Investigating the dynamics of house prices: an asymmetric analysis of macroeconomic determinants

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Abstract

Purpose – This study investigates whether real house prices in Greece respond asymmetrically to key macroeconomic fundamentals and whether such asymmetries are consistent with downward price rigidity. Motivated by the persistent rise in property prices and its implications for affordability and macro-financial stability, we examine differential effects across expansionary versus contractionary phases and assess the role of major structural disruptions.

Design/methodology/approach – We model real house prices in Greece as the dependent variable and apply the nonlinear autoregressive distributed lag (NARDL) methodology, decomposing GDP per capita, inflation (CPI) and mortgage interest rates into positive and negative partial sums to estimate asymmetric short- and long-run effects. Regime shifts are explicitly accounted for through an endogenously identified structural break at 2012Q2, aligned with the March 2012 PSI, strengthening inference on cointegration and long-run relationships over an extended, crisis-prone sample.

Findings – The results confirm cointegration with a significant speed of adjustment and pronounced asymmetries in the transmission of shocks to real house prices. In the long run, lagged GDP per capita is significant. Positive CPI shocks with a one-quarter lag raise prices, while negative shocks are insignificant, consistent with downward price rigidity. Interest-rate hikes depress prices more than cuts support them, and Wald tests indicate that long-run asymmetry operates mainly through the CPI and interest-rate channels. In the short run, positive GDP-per-capita shocks are significant, while negative changes are negligible. Lagged positive CPI changes reduce prices, while negative CPI changes remain insignificant. Interest-rate hikes have more persistent negative effects than the less durable and partly offset response to cuts, with Wald tests confirming short-run asymmetry across all three channels.

Research limitations/implications – In the Greek housing market, the long-run equilibrium appears stable; however, the transmission of macroeconomic shocks to real house prices is nonlinear and asymmetric, particularly in the short run. The findings highlight the importance of nonlinear approaches for both economic analysis and policy design. Although the empirical estimates are specific to Greece, the NARDL framework with structural breaks and formal asymmetry testing may also prove useful for analyzing similar housing-market adjustment mechanisms in other euro-area peripheral economies that experienced sovereign-debt, housing-market and banking-system stress, such as Portugal, Spain and Ireland.

Practical implications – Results imply that macroprudential policy should be calibrated to asymmetric risks. Authorities can front-load risk containment during boom phases through Loan-to-Value and Debt-to-Income limits, while supervisors can incorporate asymmetric scenarios into stress tests. In Greece, demand-support schemes such as the Golden Visa and "My Home" should be linked to local housing availability and complemented by measures that expand effective supply, including easing permitting delays, mobilizing vacant housing stock, and supporting new housing provision in high-demand areas.

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Social implications – Asymmetric house price responses can exacerbate affordability pressures because prices rise quickly in upswings but adjust slowly in downturns. This pattern can widen wealth inequality between owners and non-owners, raise barriers for first-time buyers, and increase household vulnerability when interest rates rise. Recognizing these dynamics supports policies that protect access to housing and reduce boom-driven displacement, especially in urban areas where demand shocks are strongest.

Originality/value – This study addresses a specific gap in the Greek housing-price literature by examining whether key macroeconomic determinants affect real house prices asymmetrically in both the short and long run once major structural disruptions are taken into account. It is among the few studies to apply a unified nonlinear NARDL framework with asymmetric effects, an endogenously identified structural break and a long sample covering major economic episodes. To the best of our knowledge, no previous study on Greece combines these features. The findings offer policy-relevant implications for housing policy, monetary policy and macroprudential design under heightened macro-financial risk.

Keywords Macroeconomics, Asymmetric effects, Determinants of house prices, Nonlinear ARDL model, Cointegration

Paper type Research article

1. Introduction

The housing market constitutes a fundamental pillar of economic activity, as it affects macroeconomic stability, economic growth, and household welfare. The sector operates within a complex framework shaped by macroeconomic conditions, demographic trends, and public policies, encompassing transactions, rentals, and asset management (Geltner *et al.*, 2007). In advanced economies, housing markets exhibit pronounced cyclical behavior linked to economic growth, inflation, and interest rates (Glaeser *et al.*, 2008), reflecting the broader macroeconomic environment and making it critical to understand the determinants of housing cycles (Case and Shiller, 1990).

In the Greek case, house prices increased by approximately 214% between 1993 and 2007, thus generating a strong "wealth effect" during a period of robust growth and structural reforms (Merikas *et al.*, 2009). During the prolonged financial crisis, by contrast, the market experienced a much smaller decline, with prices falling by nearly 44% between 2007 and 2017. Notably, the largest declines occurred outside major urban centers and key tourist regions, which exhibited a less pronounced decline (Eurobank, 2025). During this period of fiscal uncertainty, a substantial share of households viewed real estate as a hedge and a reliable store of value against the monetary and banking risks facing the country. Subsequently, as Greece gradually reduced default risk and improved its fiscal position, low interest rates, the strengthening of tourism through short-term rentals, and policy incentives, such as the Golden Visa and subsidized mortgage-loan programs (Gkiosis and Chapsa, 2025), supported a recovery in demand, while foreign direct investment increased from 0.1% of GDP in 2010 to 2.8% in 2024 (Eurobank, 2025). Overall, the recent period has been characterized by strong purchasing activity, excess demand, and rising prices (Bragoudakis, 2024). However, despite the prolonged recession and recent energy and geopolitical shocks, this upward trend has not reversed.

These developments motivate the present study in two ways. A primary motivation stems from the persistent rise in property prices, both in Greece and across many European countries, which has materially constrained a large share of households' access to homeownership. Intensifying urbanization and widening income inequalities further exacerbate this challenge, with implications for overall economic stability (Akinsulire *et al.*, 2024). An additional motivation relates to the fact that house prices are influenced by several determinants, including macroeconomic conditions, demographic trends, and policy measures, which may affect prices in different ways. This raises the question of whether these factors have asymmetric effects on housing markets. In this context, we examine whether positive and negative changes in the determinants affect real house prices in Greece asymmetrically, in both the short run and the long run, and whether such asymmetries are consistent with the hypothesis of downward price rigidity.

Within this framework, the study addresses three interrelated questions, examining whether positive and negative changes in key macroeconomic determinants, namely GDP per capita, inflation, and mortgage interest rates, affect real house prices in Greece asymmetrically in the short run and the long run, whether such responses are consistent with downward price rigidity and how structural breaks, such as those associated with the 2012 sovereign debt crisis, influence the dynamics and nonlinear responses of house prices. Accordingly, the Greek case constitutes a critical field of investigation for both academic research and policymakers.

The present study contributes to the literature by addressing a clear gap in research on the Greek housing market, namely the limited evidence on whether key macroeconomic determinants affect real house prices asymmetrically in the short and long run once major structural disruptions are explicitly taken into account. To our knowledge, no previous study on the Greek housing market has jointly examined asymmetric effects, structural breaks, and a sample spanning such a long period and covering major economic episodes. Methodologically, the study applies the nonlinear autoregressive distributed lag (NARDL) framework of Shin *et al.* (2014) and incorporates structural break tests in order to account for regime shifts and strengthen the robustness of the cointegration analysis, an approach that remains relatively uncommon in empirical research on house prices (Karamelikli, 2016). Empirically, it focuses on GDP per capita, inflation measured by the CPI, and mortgage interest rates, which are widely recognized as key drivers of real house prices (Glaeser *et al.*, 2008). By decomposing these variables into positive and negative changes, the analysis shows that real house prices respond more strongly during expansions and periods of monetary easing than during contractions, thereby pointing to downward price rigidity and nonlinear housing-market dynamics (Katrakilidis and Trachanas, 2012). A critical structural break is identified in 2012Q2, coinciding with the March 2012 Private Sector Involvement (PSI), which restructured part of public debt via an approximately 50% nominal haircut, triggering severe shocks to the banking system and losses addressed through three recapitalization rounds of the four systemic banks over 2013–2015 (Tzavalis *et al.*, 2025; Mamatzakis, 2024). By jointly examining asymmetric housing-price responses, their short-run and long-run dynamics, and major structural disruption within a single empirical framework, this study provides new evidence on nonlinear housing-price adjustment in Greece and offers policy-relevant insights into the effectiveness of macroeconomic stabilization and housing-market interventions in economies exposed to severe shocks. The findings further highlight the need for nonlinear frameworks in housing finance and macroeconomic management, and underscore the role of the real estate market in supporting household welfare and economic resilience.

The paper is structured as follows: Section 2 reviews the relevant literature, Section 3 outlines the methodological framework, Section 4 presents the variables and empirical findings, and Section 5 concludes with a discussion of the study's main findings and policy implications.

2. Literature review

Housing markets lie at the center of economic research due to their role in financial stability, income distribution, and overall economic performance, as house prices influence household consumption, investment, and the functioning of credit markets. Their dynamics arise from the interaction of supply and demand under the influence of macroeconomic factors, while pronounced regional heterogeneity complicates analysis and forecasting (Arvanitidis, 2014). Beyond macroeconomic variables, climate and ESG risks affect the valuation and behavior of the financial sector, with potential implications for financing conditions (Dou *et al.*, 2025). In Greece, the recent rise in prices makes it critical to investigate their determinants and macroeconomic implications. The present review summarizes empirical findings on the macroeconomic and financial determinants of house prices, with an emphasis on GDP per capita, inflation, and interest rates, and examines evidence of nonlinear adjustment and asymmetric responses to positive versus negative shocks, which may reshape both long-run equilibrium relationships and short-run dynamics.

The income basis of housing demand, captured by GDP and GDP per capita, plays a fundamental role in shaping house prices. Empirical studies investigate whether growth, typically associated with higher employment, disposable income, and consumer confidence, translates into upward pressures on prices and whether this relationship varies with market conditions. Case and Shiller (1990) argue that an increase in GDP signals improved income conditions and confidence, reflected in higher housing demand, while economic expansion encourages the construction of new housing, contributing to a rebalancing of supply and demand. Similarly, Iacoviello (2002) notes that GDP growth strengthens housing demand, as housing supply adjusts more slowly, and Égert and Mihaljek (2007) document strong associations between house prices and GDP per capita. Hardouvelis (2009) highlights that rising GDP per capita can lead to sharp price increases when housing supply does not keep pace, whereas Melecky and Paksi (2024) show a consistently positive effect of GDP growth on house prices, also amplified by the ratio of household credit to GDP. Evidence of asymmetry is reported by Pontiggia and Sivitanides (2020), who find that GDP increases exert the largest impact on house prices relative to other determinants, reflecting the role of abundant internal and borrowed capital as a market driver.

House-price movements may also influence GDP growth through wealth effects. Rising house prices improve households' net worth and perceived financial security, facilitating higher consumption and, by extension, GDP performance (Case *et al.*, 2011). Conversely, declines in incomes and house prices can undermine financial stability, raise default risk, and tighten lending standards, prolonging economic downturns. Mian and Sufi (2014) highlight that sharp declines in housing markets can trigger cascading economic distress, as illustrated by the 2008 global financial crisis. Nguyen *et al.* (2019) provide historical context, noting that nearly half of 42 major global financial crises from the 17th to the 19th centuries involved disruptions in housing markets, while the Asian and 2008 crises demonstrate how excessive credit expansion, speculation, and rising non-performing loans can cause prolonged downturns.

Housing-market fluctuations often display greater amplitude and persistence than aggregate output. Demary (2010) notes that housing-sector fluctuations exceed GDP fluctuations, while Adams and Füss (2010) stress that during recessions prices adjust slowly, supporting the hypothesis of downward rigidity. This asymmetric adjustment occurs as prices rise rapidly during expansions but decline gradually during contractions, with negative demand shocks primarily absorbed through reductions in transactions and new construction, directly affecting output, employment, and GDP (Leamer, 2007). Expectations and uncertainty further amplify this persistence, as buyers postpone purchases and sellers avoid realizing losses. Overall, the evidence suggests that economic growth and GDP per capita positively influence house prices through demand, income, credit, and wealth channels, while nonlinear and asymmetric responses are crucial to understanding market dynamics. Large price increases may also hinder growth by reducing affordability in key regions, limiting mobility and human-capital allocation (Anthony, 2023).

Alongside income-related mechanisms, the nominal macroeconomic environment, particularly inflation, decisively shapes house-price dynamics. Inflation can raise construction costs and enhance the attractiveness of real estate as a hedge, while simultaneously being associated with higher interest rates that constrain mortgage demand. Barot and Takala (1998) document that house prices and inflation move together over long horizons, reflecting a long-run equilibrium relationship, while Anari and Kolari (2002) confirm that housing serves as both consumption and investment, with strong long-run elasticity relative to general prices. Inglesi-Lotz and Gupta (2013) similarly find that house prices track inflation over time, reinforcing the hedge interpretation. Tsatsaronis and Zhu (2004) highlight that regulatory supply rigidities interact with inflation to shape housing cycles, with inflation driving the long-run trends in real house prices, while Crnadak *et al.*

(2025) show positive effects of CPI on house prices. Agnello and Schuknecht (2011) emphasize gradual but persistent pressures from inflation during boom and correction phases, and Kuang and Liu (2015) identify inflation as a dominant upward driver and document bidirectional effects between rising property prices and inflation. Finally, in the Greek context, Panagiotidis and Printzis (2016) observe the short-run sensitivity of house prices to inflation.

Monetary policy and interest rates further mediate these dynamics, as central banks use rates to stabilize output and inflation (Copaciu and Horobet, 2022). Interest-rate decisions directly affect borrowing costs and housing-market behavior, and tighter policy in response to inflation may amplify volatility (Hossain and Latif, 2009). Iacoviello and Neri (2010) show that inflation shocks and the interest-rate response shape real house prices and investment, with tightening exerting downward pressure, especially on housing investment, while persistent inflation or policy changes can link general prices and house prices upward. Generally, lower interest rates reduce borrowing costs and boost demand, increasing prices, although effects vary with credit conditions, lending standards, and macroeconomic environment. Dieckelmann *et al.* (2023) find that house prices respond nonlinearly to interest-rate changes, with stronger downside effects when rates rise from exceptionally low levels, while Aastveit and Anundsen (2022) document substantial regional heterogeneity in both the magnitude and timing of these effects. Apergis and Rezitis (2003) and Gkiosis and Chapsa (2025) further confirm the long-run negative effect of mortgage rates on house prices, with variation across countries.

In financially integrated systems, policy shifts by central banks that issue international reserve currencies can transmit to domestic interest rates through cross-border capital flows and foreign-currency liabilities, shaping borrowing costs and terms, credit availability, and ultimately investment and borrowing decisions (Horobet *et al.*, 2025). Expanded access to credit and low real interest rates strengthen demand and house prices (Égert and Mihaljek, 2007), while Glaeser *et al.* (2012) highlight the centrality of relaxed lending standards in housing booms. Housing affordability, shaped by interest rates, credit access, and supply conditions, is a critical driver of price fluctuations (Iqbal *et al.*, 2023), and competition in banking enhances policy transmission to mortgage rates (Egan and McQuinn, 2023). Because linear models often fail to capture these asymmetric and nonlinear dynamics, the present study adopts a nonlinear framework (NARDL), distinguishing positive and negative shocks. This approach provides a more realistic understanding of market behavior, as illustrated by Zhou (2010), who applies a three-step framework combining cointegration testing, nonlinear detection via the ACE algorithm, and re-testing of transformed variables. Katrakilidis and Trachanas (2012) identify long-run asymmetries in house prices relative to CPI, with faster responses to increases than decreases, consistent with downward price rigidity, while Alqaralleh (2019) and Akpolat (2024) highlight regional inequalities, affordability pressures, and long-run nonlinear effects, demonstrating the importance of flexible models.

Table 1 below summarizes and provides a constructive overview of the relevant literature discussed in detail above:

Taken together, the literature shows that GDP and GDP per capita, inflation, and interest rates are central determinants of real house prices through income, demand, credit, financing costs, and inflation-hedging channels. It also shows that housing-market adjustment is often nonlinear, asymmetric, and characterized by downward rigidity. However, the existing evidence remains relatively fragmented in the Greek case, as prior studies typically focus on specific determinants, periods, or model specifications rather than jointly assessing whether these key macroeconomic drivers affect real house prices asymmetrically in both the short run and the long run under conditions of major structural disruption. As a result, the Greek literature still provides limited evidence on the combined role of GDP per capita, inflation, and mortgage interest rates in shaping nonlinear housing-price adjustment across different phases of the cycle. This unresolved issue motivates the present study and clarifies its place within the literature.

Table 1. Summary of empirical studies on house prices, macroeconomic fundamentals, and asymmetries

Authors (Year)	Region/ Sample	Period	Methodology	Key variables	Main findings (relevant to our study)
Arvanitidis (2014)	Book–REM	–	Theoretical/ conceptual contribution	Real estate market, urban economy	RE market acts as an institutional intermediary, "materializing" urban econ. Potential by organizing the supply/ adaptation of the built environment
Dou *et al.* (2025)	27 EU ctrs. (banking firms)	2018–2021	Panel data econometrics	RI, P/B, financed emissions, ESG controversy score	Climate/ESG risks affect bank valuation beyond macro fundamentals: fewer ESG controversies are associated with higher valuations, while higher financed emissions are associated with lower valuations (RI, P/B), with implications for the cost of capital and funding conditions
Case and Shiller (1990)	U.S.A. (cities)	1970–1986	Repeat-sales (micro) + TSCS panel regressions	RHP & ERH, cons. Cost, adult popul. GDPpc	GDP growth raises housing demand/ prices; price changes and excess returns show momentum tied to fundamentals (demographics, cost-to-price), implying imperfect efficiency
Iacoviello (2002)	FR, IT, SP, SW, UK, GER	1973–1998	SVAR/ Cointegrated VAR	GDP, HP, mon. sup., infl., inter.rates	Higher GDP boosts demand and house prices, as supply adjusts slowly
Égert and Mihaljek (2007)	CE EU & 19 OECD ctrs	1995–2006	Panel Dynamic OLS	HP, GDPpc, int. rates, mortg. credit, demografic	Strong associations between house prices and GDP per capita
Hardouvelis (2009)	Greece	2007–2009	Theoretical framework	GDP, income, housing supply	In expansions, higher GDP/income raises demand and prices; with slow supply adjustment, increases can be rapid/steep
Melecky and Paksi (2024)	15 EU ctrs	2000–2020	Panel FE regression	GDP, wages, unempl., popul., house prices	A consistently positive effect of GDP on prices; a positive effect also for the household credit-to-GDP ratio

(*continued*)

Table 1. Continued

Authors (Year)	Region/ Sample	Period	Methodology	Key variables	Main findings (relevant to our study)
Pontiggia and Sivitanides (2020)	Cyprus	2006–2015	3-eq recursive system + partial adjustment	HPI, MR loans, GDP, popul., empl., int. rate, constr. cost	GDP has a significant impact on house prices; substantial asymmetry is identified in their relationship
Case *et al.* (2011)	USA	1978–2009	Panel (quarterly data)	Wealth ef., net worth, consump	Increases in house prices generate a wealth effect and strengthen consumption
Mian and Sufi (2014)	USA	2000–2012	Panel regressions (ZIP-code level)	HP, mortgage debt, income	Sharp declines in house prices can trigger broader economic distress in aggregate economic activity
Nguyen *et al.* (2019)	Vietnam	2005–2018	VAR (Vector Autoregressions)	GDP, growth rate of the REM	Housing market downturns are linked to financial crises and require time to stabilize and reconnect with GDP growth
Demary (2010)	10 OECD ctrs	1970–2005	VAR (Vector Autoregression)	RHPI, RGDP, GDP defl., sh-term int. rate	The cyclical component of real house prices is more volatile (higher standard deviation) than GDP and the price level
Adams and Füss (2010)	15 OECD ctrs	1975–2007	Panel cointegration	RHP, econ. activity, con. cost, inter. rate	Positive GDP–house price relationship, with slow adjustment and evidence of downward rigidity: in recessions, prices decline slowly
Anthony (2023)	USA	2000–2015	Multiple regression (OLS)	GDPpc, % cost-burdened, unempl. rate, popul. density	Affordability declines are linked to slower GDPpc growth via reduced labor inflows and weaker activity
Barot and Takala (1998)	Finland–Sweden	1970–1997	Error-Correction Model (ECM)	HPI, CPI, consumption, int. rates, wages, unemployment	House prices and inflation co-move; price-level pass-through to housing is rapid; feedback is weak
Anari and Kolari (2002)	USA	1968–2000	ARDL model	PEH, Price of New Homes (PNH), Nonhousing CPI	US house prices are long-run linked to the general price level, indicating housing acts as an inflation hedge

(*continued*)

Table 1. Continued

Authors (Year)	Region/ Sample	Period	Methodology	Key variables	Main findings (relevant to our study)
Inglesi-Lotz and Gupta (2013)	South Africa	1970–2011	ARDL model	House prices; CPI excluding housing costs	House prices co-move in the long-run with inflation, confirming the role of housing as an inflation hedge
Tsatsaronis and Zhu (2004)	17 ind. econ	1970–2003	SVAR (by country)	HP, GDP, CPI, short-term rate, bank credit growth	Supply rigidities limit adjustment to demand, while inflation emerges as a key long-run determinant of house prices
Crnadak *et al.* (2025)	V4	2008–2023	Pearson corr. + country OLS	RPP, CPI	For V4 countries, inflation is positively associated with, and statistically significantly affects, house prices in each country
Agnello and Schuknecht (2011)	18 industrial ctrs	1980–2007	Random-effects panel Probit	RHPI, HP gap, GDPpc, short-term rate, credit, M3, population growth	Inflation exerts gradual but persistent pressures on housing markets
Kuang and Liu (2015)	China (35 cities)	1996–2010	Dynamic panel models	HPI, CPI, GDP, hh income, int. rate, mon. supply, RPI, hh sav., SPI	Inflation is a key driver of house prices, with interest rates, supply constraints, and speculation acting complementarily. Bidirectional link: rising house prices may reinforce inflation
Panagiotidis and Printzis (2016)	Greece	1997–2013	VECM	HPI, CPI, IPI, retail trade, loan int. rate, mortg. growth, M1, unemployment	Inflation affects house prices in the short run; housing credit is the main lever both short- and long-run
Copaciu and Horobet (2022)	Romania	2002–2021	Threshold Bayesian VAR (TBVAR)	GDP, Real credit (non-gov.), Inflation, inter. Rate, leu/euro, ESI, CLIFS	Interest rates should be used to stabilize output during recessions and to stabilize inflation in normal times
Hossain and Latif (2009)	Canada	1980–2006	ARMA–GARCH, VAR/Granger	HP changes, GDP, CPI, mortg. rate, population	Inflation can increase volatility, especially when it leads to tighter monetary policy
Iacoviello and Neri (2010)	USA	1965–2006	Bayesian DSGE	RHPI, consumption, bus. inv., housing investment	Rising house prices increase housing wealth and collateral value, boosting consumption and (directly/indirectly) housing investment

(*continued*)

Table 1. Continued

Authors (Year)	Region/ Sample	Period	Methodology	Key variables	Main findings (relevant to our study)
Dieckelmann *et al.* (2023)	Euro area	2010–2021	Panel model	HPI; RPI; mortgage interest rates	Nonlinear response of real prices to real interest rates: at very low levels, even small increases exert disproportionately strong downward pressure
Aastveit and Anundsen (2022)	U.S. (263 MSAs)	1981–2007	Panel local projections	Monetary policy shocks; HP/MSA; housing supply elasticity/MSA	Interest-rate effects are asymmetric and spatially heterogeneous; supply adjustment differs, bank competition affects pass-through, and downward rigidity varies in intensity/ timing across areas
Apergis and Rezitis (2003)	Greece	1981–1999	ECVAR/VECM	HPI, mortg. int. rate, CPI, empl. rate, M1	Mortgage interest rates are the strongest determinant of house prices; negative association with prices
Gkiosis and Chapsa (2025)	Greece, Portugal	1997–2023	ARDL model	RHPI, CPI, empl. rate, GDPpc, mortg. int. rate	Greece: inflation and rates are negative in the long-run. Portugal: rates are consistently negative in the short/ long-run (transmission differences)
Horobet *et al.* (2025)	Non-euro EU (CZ, HU, PL, RO)	2010–2021	Bayesian VAR (+ panel evidence)	Ind. Prod., inflation, REER, unemployment, inter. Rate, Euribor, ECB total assets, VSTOXX index	According to their results, the interest-rate channel is a key external transmission mechanism. Changes in the ECB's rates can pass through to domestic interest rates in financially linked economies or those with euro-denominated liabilities, thereby shaping capital flows, borrowing conditions, and investment decisions
Glaeser *et al.* (2012)	USA	1980–2008	Valuation model + time-series regres	RHP, int. Rates, CPI-U, mortg. Approv., LTV	Looser credit standards and increased mortgage approvals boosted demand and fueled pre-crisis house price growth

(*continued*)

Table 1. Continued

Authors (Year)	Region/ Sample	Period	Methodology	Key variables	Main findings (relevant to our study)
Iqbal *et al.* (2023)	20 OECD ctrs	1970–2019	Asymmetric–Nonlinear ARDL	RHP unemployment rate	Affordability depends mainly on the elasticity/adequacy of supply and on access conditions to mortgage credit
Egan and McQuinn (2023)	16 euro ctrs	2000–2021	Panel fixed effects	MR. int. rate, Euribor, bank concentration. indicators	Lower bank concentration strengthens pass-through from policy rates to mortgage rates and, by extension, monetary-policy effectiveness
Zhou (2010)	USA (10 cities)	1978–2007	Augmented Engle–Granger, Johansen	HP, income, constr. Cost, MR inter. rates	US house prices–fundamentals may be nonlinear; proposes EG/Johansen testing with ACE transforms and re-testing
Katrakilidis and Trachanas (2012)	Greece	1999–2011	Asymmetric–Nonlinear ARDL (NARDL)	HPI, CPI, IPI	Asymmetric HP–inflation relationship: long-run asymmetries and stronger short-run response to CPI increases (vs decreases), cycle-dependent intensity
Alqaralleh (2019)	UK	1998–2017	STAR	HPI, HA, unempl. rate, mortg. rate, inflation rate	Strong regional heterogeneity and asymmetries; affordability is a key mechanism behind nonlinear dynamics in high-volatility periods
Akpolat (2024)	Turkey	2010–2021	Asymmetric–Nonlinear ARDL (NARDL)	RHPI, exch. Rate, MR.rates, M2, CCI, HS	Significant long-run asymmetries; nonlinear/flexible models are required to capture housing-market dynamics accurately

Source(s): Created by authors

3. Methodological framework

This section presents the methodological framework employed to estimate asymmetric short- and long-run relationships among real house prices and selected macroeconomic determinants, using the NARDL model of Shin *et al.* (2014).

To examine the presence of potential nonlinearities and asymmetric dynamics in the relationship between macroeconomic fundamentals and real house prices, this study employs the Nonlinear Autoregressive Distributed Lag (NARDL) model, as developed by Shin *et al.* (2014). The NARDL framework builds upon the linear ARDL approach (Pesaran *et al.*, 1999;

Pesaran *et al.*, 2001) by allowing for asymmetric adjustment paths in both the short and long run. This feature is particularly relevant for housing markets, where responses to macroeconomic shocks may differ depending on the direction of change due to behavioral, institutional, or financial frictions.

The modeling procedure commences with unit root testing using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests, aimed at confirming that none of the variables are integrated of order two or higher, as the bounds-testing procedure underlying both the ARDL and NARDL methodologies is valid only when variables are I(0) or I(1), but not I(2).

Following this, each explanatory variable is further decomposed into two partial sum processes: one capturing the cumulative positive changes and the other capturing the cumulative negative changes over time. Specifically, for any variable X_t, the positive and negative components are constructed as:

$$X_t^+ = \sum_{j=1}^{t} \max\left(\Delta X_j, 0\right), X_t^- = \sum_{j=1}^{t} \mathrm{m}in\left(\Delta X_j, 0\right)$$

Since X_t^+ and X_t^- are deterministic transforms of the same underlying series, some correlation may arise by construction. Nevertheless, this does not pose an identification problem, and asymmetry is assessed via Wald tests on the equality of the associated coefficients.

This transformation allows the model to estimate the effects of positive and negative shocks separately, thereby enabling formal testing for long-run and short-run asymmetries.

The general NARDL (p, q) specification is formulated as a nonlinear error correction model (ECM), in which the dependent variable is regressed on its own lags, the lagged levels of the decomposed positive and negative components of each regressor, and their respective first differences. The lag orders p and q are chosen based on the Akaike Information Criterion (AIC; Akaike, 1981), ensuring model parsimony and an optimal in-sample fit. Additionally, a structural break dummy is incorporated to account for observed disruptions in the Greek housing market, particularly in the post-crisis period.

Within this framework, the long-run effects of the explanatory variables are captured by two sets of parameters: β_j^+ and β_j^-, representing the coefficients on the lagged levels of the positive and negative components, respectively. The short-run dynamics are described by $\gamma_{j,i}^+$ and $\gamma_{j,i}^-$, denoting the coefficients on the differenced positive and negative components at lag i. The error correction mechanism is reflected in the coefficient on the lagged level of the dependent variable, which should be negative and statistically significant, indicating convergence toward long-run equilibrium.

The existence of asymmetric long-run relationships is formally tested using Wald-type restrictions on the null hypothesis $\beta_j^+ = \beta_j^-$, while short-run asymmetries are examined through joint restrictions on the parameters $\sum\gamma_{j,i}^+ = \sum\gamma_{j,i}^-$. Post-estimation diagnostic tests are applied to assess serial correlation, heteroscedasticity, normality of residuals, and parameter stability. The exact formulation of the symmetry hypotheses, as well as the results of the corresponding Wald tests, are detailed in the next section.

By employing the NARDL methodology, the present study enables a more nuanced understanding of the transmission channels through which macroeconomic forces impact house prices. This modeling strategy accounts for both the possibility of asymmetric adjustment and structural shifts, thereby offering a more realistic and policy-relevant depiction of housing market dynamics.

4. Model and empirical results

This study employs quarterly data from 1997Q1-2024Q4 to investigate the dynamic and asymmetric effects of key macroeconomic variables on real house prices in Greece. The dependent variable is the real house price index (LRHPI), while the explanatory variables include GDP per capita (LGDPpc), the Consumer Price Index (LCPI), and mortgage interest rates (INTER, in percentage points). All variables, except for the interest rates, are transformed into natural logarithms to ensure comparability, reduce potential heteroscedasticity, and allow the estimated coefficients to be interpreted as elasticities, while Table 2 reports the definition, measurement scale, and data source of each variable. These variables are selected because they capture the income-demand, nominal-price, and financing-cost channels that are widely recognized in the housing literature as key drivers of real house prices (Glaeser *et al.*, 2008). Although other factors may also affect house prices, the present study examines the asymmetric transmission of the main macroeconomic fundamentals within a quarterly NARDL framework. Since the NARDL framework requires the decomposition of each explanatory variable into positive and negative partial sums, including additional regressors would lead to a more highly parameterized specification and, given the available quarterly sample, fewer degrees of freedom. The baseline specification therefore focuses on the variables most directly aligned with the research question.

Table 3 reports descriptive statistics for the variables used in the empirical analysis.

In the present study, the analysis is conducted using the following general empirical model:

$$LRHPI_t = f\left(LCPI_t^+, LCPI_t^-, LGDPPC_t^+, LGDPPC_t^-, INTER_t^+, INTER_t^-\right) \qquad (1)$$

where $LCPI^+$, $LCPI^-$, $LGDPPC^+$, $LGDPPC^-$, $INTER^+$, and $INTER^-$ denote the accumulated positive and negative partial sums of changes in the logarithmic values of the respective variables.

For the NARDL approach to be valid, none of the variables should be integrated of order two or higher, as this would violate the underlying assumptions of the model. To assess this, unit root tests are applied, specifically, the Augmented Dickey-Fuller (Dickey and Fuller, 1979) and Phillips-Perron (Phillips and Perron, 1988) tests. As shown in Table 4, all variables are non-stationary in the levels but become stationary after the first differencing, indicating integration of order one, I(1).

Table 2. Data description

Variable	Description	Source	Unit/Scale
LRHPI	Natural logarithm of the real house price index	OECD	ln(index), Base: 2015 = 100
LGDPpc	Natural logarithm of real GDP per capita	OECD	ln(level), Constant 2015 prices
LCPI	Natural logarithm of the Consumer Price Index	OECD	ln(index), Base: 2015 = 100
INTER	mortgage lending interest rate	ECB	percentage (%), (level)

Source(s): Created by authors

Table 3. Descriptive statistics

Statistic	LRHPI	LGDPPC	LCPI	INTER
Mean	4.84	10.312	4.575	3.586
Median	4.833	10.264	4.603	3.343
Maximum	5.139	10.537	4.744	5.3
Minimum	4.574	10.076	4.363	2.538
Std. dev.	0.189	0.127	0.091	0.818

Source(s): Authors' calculations; created by authors

Table 4. Unit root tests

Level	Augmented dickey-fuller test				Phillips-Perron test	
	Intercept		Intercept and trend		Intercept	Intercept and trend
	k	*T*-statistic	k	*T*-statistic		
LRHPI	2	−2.10	2	−2.20	−21.73	−22.83
LCPI	4	−1.28	4	−2.12	−20.16	−18.96
LGDPPC	0	−1.36	0	−1.72	−16.04	−18.77
INTER	1	−1.94	1	−1.33	−16.89	−0.71
First difference						
ΔLRHPI	1	−2.69*	1	−2.64	−3.93***	−4.24***
ΔLCPI	4	−3.67***	4	−3.71**	−15.30***	−15.50***
ΔLGDPPC	0	−9.05***	0	−9.05***	−9.31***	−9.31***
ΔINTER	0	−6.19***	0	−6.38***	−6.13***	−6.27***

Variable	k	*T*-statistic	Break point
LRHPI	1	−4.88**	2012Q2

Note(s): The number of lags (k) is based on the Akaike Criterion (AIC). *, **, and *** denote rejection at the 10%, 5%, and 1% level, respectively

Source(s): Authors' calculations; created by authors

However, it is well-established that traditional unit root tests like ADF and PP may suffer from low power in the presence of structural breaks, particularly during periods of economic turmoil or disruption (Perron, 1989; Lee and Chang, 2005). To address the possibility of structural change, we apply a breakpoint unit root test with a single endogenously determined break to LRHPI, allowing for changes in both the intercept and the deterministic trend. The breakpoint is selected using the Dickey-Fuller min-t criterion, and the lag length is chosen according to the Schwarz criterion. The test identifies 2012Q2 as the structural break date.

In the next step, to test for potential asymmetries between the variables, a nonlinear error correction model is estimated, capturing both the short-run and long-run asymmetric effects of the explanatory variables on real house prices. This model, based on the NARDL framework, serves as the primary estimating equation of the empirical analysis. Specifically, short-run asymmetries are represented by the differenced positive and negative changes of each explanatory variable, while the long-run relationship is captured by their respective lagged levels. The estimated specification is expressed as follows:

$$\begin{aligned}\Delta LRHPI_t = {} & c + \rho\, LRHPI_{t-1} + {\beta_1}^{+} LCPI^{+}_{t-1} + {\beta_1}^{-} LCPI^{-}_{t-1} + {\beta_2}^{+} LGDPPC^{+}_{t-1} \\ & + {\beta_2}^{-} LGDPPC^{-}_{t-1} + {\beta_3}^{+} INTER^{+}_{t-1} + {\beta_3}^{-} INTER^{-}_{t-1} \\ & + \sum_{i=1}^{p-1} \varphi i \Delta LRHPI_{t-i} + \sum_{i=0}^{q} \gamma^{+}_{1,i} \Delta LCPI^{+}_{t-i} + \sum_{i=0}^{q} \gamma^{-}_{1,i} \Delta LCPI^{-}_{t-i} \\ & + \sum_{i=0}^{q} \gamma^{+}_{2,i} \Delta LGDPPC^{+}_{t-i} + \sum_{i=0}^{q} \gamma^{-}_{2,i} \Delta LGDPPC^{-}_{t-i} + \sum_{i=0}^{q} \gamma^{+}_{3,i} \Delta INTER^{+}_{t-i} \\ & + \sum_{i=0}^{q} \gamma^{-}_{3,i} \Delta INTER^{-}_{t-i} + \delta D_t + \varepsilon_t \end{aligned} \quad (2)$$

where: $\Delta LRHPI_t$ denotes the first difference of LRHPI. The coefficient ρ reflects the speed of adjustment to the long-run equilibrium. $LRHPI_{t-1}$ is the lagged level of the dependent variable, while $LCPI^{+}_{t-1}$ and $LCPI^{-}_{t-1}$, $LGDPPC^{+}_{t-1}$ and $LGDPPC^{-}_{t-1}$, and $INTER^{+}_{t-1}$ and $INTER^{-}_{t-1}$ respectively denote the positive and negative partial sums of changes in the respective variables. The long-run effects of positive and negative changes in each independent variable are represented by the coefficients β^{+}_{j} and β^{-}_{j}, while the short-run asymmetric effects are captured by $\gamma^{+}_{j,i}$ and $\gamma^{-}_{j,i}$, which correspond to positive and negative changes in variable j at lag i. The coefficient φ_i measures the effect of the lagged difference of the dependent variable. The parameter p denotes the maximum lag order for the dependent variable, and q denotes the maximum lag order for the independent variables, both determined by minimizing the Akaike Information Criterion (AIC). The summations in the short-run component of the model run over the corresponding lag lengths. The term c represents the constant in the model, δD_t is a dummy variable accounting for the structural break observed in $2012Q_2$, and ε_t is the error term, which is assumed to be white noise.

The results presented in Table 5 provide strong and statistically significant evidence supporting the presence of a long-run cointegrating relationship. The F-statistic for the joint significance of the lagged level variables is 26.229, well above the upper bound critical value at all conventional significance levels.

The estimated long-run coefficients provide further evidence supporting the presence of asymmetric transmission mechanisms (Table 6). Positive changes in GDP per capita exert a strong and statistically significant positive effect on real house prices (coef. 1.593, $p = 0.000$), indicating that a 1% increase in GDP per capita corresponds to an approximate 1.6% rise in real house prices.

Conversely, negative changes increase house prices to a slightly lesser extent (coef. 1.429, $p = 0.000$). This asymmetry suggests that house prices in Greece tend to rise during economic expansions but do not fall proportionally during downturns, reflecting downward price rigidity. Homeowners often resist lowering prices due to loss aversion or expectations of future recovery. Leamer (2007) refers to this as "sticky prices" in housing, where downward adjustments are limited despite weakening demand. Moreover, Katrakilidis and Trachanas (2012) document that

Table 5. Asymmetric ARDL (Non-linear) bounds test for cointegration results

Dependent variable Δ(LRHPI)	F-statistic	Break time	I(0)	I(1)	Outcome
Non-linear ARDL	26.229	2012Q2	2.45	3.61	Cointegration

Source(s): Authors' calculations; created by authors

Table 6. Long-run asymmetric NARDL results with structural break

Variable	Coefficient	Std. error	*t*-statistic	*p*-value
LGDPPC_POS	1.593***	0.382	4.166	0.000
LGDPPC_NEG	1.429***	0.384	3.723	0.000
LCPI_POS	3.389***	1.078	3.143	0.002
LCPI_NEG	−1.440	0.974	−1.478	0.144
INTER_POS	−0.201**	0.076	−2.634	0.010
INTER_NEG	0.181***	0.059	3.051	0.003

Note(s): *, **, and *** denote rejection at the 10%, 5%, and 1% level, respectively
Source(s): Authors' calculations; created by authors

the housing market reacts more strongly during expansions than contractions, further supporting the existence of asymmetric price dynamics.

Inflation exhibits similarly asymmetric effects. Positive shocks in CPI, with a one-quarter lag, significantly increase house prices. More specifically, the coefficient of 3.389 ($p = 0.002$) indicates that a 1% rise in CPI is associated with an approximate 3.4% increase in real house prices. This finding aligns with Barot and Takala (1998) and Apergis and Rezitis (2003), who demonstrate that house prices and inflation often move in the same direction over time, reflecting shared long-term dynamics. Moreover, Inglesi-Lotz and Gupta (2013) consider housing as an effective hedge against inflation, as rising CPI encourages households to invest in real estate to preserve purchasing power. In contrast, negative LCPI shocks, such as deflation, are statistically insignificant ($p = 0.144$), suggesting they do not meaningfully depress house prices, consistent with downward price rigidity.

Regarding mortgage interest rates, the estimated coefficients highlight significant long-run asymmetry with a one-quarter lag. Negative interest rate changes are associated with a statistically significant increase in house prices (coef. = 0.181, $p = 0.003$), in line with Iacoviello (2002) and Agnello and Schuknecht (2011), who identified low interest rates as a key factor contributing to housing price growth. In contrast, positive interest rate changes (rate hikes) are linked to a statistically significant decrease in house prices (coef. = −0.201, $p = 0.010$), indicating that higher mortgage rates tend to dampen housing demand. This finding is consistent with Iacoviello (2002), who reported that rising interest rates tend to depress real house prices, although the magnitude of these effects may vary across countries depending on financial and housing market structures.

The short-run estimates confirm the presence of short-run effects (Table 7). Notably, the error correction term COINTEQ* = −0.111 is negative and statistically significant ($p = 0.000$), validating the existence of a stable long-run relationship. Its magnitude indicates that approximately 11% of the deviation from the long-run equilibrium is corrected each quarter. This reflects a relatively moderate speed of adjustment, implying that house prices gradually converge toward their long-run path following short-run disturbances.

Asymmetric effects are clearly evident across the macroeconomic variables. Starting with GDP per capita, positive shocks exert a statistically significant ($p = 0.000$) and positive effect with the coefficient of 0.433, indicating that a 1% increase in GDP per capita leads to an

Table 7. Short-run asymmetric NARDL results with a structural break

Variable	Coefficient	Std. error	*t*-statistic	*p*-value
COINTEQ*	−0.111***	0.008	−14.222	0.000
ΔLGDPPC_POS	0.433***	0.094	4.612	0.000
ΔLGDPPC_NEG	0.008	0.050	0.161	0.872
ΔLCPI_POS	−0.141	0.106	−1.322	0.191
ΔLCPI_POS(−1)	−0.512***	0.110	−4.642	0.000
ΔINTER_POS	−0.032**	0.011	−2.881	0.005
ΔINTER_POS(−1)	−0.013	0.011	−1.163	0.249
ΔINTER_POS(−2)	−0.027**	0.011	−2.439	0.017
ΔINTER_POS(−3)	−0.024**	0.010	−2.287	0.025
ΔINTER_NEG	0.021**	0.010	2.192	0.032
ΔINTER_NEG(−1)	−0.021**	0.009	−2.187	0.032
ΔLRHPI	−0.006**	0.002	−2.619	0.011
Constant (c)	0.376***	0.027	14.074	0.000

Note(s): Model fit: R^2 = 0.826, Adj. R^2 = 0.793, S.E. = 0.00835, AIC = −6.581, DW = 2.225. COINTEQ* is the error correction term (speed of adjustment). "POS/NEG" = positive/negative partial sums (asymmetric decomposition). *, **, and *** denote rejection at the 10%, 5%, and 1% level, respectively

Source(s): Authors' calculations; created by authors

approximate 0.43% rise in real house prices. In contrast, negative LGDP shocks have no significant impact on house prices ($p = 0.872$), suggesting that during economic downturns, house prices tend not to decline proportionally, which is consistent with the notion of downward price rigidity. These findings are in line with Adams and Füss (2010), who argue that sellers are often reluctant to accept lower prices in recessions, delaying market adjustment.

Turning to inflation, the results also indicate an asymmetric lagged effect. Contemporaneous positive LCPI shocks do not significantly influence house prices (coef. – 0.141, $p = 0.191$). However, a one-quarter lag in positive LCPI changes exerts a strong negative effect on house prices (coef. – 0.512, $p = 0.000$), indicating that a 1% increase leads to a 0.51% decline. This delayed response suggests that inflationary pressures affect the housing market with a lag, likely due to expectations, reduced purchasing power, or tighter financial conditions. In the short run, negative changes in LCPI do not appear statistically significant for house prices.

A clear asymmetry is also demonstrated in the case of mortgage interest rates. Specifically, a 1% increase in interest rates reduces real house prices by approximately 0.32% (coef. = – 0.032, $p = 0.005$). By contrast, a 1% decrease in interest rates has a smaller contemporaneous impact, with a coefficient of 0.021 ($p = 0.032$), corresponding to an increase of only 0.21% in house prices. Moreover, the lagged effects show that positive interest rate changes remain statistically significant in the second and third quarters, whereas a negative change is significant in the first quarter, providing further evidence of short-run asymmetry in the housing market's response to interest rate movements.

In summary, the empirical findings indicate that Greece's housing market responds more strongly to favorable than to adverse macroeconomic shocks in both the long and short run. This effect is mainly observed in periods of expansion, suggesting that linear models may misrepresent market dynamics by underestimating price growth during booms and overstating the impact of restrictive policies.

In the next step, to assess the robustness and the reliability of the empirical findings, a comprehensive set of diagnostic and specification tests is employed. These include the Wald tests to evaluate long- and short-run asymmetries within the NARDL framework, the Jarque–Bera test for testing residual normality (Jarque and Bera, 1987), the LM test for detecting serial correlation (Breusch and Paqan, 1979), the Breusch–Pagan–Godfrey test for heteroscedasticity, the Ramsey RESET test for functional form misspecification (Ramsey, 1969), and the CUSUM and CUSUM of Squares tests for parameter stability over time (Brown *et al.*, 1975).

The Wald tests are employed to examine the joint significance of the long-run and short-run asymmetric coefficients separately. The corresponding null hypotheses of symmetry are formally specified below and denoted as Equations (3) and (4):

$$Long - run\, symmetry : H_0 : \beta_\kappa^+ = \beta_\kappa^- \tag{3}$$

$$Short - run\, symmetry : H_0 : \sum_{I=0}^{P-1} \gamma_{\kappa,t}^+ = \sum_{I=0}^{P-1} \gamma_{\kappa,t}^- \tag{4}$$

where the superscripts (+) and (−) denote positive and negative changes, respectively, and k refers to each explanatory variable. Rejection of the null hypothesis of symmetry occurs when the computed F-statistic for the Wald test exceeds the corresponding critical value at the 1%, 5%, or 10% significance levels, or equivalently, when the *p*-value falls below the selected threshold (Shin *et al.*, 2014).

In this study, Wald tests within the NARDL framework are used to assess long-run and short-run asymmetries between macroeconomic fundamentals and real house prices (Table 8). The null hypothesis of coefficient equality between positive and negative changes was rejected in most cases. In particular, the results provide strong evidence of long-run asymmetry for both

Table 8. Diagnostic tests

Test	Null hypothesis	Wald statistic (F)	*p*-value
W–LGDPPC	No long-run asymmetry	0.052	0.821
W–LCPI	No long-run asymmetry	32.520	0.000
W–INTER	No long-run asymmetry	41.890	0.000
W–ΔLGDPPC	No short-run asymmetry	5.740	0.020
W–ΔLCPI	No short-run asymmetry	5.780	0.019
W–ΔINTER	No short-run asymmetry	10.510	0.002

Test	Null hypothesis	Statistic	*p*-value
Jarque-Bera	Normality of residuals	0.079	0.961
LM (Breusch–Godfrey)	No serial correlation in residuals	0.105	0.363
Breusch-Pagan-Godfrey	Homoscedasticity of residuals	28.436	0.056
Ramsey reset	The model is correctly specified	1.999	0.163
Durbin–Watson	Test for autocorrelation	2.014	

Note(s): Centered VIFs (NARDL regressors) range 1.75–4.21 (max 4.21), no material multicollinearity
Source(s): Authors' calculations; created by authors

the LCPI and INTER ($p < 0.001$), supporting the appropriateness of the nonlinear model specification for capturing these relationships. In contrast, the null hypothesis cannot be rejected for LGDPPC ($p = 0.821$), suggesting no evidence of long-run asymmetry. Regarding the short-run dynamics, the Wald tests revealed statistically significant asymmetries across all macroeconomic variables, indicating that house prices respond asymmetrically to macroeconomic shocks in the short run.

The normality of the residuals is evaluated using the Jarque–Bera test, which yielded a JB statistic of 0.079 and a *p*-value of 0.961, supporting the hypothesis of normality. Serial correlation is tested using the Breusch–Godfrey LM test, with results showing no evidence of serial correlation up to four lags (LM F-statistic = 0.105, $p = 0.363$). Additionally, the Durbin–Watson statistic (2.014) corroborates the absence of autocorrelation, which is a key requirement for the validity of the NARDL model.

Regarding heteroscedasticity, the Breusch–Pagan–Godfrey test indicates homoscedastic residuals, as the test statistic (28.436) yields a *p*-value of 0.056.

The Ramsey RESET test ($F = 1.999$, $p = 0.163$) suggests that the NARDL specification is correctly specified, providing no evidence that relevant nonlinear functional forms have been omitted.

Finally, parameter stability is examined using the CUSUM (Figure 1) and CUSUM of Squares (Figure 2) tests. The CUSUM test indicates that the cumulative sum of recursive residuals remained within the 95% confidence bands over the entire sample period, providing evidence of parameter stability. Similarly, the CUSUM of Squares test shows that the squared recursive residuals stay well within the critical bounds, indicating the absence of structural instability or variance shifts.

Overall, the diagnostic tests confirm that the functional form and the specification of the NARDL model are robust and well-suited to capturing the dynamic behavior of house prices in response to macroeconomic shocks. The findings thus validate the adoption of a nonlinear ARDL specification. In contrast, traditional linear models that impose symmetry would likely fail to uncover the asymmetric macroeconomic transmission mechanisms that characterize the Greek housing market, underscoring the importance of accounting for asymmetries in both short- and long-run dynamics.

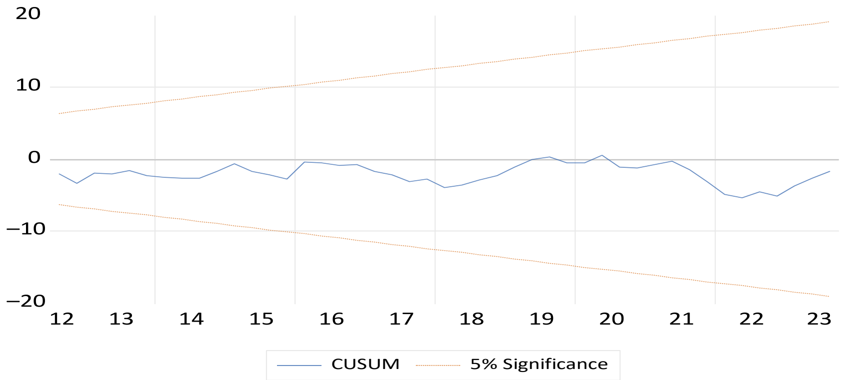

Figure 1. CUSUM: Plot of the cumulative sum of the recursive residuals. Note: The straight lines represent the critical bounds at the 5% significance level. **Source(s):** Authors' calculations; created by authors

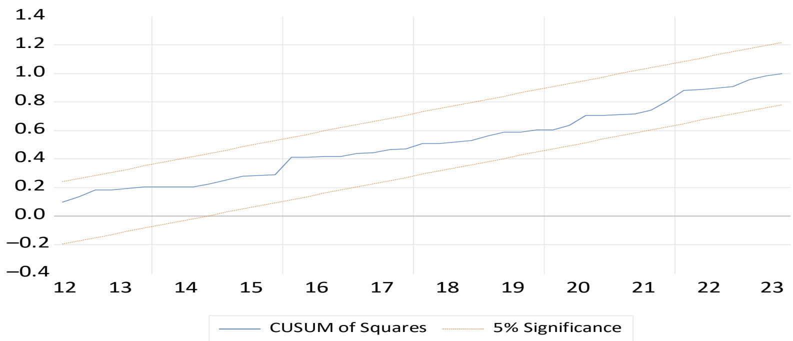

Figure 2. CUSUM of squares: Plot of the cumulative sum of squares of the recursive residuals. Note: The straight lines represent the critical bounds at the 5% significance level. **Source(s):** Authors' calculations; created by authors

5. Conclusion

Within the euro area, Greece should be viewed as a crisis-affected case marked not only by the repercussions of the 2008 global financial crisis, but also by a prolonged sovereign debt crisis that required successive financial assistance programs involving the European Commission, the European Central Bank, and the International Monetary Fund. Against this background, the present study applies a methodologically robust NARDL framework to examine asymmetric short- and long-run housing-market dynamics in an economy exposed to severe and persistent macro-financial stress, using an extended sample that explicitly incorporates structural breaks.

The bounds test supports cointegration, and the error-correction term is negative and statistically significant, indicating convergence toward the long-run equilibrium at a moderate pace. Overall, the results document a nonlinear and asymmetric transmission mechanism from macroeconomic variables to real house prices, with a clear differentiation between short-run and long-run effects. In the long run, asymmetry is mainly detected through the inflation and interest-rate channels, whereas in the short run it is statistically significant across all three channels, with interest-rate increases exerting a stronger and more persistent negative effect than the comparatively less durable response associated with rate cuts.

The findings are consistent with the relevant literature on asymmetric adjustment and evidence of downward price rigidity in housing markets (Leamer, 2007; Adams and Füss, 2010; Katrakilidis and Trachanas, 2012), and they align with the role of housing as a long-run hedge against inflation (Anari and Kolari, 2002; Inglesi-Lotz and Gupta, 2013) and broader economic uncertainty (Christou *et al.*, 2018). Moreover, they reflect the longstanding and deeply embedded preference for real estate investment within the Greek economy (Hardouvelis, 2009). Finally, the diagnostic tests confirm the adequacy of the model specification as indicated by residual normality, absence of serial correlation, and no indication of misspecification. Although the heteroscedasticity results are borderline, they do not provide strong evidence of a violation at conventional significance levels, thereby reinforcing the robustness of the conclusions regarding asymmetric housing market dynamics in Greece.

The study provides clear and actionable guidance for policymakers by underscoring the central role of housing in household welfare and income formation. Beyond macroeconomic fundamentals, the active use of targeted macroprudential instruments, such as Loan-to-Value (LTV) and Debt-to-Income (DTI) limits, which shape households' borrowing capacity and access to credit, is required to contain systemic risks in housing markets exhibiting nonlinear behavior (Crowe *et al.*, 2011). Given asymmetric shock transmission, risk mitigation should be front-loaded during boom phases, while supervision and stress testing should explicitly incorporate asymmetric macroeconomic scenarios, with particular emphasis on interest rates, where tightening effects appear stronger and more persistent than easing effects. In addition, the Greek experience suggests that demand-support instruments, such as the Golden Visa and the "My Home" program, should be designed in line with housing-supply conditions. In practice, this means linking such measures to local housing availability and complementing them with actions that expand effective supply, such as easing permitting delays, mobilizing vacant housing stock, and supporting new housing provision in high-demand areas. Otherwise, when supply responds slowly, stronger demand is more likely to raise house prices than to improve access to housing (Iqbal *et al.*, 2023).

Accordingly, such measures should be accompanied by explicit safeguards against speculative pressures and calibrated to improve access without fueling overheating dynamics.

In sum, this study documents that the Greek housing market is governed by stable long-run equilibria, while the transmission of macroeconomic shocks is inherently nonlinear and asymmetric, particularly in the short run. These findings highlight the importance of nonlinear modeling for both economic analysis and policy design. Moreover, they provide a foundation for future research on regional disparities, household debt, and the interaction between housing policies and demographic dynamics. Although the empirical estimates are specific to Greece, the framework employed here, NARDL with structural breaks and formal asymmetry testing, may also be useful for analyzing similar housing-market adjustment mechanisms in other euro-area peripheral economies that experienced sovereign-debt, housing-market, and banking-system stress, such as Portugal, Spain, or Ireland.

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