundamentals are smaller and less persistent, particularly after 2015. This suggests that supply-side pressures, credit conditions, income dynamics, and foreign demand play an important role in explaining recent housing price developments in Portugal (Oliveira & Queiró, 2023; Januário & Cruz, 2023).

Figure 13 provides a decomposition that is fully consistent with the deviations observed in Figure 10. Periods in which real house prices are above the IVX-implied

fundamental component in Figure 10 correspond to positive values of the non-fundamental component in Figure 13, indicating an upward deviation from fundamentals. This occurs between 2009 and 2012 and again between 2018 and 2022, when the IVX-based non-fundamental component becomes predominantly positive and reaches its highest levels. In contrast, during 2012-2014, when observed prices fell below the IVX-implied fundamental values, the non-fundamental component turned negative, reflecting a downward deviation from fundamentals. Overall, Figures 10 and 13 jointly indicate that, even after accounting for additional macroeconomic and structural determinants, a non-negligible share of price dynamics, particularly during 2018-2022, remains attributable to non-fundamental forces.

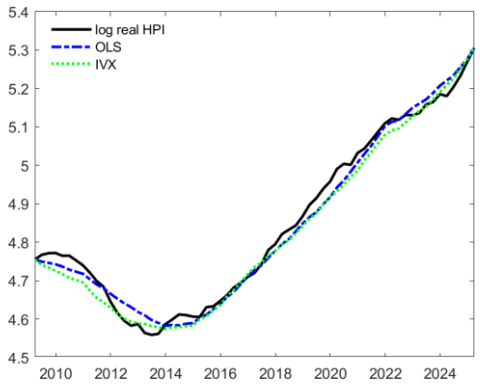

Figure 13 – Set 3 (F)

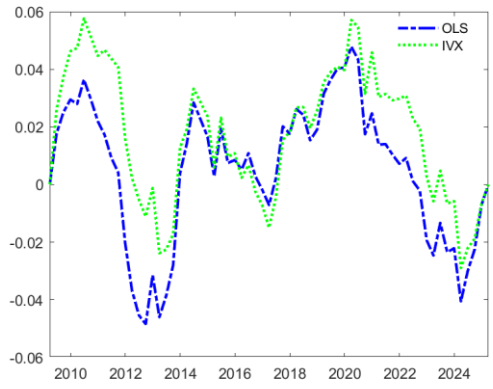

Figure 14 – Set 3 (NF)

Source: Own calculations using the PSY-IVX methodology in MATLAB, with code provided by Shi and Phillips.

4.3. Application of PSY to the non-fundamental Components

Regarding the deviations detected in the non-fundamental components, which are informative about potential episodes of exuberance in the real estate market, Figures 14 to 16 report the results of applying the PSY test to the dependent variable and to its estimated non-fundamental components, across the three sets of explanatory variables considered.

For the sample period 2009-2025, the results for Set 1 indicate the presence of a sustained episode of explosive behaviour. Specifically, between 2017Q3 and 2020Q2, the recursive test statistic persistently exceeds the 95% critical value, forming a continuous sequence above the threshold. According to the PSY methodology, such persistence constitutes statistical evidence consistent with a bubble episode. This period coincides with a phase of rapid real house price growth, during which the non-fundamental component displays a marked upward trajectory. However, once additional explanatory variables are introduced in Sets 2 and 3, the explosive dynamics identified under the parsimonious specification disappear. In these sets, the test statistics do not persistently exceed the critical value, and no statistically significant episodes of explosiveness are detected. This suggests that the bubble signal obtained in Set 1 may reflect omitted fundamental factors that are progressively captured in the expanded models.

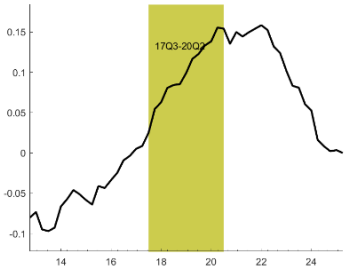

Figure 15 – Results PSY (Set 1)

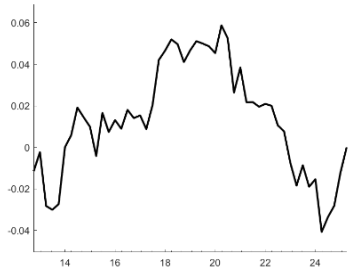

Figure 16 – Results PSY (Set 2)

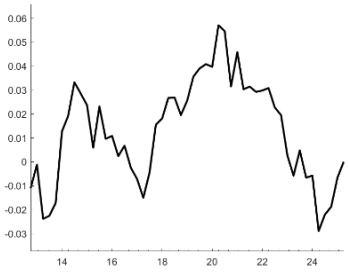

Figure 17 – Results PSY (Set 3)

Source: Own calculations using the PSY-IVX methodology in MATLAB, with code provided by Shi and Phillips

Consequently, the methodology suggests that house prices deviated from their estimated fundamentals during specific periods. The first occurs between 2012 and 2014, coinciding with the peak of the sovereign debt crisis, when real house prices fell below the levels implied by the fundamental component, indicating a period of undervaluation relative to economic conditions.

The second, more prolonged episode emerges between 2016/18 and 2022, during which observed real house prices remained above the IVX-implied fundamentals. This pattern is consistent with the behaviour of the non-fundamental component, which remains predominantly positive and displays an upward tendency over this interval. While this may reflect factors such as heightened expectations or demand pressures not fully captured by the model, the recursive PSY procedure does not identify sustained explosive dynamics. In particular, the test statistics do not persistently exceed the 95% critical value threshold.

Although the Set 1 detects a period of explosive behaviour, the joint Wald test indicates that the included fundamentals lack explanatory power. In contrast, Sets 2 and 3 display strong joint statistical significance, suggesting that these specifications more adequately capture the underlying economic drivers of house price dynamics. Once these broader demand, financial and supply-side fundamentals are incorporated, the previously identified explosive episode disappears. This evidence indicates that the apparent bubble detected under Set 1 is more consistent with model misspecification than with a speculative process.

5. CONCLUSION

The strong increase in house prices in Portugal over the last decade has intensified concerns regarding the possible formation of a speculative housing bubble. In a context of strong domestic demand, resilient employment, and recovering real incomes, housing prices have continued to rise rapidly, further amplifying public debate about overheating and speculative pressures. At the same time, international uncertainty, rising trade tensions and structural constraints identified in recent policy assessments reinforce the importance of carefully distinguishing between exuberance and fundamentals driven growth.

The PSY IVX framework developed by Shi and Phillips (2023) was employed to decompose real house prices into fundamental and non-fundamental components and to directly test for explosive behaviour. The findings indicate that the diagnosis of exuberance is highly sensitive to model specification. Under a restricted model, a prolonged episode of explosive behaviour is observed between 2017 and 2020. However, when broader demand, financial, and supply-side determinants are included, such as income, labour market dynamics, credit conditions, construction costs, and foreign demand, the estimated fundamental component closely aligns with observed prices, and the explosive pattern is no longer evident. This result is economically significant, as it suggests that apparent signs of exuberance may be attributable to omitted variable bias rather than genuine speculative dynamics. Across these specifications, no sustained explosive behaviour is identified between 2009 and 2025, although deviations from fundamentals are present in certain subperiods. Consequently, the evidence does not support the existence of a classic bubble process during the analysed period.

This does not mean that there is no tension in the Portuguese real estate market. Particularly for younger households and renters, affordability has substantially declined, and supply constraints still restrict how quickly the construction industry can react to demand shocks. Distributional pressures and social concerns have increased due to historically limited housing investment and strong demand from both domestic and foreign buyers. Even though they are significant issues, high prices and affordability issues are not the same as explosive bubble dynamics.

In conclusion, while recent house price growth has fuelled widespread concerns about a housing bubble in Portugal, the empirical evidence obtained through the PSY IVX methodology does not indicate the presence of a sustained explosive process over the period analysed. The Portuguese housing market appears to reflect strong fundamentals interacting with persistent supply constraints and evolving macroeconomic conditions. A long-term stability will not be secured automatically, as it requires consistent oversight, structural improvements in housing markets and disciplined fiscal choices to prevent today's pressures from becoming tomorrow's imbalances.

5.1. Academic Contributions

This research contributes to the academic literature on housing bubbles by applying the PSY-IVX methodology to the Portuguese housing market. The PSY framework (Phillips, Shi, and Yu) provides a recursive econometric approach capable of identifying periods of explosive behaviour and date-stamping bubble episodes, while the IVX methodology allows for robust estimation in the presence of persistent and endogenous regressors. By combining these approaches, this study is able to distinguish more effectively between price movements driven by fundamentals and those associated with speculative dynamics.

The primary contribution of this study lies in extending the application of this relatively recent econometric framework to a new geographical context, namely Portugal, where empirical evidence on housing bubbles remains limited. In doing so, the study provides new insights into the dynamics of the Portuguese housing market and highlights the importance of controlling for macroeconomic fundamentals when conducting bubble detection.

Furthermore, the findings reinforce a key insight in the literature: bubble detection results are highly sensitive to model specification and the treatment of fundamentals. In this sense, the research contributes to the ongoing academic debate by emphasizing that housing bubbles should not be interpreted as purely statistical phenomena, but rather as outcomes that depend on the underlying economic framework and modelling choices.

Finally, this study supports and extends existing empirical work that applies the PSY methodology in real-world settings. Similar approaches have been used by institutions such as the Federal Reserve Bank of Dallas to monitor housing market exuberance across

countries, reinforcing the relevance of this methodology as a practical and policy-relevant tool for real-time bubble detection . By applying and adapting this framework to Portugal, this research contributes to its external validity and demonstrates its usefulness beyond the contexts in which it has been most applied.

5.2. Practical Implications

The findings of this study offer relevant implications for policymakers, financial institutions, and market participants involved in housing markets. However, these implications should be interpreted with caution, as they are conditional on the empirical framework adopted and the set of variables included in the model.

First, the results highlight the importance of distinguishing between price movements driven by fundamentals and those associated with speculative dynamics, when assessing housing market conditions. By employing the PSY-IVX methodology, this study provides a more robust framework to evaluate whether observed housing prices are aligned with underlying economic fundamentals. This contributes to a more accurate interpretation of housing market developments, showing that relying solely on observed price increases may lead to misleading conclusions regarding the existence of housing bubbles. This is particularly relevant for Portuguese policymakers, who face increasing pressure to address housing affordability while avoiding premature or misdirected interventions.

Second, this has important implications for the interpretation of recent developments in the Portuguese housing market. It suggests that rising prices may reflect an imbalance between demand and supply rather than purely speculative dynamics. The persistence of price growth despite rising interest rates further indicates that demand remains relatively resilient. In this context, the findings point to the importance of supply-side considerations. Structural constraints in housing supply may be playing a central role in sustaining upward pressure on prices, suggesting that policy responses should not focus exclusively on demand-side measures but also address limitations in housing availability.

Finally, this research highlights the importance of incorporating specific structural characteristics for each county when analysing housing markets. The Portuguese case demonstrates that housing price dynamics are shaped not only by macroeconomic fundamentals but also by institutional and structural factors. Recognising these elements

is essential for designing effective policy responses and for ensuring that econometric results are interpreted within their context.

5.3. Study Limitations and Suggestions for Future Research

The initial objective of this study was to conduct the analysis at the NUTS II 2024 regional level, in order to capture potential regional differences in housing market dynamics. However, during the data collection process, it became clear that several key variables, particularly the House Price Index, were only consistently available at the national level. Although alternative proxies were considered, they did not provide sufficiently reliable or consistent results. For this reason, the analysis was ultimately conducted using national-level data, ensuring greater data quality and robustness of the results.

A second limitation relates to the specification of the empirical framework. The model focuses on a set of macroeconomic fundamentals, such as interest rates and other observable variables, that are standard in the literature. However, it does not capture all relevant factors influencing housing market dynamics. In particular, recent developments in the Portuguese housing market suggest that price behaviour may not be fully explained by domestic monetary conditions. Despite rising interest rates in recent years, housing prices have continued to increase, which appears inconsistent with standard economic theory. This may reflect the growing importance of external demand factors, such as foreign investment and the inflow of higher-income individuals (e.g., digital nomads), whose purchasing decisions are less sensitive to domestic credit conditions. Incorporating such factors into the analysis represents a relevant avenue for future research.

Furthermore, the model does not account for structural constraints on the supply side of the housing market. Factors such as regulatory barriers, lengthy construction processes, and limited availability of new housing developments may exert upward pressure on prices independently of demand-side fundamentals. The omission of these elements may lead to an incomplete representation of housing market dynamics. Future research could benefit from incorporating these indicators in order to provide a more comprehensive assessment of price behaviour.

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APPENDICES

APPENDIX 1: Data Details

Appendix 1.1 – Data: Variables and Transformations

Variables	ID	Sources	Data Transformations
House price index (2015 = 100) - quarterly data	HPI	Eurostat	N/A
Completed dwellings in new residential buildings: total and by dwelling type	HS	Pordata	As the dataset was provided at a monthly frequency, observations corresponding to each three-month period were aggregated to construct quarterly data.
Consumer price index (cpi, base - 2012) excluiding housing	CPI_Core	INE	Since the data were expressed with base year 2012 = 100, the series was rebased to 2015 = 100.
Consumer price index (cpi, base - 2012)	CPI	INE	Since the data were expressed with base year 2012 = 100, the series was rebased to 2015 = 100.
Business volume-loans-individuals mu-house purchase-m€ (new business)	Credit	Bstat	As the dataset was provided at a monthly frequency, observations corresponding to each three-month period were aggregated to construct quarterly data. The series was also multiplied by 1,000 to express the values in thousands.
GDP at market prices – CP-A	GDP	INE	Since this dataset was only available at an annual frequency, each yearly observation was replicated four times to construct a quarterly series.
New housing construction cost index (base - 2021)	CC	INE	Given that the information was available at a monthly frequency, quarterly values were computed by

(total, materials and labour)			taking the average of the three corresponding monthly observations.
Interest rate (apr) on new home loan operations	i_nominal	Bstat	Given that the information was available at a monthly frequency, quarterly values were computed by taking the average of the three corresponding monthly observations.
Resident population (long series, start 1991 - no.)	POP	INE	Since this dataset was only available at an annual frequency, each yearly observation was replicated four times to construct a quarterly series.
Net real disposable household income, 2014 = 100	GRI	OECD	Since this dataset was only available at an annual frequency, each yearly observation was replicated four times to construct a quarterly series. The index base year was also adjusted to 2015 = 100.
Foreign population with legal resident status	Foreign	INE	N/A
Rent prices (base - 2015)	RENT	OECD	N/A
Employed population	EMP	OECD	N/A
Inward FI in construction and real estate of all countries-quarterly stock	FI	Bstat	N/A

APPENDIX 2: Results

Appendix 2.1 – Significance results – Set 1

Data Imported	OLS_pval	IVX_pval
log_real_rent	*0.43568*	*0.4204*
real_int	*0.88331*	*0.97142*
Wald_statistic		*0.7496*

IVX_joint_pval	*0.68743*

Source: Own calculations using the PSY-IVX methodology in MATLAB, with code provided by Shi and Phillips.

Appendix 2.2 – Significance results – Set 2

Data Imported	**OLS_pval**	**IVX_pval**
log_hs	*2.3025e-09*	*0.2217*
log_real_rent	*5.6638e-07*	*0.046361*
log_gri	*5.1983e-10*	*0.01378*
log_pop	*0.00035351*	*0.34743*
real_int	*0.11397*	*0.046275*
log_emp	*7.0756e-07*	*0.79063*
Wald_statistic		*73.31*
IVX_joint_pval		*1.3722e-13*

Source: Own calculations using the PSY-IVX methodology in MATLAB, with code provided by Shi and Phillips.

Appendix 2.3 – Significance results – Set 3

Data Imported	**OLS_pval**	**IVX_pval**
log_hs	*0.00026437*	*0.33117*
log_cc	*0*	*0.0044701*
log_real_credit	*2.1525e-11*	*0.71095*
log_gri	*0.098819*	*0.03874*
log_foreign	*0*	*0.27686*
log_real_gdp	*0*	*0.14105*
log_real_FI	*0.0010974*	*0.45615*
Wald_statistic		*78.333*
IVX_joint_pval		*3.0087e-14*

Source: Own calculations using the PSY-IVX methodology in MATLAB, with code provided by Shi and Phillips.