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# Working Paper

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JUNE 2026

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ISSN: 2654-1912 (online)  
DOI: <https://doi.org/10.52903/wp2026365>

# MODELLING HOUSE PRICE DYNAMICS IN GREECE

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## ABSTRACT

This paper studies the long-run dynamics of real house prices in Greece and their structural drivers. We develop a Bayesian VAR model with time-varying unconditional means that allows to decompose real house prices into a slow-moving structural trend and a transitory cyclical component. The proposed empirical framework accounts for structural changes in the housing market and episodes of heightened macroeconomic volatility. Applied to Greece over 2002-2025, it identifies a pronounced and persistent upward shift in the long run house price trend from 2017 onward. Historical decomposition of the structural shocks attributes this shift mainly to self-reinforcing house price dynamics, but also to the joint effect of strong demand and constrained supply in the housing market. Allowing for time variation in the long run equilibrium of house prices yields a more appropriate assessment of potential housing market imbalances compared with a constant steady state benchmark.

**Keywords:** House prices; Bayesian methods; time-varying trend; structural shocks; Greece; housing market

**JEL classification:** C11; C32; E32; R21; R31

**Disclaimer:** The views expressed are those of the authors and do not necessarily reflect those of their respective institutions. The usual caveat applies.

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# 1 Introduction

The evolution and drivers of house prices are central to the assessment of macroeconomic and financial stability. Identifying imbalances in the housing sector is critical, as house prices influence household and bank balance sheets, while they can also shape the transmission of monetary policy through wealth and collateral channels, thereby affecting private consumption, credit growth, and economic activity. However, rapid house price growth does not, per se, signal mispricing in the housing market (Himmelberg et al., 2005). Overvaluation arises when prices deviate persistently from levels justified by their long-run fundamentals (Stiglitz, 1990). In this regard, disentangling the trend from the cyclical component of house prices can enable policymakers to separate persistent structural movements from temporary fluctuations. This distinction is crucial for assessing underlying structural imbalances in the housing market and designing policy responses that are both timely and appropriate.

In this paper, we develop a novel econometric framework that explicitly decomposes real house prices into time-varying trend and cyclical components, and identifies the structural drivers of the trend component. Our primary contribution is methodological given that the relevant empirical literature remains incomplete in several respects. More specifically, we employ a vector autoregression (VAR) model with time-varying unconditional means, which allows for the efficient decomposition of the endogenous variables into non-stationary (trend) and stationary (cyclical) components (Louzis, 2019, 2026). The proposed model is estimated using the recent advancements in band matrix algorithms, enabling the inclusion of a relatively large number of variables that is an essential feature in our analysis. In addition, Bayesian shrinkage techniques are applied to improve the filtering process, resulting in more accurate and less biased estimates of the trend component, which is critical for assessing potential house price overvaluation dynamics. Furthermore, we incorporate in

the model stochastic volatility and Student’s t-distributed errors. Recent evidence suggests that neglecting time-varying macroeconomic volatility and extreme observations—such as those observed during the COVID-19 period—can lead to biased parameter estimates in VAR models (Bobeica & Hartwig, 2023). While a large literature studies the determinants of house price fluctuations, to the best of our knowledge, the explicit empirical separation of the long run trend and cycle of house prices, coupled with a structural interpretation of the time-varying trend, has not been the primary focus of existing work.

We apply this empirical modelling approach to the Greek housing market, which offers a compelling case for assessing house price dynamics. Over the past two decades, the Greek economy has experienced pronounced structural breaks, macroeconomic volatility and institutional transformations. Unlike other advanced economies that experienced relatively smooth housing cycles, Greece underwent an extraordinary boom–bust episode during the sovereign debt crisis, with house prices rising steadily prior to 2008, collapsing sharply during the prolonged recession, and recovering thereafter. This adjustment occurred amidst credit contraction, austerity-driven income falls, high unemployment, and significant tax and regulatory changes, affecting property ownership. Moreover, the Greek housing market is generally characterised by high homeownership rates, a historically limited rental sector, while before the crisis, the banking system was largely exposed to the real estate sector.

More recently, the housing market has faced new supply-side pressures: the energy crisis in 2022 triggered by the Russia-Ukraine war significantly increased construction costs. In Greece, where new construction had already collapsed during the debt crisis and residential investment remained subdued for years, these cost pressures contributed to renewed upward pressure on house prices. Additional demand-related factors, such as foreign investment inflows, the Golden Visa programme and the expansion of short-term rental platforms on account of post-pandemic demand shifts in tourism services, have boosted domestic and foreign demand for housing. The coexistence of demand-side positive shocks and supply-

side constraints makes the Greek housing market an empirically rich and policy-relevant case.

This paper contributes to the empirical literature on the macroeconomic determinants of house prices and to the growing body of work on housing market overvaluation (Muellbauer, 2012; Álvarez-Román & García-Posada, 2021; Panagiotidis & Printzis, 2016). First, it relates to the research on the cyclical determinants of house prices (Assenmacher-Wesche & Gerlach, 2008; Iacoviello, 2000). While recent studies emphasise the role of monetary shocks (Nocera & Roma, 2017) and housing demand shocks (Battistini & Gareis, 2025) in shaping real house price growth, we focus on the structural drivers of the long run trend of house prices. Second, we build on the housing market overvaluation literature that utilises cointegration and VECM models to assess the long run trend of house prices (Muellbauer, 2012; Philipponnet & Turrini, 2017; Geng, 2018). Our approach complements these works by allowing for time variation in the long-run equilibrium of house prices, rather than assuming a constant trend.

Finally, we add to the empirical evidence on the Greek economy. Existing studies mainly through estimating VECM models have identified output growth, mortgage credit, and construction costs as key drivers of house prices (Apergis & Rezitis, 2003; Brissimis & Vlassopoulos, 2009; Gounopoulos et al., 2012). Recent work by Panagiotidis & Printzis (2016) confirms that while certain fundamentals drive long-run trends, shocks lead to persistent short-run deviations of house prices from equilibrium. We move beyond these standard VECM frameworks by explicitly modelling the structural forces shaping the time-varying trend in an economy that has undergone extreme macro-financial stress and subsequent transformation in the housing market.

The main findings that stand out are as follows. First, by allowing the long run house price trend to vary over time, our empirical framework provides a more appropriate benchmark for assessing house price misalignment. In particular, it shows that a constant steady

state model overstates post-pandemic deviations of actual house prices from their trend by treating structural shifts in house prices as cyclical overvaluation. By contrast, the time-varying framework suggests that there is a marked upward shift in the long run trend of Greek house prices since 2017 which has been driven by structural changes in the Greek housing market. The latter demonstrates that part of the recent rise in house prices is largely in line with changes in fundamentals and the new structural equilibrium of the Greek housing market. Second, the historical decomposition of the time-varying house price trend shows that its recent acceleration and subsequent stabilisation at a higher level reflect the combined interplay of house price persistence and structural forces, notably elevated construction costs, constrained building activity, improving credit and financial conditions, and the recovery of the Greek economy.

The remainder of the paper is structured as follows. Section 2 outlines a short review of the relevant empirical literature. Section 3 presents the empirical methodology and describes the data and the baseline specification. Section 4 reports the empirical estimates and provides a historical decomposition of the structural drivers of the time-varying house price trend in Greece. Section 5 concludes.

## **2 A review of the literature**

This paper relates to several strands of the literature. A large body of research examines the cyclical determinants of house prices, emphasising the role of monetary policy and credit conditions (Assenmacher-Wesche & Gerlach, 2008). Structural BVAR with stochastic search variable selection estimates for seven euro area countries suggests that monetary policy shocks compress real house prices, albeit with notable cross-country heterogeneity (Nocera & Roma, 2017). A historical decomposition analysis highlights the strong contribution of monetary shocks to real house price growth in the euro area. Other empirical

studies highlight the role of institutional investors' demand in amplifying the response of house prices in the euro area to financial conditions (Bandoni et al., 2025). Battistini & Gareis (2025) assess the fundamental drivers of house price cycles in the euro area using a structural BVAR model with sign and zero restrictions. Housing demand shocks were the leading driver of downturns in house prices in the euro area. The analysis stresses the growing importance of supply shocks, including energy price increases and pandemic-related disruptions, in shaping the post-2019 downturn in euro area house prices, along with a larger contribution of monetary policy tightening. Iacoviello (2000) underscores the importance of both demand (income, preferences) and supply (construction, housing supply) shocks for house price fluctuations, showing that house price cycles cannot be interpreted solely through demand or financial channels.

Empirical evidence on the trend component of house prices remains scarce. A strand of the empirical literature focuses on house price overvaluation by typically estimating long-run equilibrium relationships using cointegration or VECM models and interpreting deviations of observed real house prices as misalignments (see, among others, Muellbauer, 2012; Álvarez-Román & García-Posada, 2021; Philipponnet & Turrini, 2017; Claussen, 2013). Using a panel error correction model, Ott (2014) shows that the short-term dynamics of euro area house prices are driven by the autoregressive term (persistence), disposable income and mortgage loans, whereas interest rates have a small effect. The long-term house price equilibrium is mainly driven on the demand side by disposable income, interest rates, and mortgage loans, while on the supply side costs (mostly land) matter. In a panel of 20 OECD economies, Geng (2018) assesses house price valuation risks by estimating the fundamental drivers of long run house price trends, including institutional and structural factors. He concludes that more generous tax relief, stricter rent control, and below-average long-run supply responsiveness drive up house prices. Our empirical approach complements and extends these works by embedding the trend-cycle decomposition within a structural

framework that allows for time variation in the trend and for a historical decomposition of its drivers.

In the case of Greece, empirical studies confirm that house prices have been driven by macroeconomic fundamentals, financial conditions and institutional changes (Apergis & Rezitis, 2003; Brissimis & Vlassopoulos, 2009; Katrakilidis & Trachanas, 2012; Panagiotidis & Printzis, 2016; Bragoudakis, 2024). From an empirical perspective, most studies rely on VECM models to assess long run equilibrium relations between house prices and fundamentals as well as short run deviations. Panagiotidis & Printzis (2016) find that retail activity and mortgage loans are leading long run determinants of house prices in Greece. Mortgage loans also have the strongest explanatory power for short run deviations of house prices from equilibrium. The authors document a slow error-correction process following shocks, which suggests the persistence of deviations from long run fundamentals. Brissimis & Vlassopoulos (2009) recognise the role of financial intermediation in affecting house prices over the period 1993Q4 to 2005Q2. They show a bidirectional relationship between mortgage credit expansion and increases in house prices prior to the global financial crisis. Rising house prices further stimulated credit growth through collateral effects. Credit expansion may generate short term price pressures that push house prices away from their long run equilibrium.

Gounopoulos et al. (2012) identify output growth, interest rates, inflation, and construction costs as key determinants of house prices in Greece. House prices respond to both demand-side macroeconomic conditions and supply-side factors, which implies that housing markets cannot be examined independently of broader economic conditions. The direction of causality is from the financial sector to the housing market, while following a shock, the adjustment to the long-run equilibrium is slow. By employing an ARDL cointegration model, Katrakilidis & Trachanas (2012) show that house prices respond asymmetrically to positive and negative shocks in selected macroeconomic fundamentals, such

as the consumer price index and industrial production. Their findings suggest downward rigidity and nonlinear adjustment in house prices.<sup>1</sup>

In this paper, we build on existing empirical evidence but move beyond the standard methodological frameworks by explicitly modelling a time-varying long run trend of house prices as well as the structural forces shaping its fluctuations over time. In doing so, we provide a unified perspective on housing market imbalances in an economy that has undergone structural transformations that may have affected the long run equilibrium of house prices.

### 3 Empirical methodology

This section outlines the econometric methodology alongside the variables employed in the baseline specification. We employ a vector autoregression (VAR) model that allows the unconditional mean of the process to vary over time, thereby capturing potential structural breaks in the steady-state of the system’s endogenous variables (Louzis, 2019, 2026). We also present the methodology for identifying the structural forces that drive the long-run trends of these variables, along with key details on prior elicitation.

#### 3.1 Econometric model

Let  $\mathbf{y}_t$  denote an  $n \times 1$  vector of endogenous variables. Then, the proposed VAR model with time-varying unconditional mean can be written as a multivariate Gaussian state-space model comprising a slow-moving non-stationary (trend) component,  $\boldsymbol{\tau}_t$ , and a stationary transitory component,  $\tilde{\mathbf{y}}_t$  (see also Fosso, 2025). In more detail, the full model employed

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<sup>1</sup>By using a VECM model over the 2000 to 2024 period, Bragoudakis (2024) examines whether house prices have departed from macroeconomic fundamentals. A cointegration long-run relationship is found between real house prices, real GDP, real interest rates for housing loans, real construction cost and the HICP. While the analysis suggests that the long-run trends of house prices are driven by fundamentals, short-run fluctuations are driven by cyclical shocks.

in this study is:

$$\mathbf{y}_t = \boldsymbol{\tau}_t + \tilde{\mathbf{y}}_t \tag{1}$$

$$\tilde{\mathbf{y}}_t = \mathbf{B}_1 \tilde{\mathbf{y}}_{t-1} + \dots + \mathbf{B}_p \tilde{\mathbf{y}}_{t-p} + \boldsymbol{\varepsilon}_t, \quad \boldsymbol{\varepsilon}_t \sim \mathcal{N}(\mathbf{0}, \lambda_t \exp(h_t) \boldsymbol{\Sigma}) \tag{2}$$

$$h_t = h_{t-1} + \eta_t, \quad \eta_t \sim \mathcal{N}(0, \kappa^2) \tag{3}$$

$$\lambda_t | \nu \sim \mathcal{IG}(\nu/2, \nu/2) \tag{4}$$

$$\boldsymbol{\tau}_t = \boldsymbol{\gamma} + \boldsymbol{\mu}_t \tag{5}$$

$$\boldsymbol{\mu}_t = \boldsymbol{\mu}_{t-1} + \mathbf{u}_t, \quad \mathbf{u}_t \sim \mathcal{N}(\mathbf{0}, \mathbf{Q}) \tag{6}$$

In the VAR equation (2)  $\mathbf{B}_1, \dots, \mathbf{B}_p$  are  $n \times n$  coefficient matrices and  $p$  is the lag order. The error term  $\boldsymbol{\varepsilon}_t$  is a Gaussian process with a covariance structure that incorporates common stochastic volatility (CSV) (see, e.g., Chan, 2020). The matrix  $\boldsymbol{\Sigma}$  is an  $n \times n$  covariance matrix, and  $h_t$  is a common log-volatility factor that evolves as a random walk in (3).

The latent variable  $\lambda_t$  follows an inverse-gamma distribution (4). This specification implies that, marginally (i.e., unconditional on  $\lambda_t$ ), the error term  $\boldsymbol{\varepsilon}_t$  follows a Student's  $t$ -distribution with  $\nu$  degrees of freedom. Consequently, the model jointly accounts for time-varying macroeconomic volatility through the CSV component and fat-tailed innovations via the  $t$ -distributed errors.

The unconditional mean of the process is actually the slow-moving trend component  $\boldsymbol{\tau}_t$  in (5). It consists of a time-invariant component,  $\boldsymbol{\gamma}$ , and a time-varying component,  $\boldsymbol{\mu}_t$ . The time-varying component  $\boldsymbol{\mu}_t$  follows a random walk process (6) with initial condition  $\boldsymbol{\mu}_0 = \mathbf{0}$  and Gaussian innovations  $\mathbf{u}_t$ . The covariance matrix  $\mathbf{Q}$  of  $\mathbf{u}_t$  is not necessarily diagonal, allowing for potential correlation among the innovations. We further assume that  $\mathbf{u}_t$  and  $\boldsymbol{\varepsilon}_t$  are orthogonal. This orthogonality condition permits a decomposition of  $\mathbf{y}_t$  into a stochastic trend,  $\boldsymbol{\tau}_t$ , and a stationary component,  $\tilde{\mathbf{y}}_t = \mathbf{y}_t - \boldsymbol{\tau}_t$  in (1) (Del Negro et al., 2017). Intuitively,  $\boldsymbol{\gamma}$  defines the average steady-state level, while  $\boldsymbol{\mu}_t$  captures the persistent

deviations from this level.

## 3.2 Model set-up: variables and priors

The vector of endogenous variables  $\mathbf{y}_t$  comprises seven macroeconomic variables for the Greek economy: real GDP, foreign direct investment in the housing sector, the volume of building permits, the real construction cost index, the stock of housing loans (total economy), interest rates on new housing loans, and the real house price index. For later reference and ease of presentation we define the variable vector as  $\mathbf{y}_t = (gdp_t, fdi_t, bp_t, cc_t, cr_t, lr_t, hp_t)'$  corresponding to the order listed. Consequently, each element of  $\boldsymbol{\tau}_t$  is defined as:

$$\tau_t^s = \gamma^s + \mu_t^s \tag{7}$$

where  $s \in \{gdp, fdi, bp, cc, cr, lr, hp\}$ .

All variables are transformed into annualised quarter-on-quarter logarithmic differences, except for the lending interest rate, which enters in levels. The house price index is seasonally adjusted using the Census X-13 method, and both the house price index and construction cost index are deflated using the seasonally adjusted HICP index. The sample covers the 23-year period from 2002:Q2 to 2025:Q2, and our model employs four lags ( $p = 4$ ).

The choice of variables aims to model the idiosyncratic features of the Greek housing market and is in line with the relevant empirical literature (see, among others, Ott, 2014; Geng, 2018). Demand-side dynamics are captured by foreign direct investment in the housing sector ( $fdi$ ), while supply-side adjustments are reflected in building permits ( $bp$ ) and construction costs ( $cc$ ). The interaction between demand and supply is mediated by credit conditions, represented by the stock of housing loans ( $cr$ ) and the corresponding lending rate ( $lr$ ). A strong positive correlation between credit cycles and housing cycles is also supported by the literature (see, e.g., Rünstler & Vlekke, 2018). Finally, real GDP

(*gdp*) controls for the overall state of the domestic economy, ensuring that housing market dynamics are identified conditional on the macroeconomic environment.

### 3.2.1 Priors

We estimate the model using Bayesian techniques, which requires specifying prior distributions for all parameters. We begin with the priors for the stationary VAR process defined in equations (2) to (4):

$$\boldsymbol{\beta}|\boldsymbol{\Sigma} \sim \mathcal{N}(\boldsymbol{\beta}_0, \boldsymbol{\Sigma} \otimes \mathbf{V}_B)I(\boldsymbol{\beta}) \quad (8)$$

$$\boldsymbol{\Sigma} \sim \mathcal{IW}(w_\varepsilon, (w_\varepsilon + n + 1)\underline{\boldsymbol{\Sigma}}) \quad (9)$$

$$\kappa^2 \sim \mathcal{IG}(\nu_{h0}, S_{h0}) \quad (10)$$

$$\nu \sim \mathcal{U}(a, b) \quad (11)$$

The priors for  $\boldsymbol{\beta} = \text{vec}(\mathbf{B}_1, \dots, \mathbf{B}_4)'$  and  $\boldsymbol{\Sigma}$  follow a normal-inverse-Wishart distribution, where  $\mathcal{IW}$  denotes the inverse Wishart distribution with  $w_\varepsilon$  degrees of freedom and mode  $\underline{\boldsymbol{\Sigma}}$ . The indicator function  $I(\boldsymbol{\beta})$  enforces the stationarity assumption by taking a value of one for stable systems and zero otherwise. The variance of the common volatility factor,  $\kappa^2$ , follows an inverse Gamma distribution ( $\mathcal{IG}$ ), while the degrees of freedom parameter  $\nu$  has a uniform prior.

We generally follow standard practices in the literature for prior elicitation (see, among others, Chan, 2020; Del Negro et al., 2017). Specifically, we set  $\boldsymbol{\beta} = \mathbf{0}$ , and formulate the  $\mathbf{V}_B$  matrix to resemble a Minnesota prior with an overall tightness hyperparameter of 0.2. For  $\boldsymbol{\Sigma}$ , we use an uninformative prior with  $w_\varepsilon = n + 3$  degrees of freedom—the minimum required for a well-defined mean. The scale matrix  $\underline{\boldsymbol{\Sigma}}$  is diagonal, with elements set to the mean squared residuals from a VAR(4) model, i.e.  $\underline{\boldsymbol{\Sigma}} = \text{diag}(\mathbf{s}_\varepsilon)$ , where  $\mathbf{s}_\varepsilon$  is the vector of

mean squared residuals.<sup>2</sup> Finally, we set  $\nu_{h0} = 5$ ,  $S_{h0} = 0.01$ ,  $a = 2$ , and  $b = 100$ .

Next, we specify the necessary priors for the slow-moving component,  $\boldsymbol{\tau}_t$ :

$$\mathbf{Q} \sim \mathcal{IW}(w_u, (w_u + n + 1)\underline{\mathbf{Q}}) \quad (12)$$

$$\boldsymbol{\gamma} \sim \mathcal{N}(\boldsymbol{\gamma}_0, \mathbf{V}_\gamma) \quad (13)$$

$$\boldsymbol{\mu}_0 \sim \mathcal{N}(\mathbf{0}, \mathbf{V}_{\mu_0}) \quad (14)$$

The choice of  $w_u$  and scale matrix  $\underline{\mathbf{Q}}$  in (12) critically influences the evolution of the time-varying component  $\boldsymbol{\mu}_t$ . To ensure that the trend component captures genuine shifts in the steady state rather than transitory business cycle fluctuations, the literature typically employs conservative priors with high  $w_u$  values and small diagonal elements in  $\underline{\mathbf{Q}}$ . This typically translates to expected trend changes of 0.5–1 percentage points per century for the US economy (e.g., Del Negro et al., 2017; Maffei-Faccioli, 2025).

We adopt a similar approach, setting an informative prior with  $w_u = 100$ . For GDP and lending rates, we use the standard conservative value of 1/400 for the diagonal elements of  $\underline{\mathbf{Q}}$ . For other variables, we incorporate sample information as in (9). Specifically, the  $j$ -th diagonal element of  $\underline{\mathbf{Q}}$ , denoted  $\underline{q}_j$  for  $j \notin \{\text{GDP, Lending rate}\}$ , is specified as:

$$\underline{q}_j = s_\varepsilon^j / \lambda \quad (15)$$

where  $s_\varepsilon^j$  is the  $j$ -th element of the mean squared residual vector  $\mathbf{s}_\varepsilon$ , and  $\lambda$  is a scaling factor that controls the smoothness of the trend component by determining the relative variance between trend and VAR residuals. Our baseline choice of  $\lambda = 200$ —making trend residuals 200 times less volatile than VAR residuals—ensures that the trend captures only persistent structural shifts rather than transitory fluctuations, consistent with its interpretation as a slow-moving economic steady state.

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<sup>2</sup>The VAR(4) model is estimated via ordinary least squares using the full sample.

In summary, our use of sample information in specifying the priors for  $\Sigma$  and  $\mathbf{Q}$  offers a flexible approach that accounts for both the differential volatility across variables and the specific features of the Greek economy. Moreover, this methodology proves especially beneficial for variables such as foreign direct investment and house prices, where the literature provides little guidance on their long-term trend behaviour.

Finally, for the time-invariant component  $\gamma$  and the initial value  $\mu_0$  we set  $\gamma_0 = (3, 10, 2, 2, 5, 4, 4)'$  (corresponding to the variable ordering in Section 3.2),  $\mathbf{V}\gamma = \mathbf{I}_n$  and  $\mathbf{V}_{\mu_0} = 10^{-3} \times \mathbf{I}_n$ .

### 3.3 Identification of structural shocks in trends

This section outlines the methodology for identifying the structural drivers underlying the slow-moving component  $\mu_t$ . We build upon the trend equations specified in (5) and (6) and follow the recent contribution of Maffei-Faccioli (2025) to identify structural shocks in these trend components.

We begin by expressing the reduced-form trend equations in (6) as:

$$\mu_t = \mu_0 + \sum_{j=0}^{t-1} \mathbf{u}_{t-j} \tag{16}$$

Equation (16) indicates that the evolution of the trend component depends on the cumulative effect of potentially correlated reduced-form shocks  $\mathbf{u}_t$ . As in the structural VAR literature, the covariance matrix  $\mathbf{Q}$  plays a crucial role in recovering orthogonal and economically meaningful shocks from the estimated residuals. In particular, we seek a non-singular mapping matrix  $\mathbf{A}$  such that  $\mathbf{u}_t = \mathbf{A}\epsilon_t$  and  $\mathbf{A}\mathbf{A}' = \mathbf{Q}$ , where  $\epsilon_t$  denotes normally distributed, independent structural shocks with unitary variance, i.e.  $\epsilon_t \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$ .

This allows us to express (16) in structural form as:

$$\boldsymbol{\mu}_t = \boldsymbol{\mu}_0 + \sum_{j=0}^{t-1} \mathbf{A}\boldsymbol{\epsilon}_{t-j} \quad (17)$$

The matrix  $\mathbf{A}$  captures the impact effects of structural shocks on  $\boldsymbol{\mu}_t$ , necessitating identification restrictions. We employ a zero contemporaneous restriction identification scheme via the Cholesky decomposition of the variance-covariance matrix  $\mathbf{Q}$ , such that  $\mathbf{P}\mathbf{P}' = \mathbf{Q}$ , where  $\mathbf{P}$  is a lower triangular matrix. This structure implies that the ordering of variables in  $\mathbf{y}_t$  is crucial for shock identification. Intuitively, variables ordered last have no contemporaneous effect on those ordered first.

In our analysis, we assume that house price shocks do not contemporaneously affect other variables in  $\mathbf{y}_t$ . Accordingly, we adopt the variable ordering presented in Section 3.2, with the house price variable ordered last.

## 4 Empirical results

We estimate the proposed model using the Markov Chain Monte Carlo (MCMC) algorithm proposed in Louzis (2026). All reported estimates are based on 5,000 posterior draws, obtained after a burn-in period of 25,000 draws and applying a thinning factor of 5 to mitigate autocorrelation.<sup>3</sup>

### 4.1 Estimates of house price trend in Greece

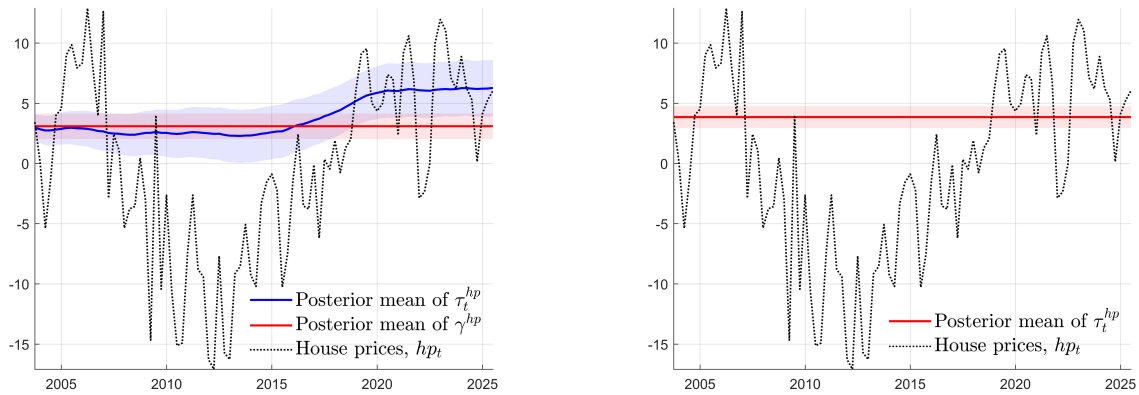
Figure 1 presents the estimation results for the slow-moving component  $\tau_t^{hp}$  (i.e. the trend) of real house price changes in Greece. The estimates in Figure 1a reveal that  $\tau_t^{hp}$  (blue line) evolves smoothly over time and exhibits substantially lower volatility than actual house prices ( $hp_t$ ) (black dotted line), consistent with theoretical expectations. Specifically,

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<sup>3</sup>This procedure entails generating 50,000 draws in total: the first 25,000 are discarded as burn-in, from the subsequent 25,000 draws, we retain every fifth draw, resulting in a final sample of 5,000 approximately independent draws for posterior analysis.

$\tau_t^{hp}$  fluctuates around 2.8% from the beginning of the sample period until 2016, gradually increases to 6.5%, and remains at this level from 2020 through the end of the sample (2025:Q2). These results indicate a substantial upward structural shift in the steady-state level of Greek house prices during the last decade.

The red line, representing the estimates of  $\gamma^{hp}$ , shows that the average level of house price returns is approximately 3.1% throughout the sample period. This value represents the constant unconditional mean that would be estimated without accounting for time variation in  $\mu_t$ . To demonstrate the empirical relevance of our proposed model, we also estimate a restricted version of the baseline model where  $\mu_t^{hp} = 0$  for all  $t$ . This restriction effectively reduces the model to a steady-state VAR with fat tails and common stochastic volatility (Louzis, 2019). As shown in Figure 1b, the restricted model yields estimates of  $\tau_t^{hp}$  close to 3.8%, which is statistically indistinguishable from 3.1% at the 95% confidence level. This comparison confirms that our proposed specification provides a consistent framework for analyzing potential deviations of actual house prices from both the average constant and the time-varying steady state level of house prices.



(a) Baseline model,  $\tau_t^{hp} = \gamma_t^{hp} + \mu_t^{hp}$

(b) Restricted model,  $\tau_t^{hp} = \gamma_t^{hp}$

Figure 1: Real house prices and estimated trends in Greece. Light blue and red shaded areas are the 68% confidence intervals for  $\tau_t^{hp}$  and  $\gamma_t^{hp}$ , respectively. The restricted model implies that  $\mu_t^{hp} = 0 \forall t$ . Annualised real house price changes are calculated as  $hp_t = 400 \times \log \left( \frac{HP_t}{HP_{t-1}} \right)$ , where  $HP_t$  is the deflated house price index in Greece.

Importantly, the empirical analysis suggests that relying solely on the estimates of a constant unconditional mean BVAR model (red line) can be misleading in terms of identifying a potential overvaluation of the Greek housing market, namely periods when actual house prices are higher than their long run trend implied by fundamentals. In particular, Figure 1 suggests that when comparing the time-invariant steady-state (red line) with the actual real house price growth, house prices in Greece have been growing above their long run trend broadly over the period prior to the global financial crisis (i.e. 2005 to 2008) and after the sovereign debt crisis (i.e. 2018 to 2024). From 2009 to 2017, actual house price growth stood below its time-invariant long run trend, indicating an undervalued housing market.

By contrast, accounting for a time-varying house price trend allows us to account for structural shifts that can affect the steady-state of real house prices. In this regard, the time-varying long run house price trend in Greece has actually been lower broadly over the period 2004-2016 and higher during 2017-2025 than that implied from a time-invariant steady-state VAR empirical setting. In effect, post-pandemic, real house prices have actually stood below their time-varying long run trend, apart from the second half of 2021 and during the years 2023-2024. In 2025, actual house price growth is lower compared to that implied by fundamentals.

Moreover, the size of the deviation of actual real house price growth from its trend matters in order to assess potential large imbalances in the housing market. Our time-varying modelling approach accounts for the fact that structural changes in the real estate market can affect the level of the long term trend. Such structural shifts in the housing market since 2017 seem to have moved upwards the house price long term trend compared to previous decades. Consequently, the potential deviation of actual real house price growth from trend is smaller than that implied from a constant steady-state VAR model.

## 4.2 Drivers of house price trend

In this Section, we present the empirical estimates of the structural drivers of the time-varying house price trend,  $\tau_t^{hp}$ , based on the methodology discussed in Section 3.3.

Figure 2 reports the posterior estimates of the slow-moving trend component,  $\tau_t$ , for all endogenous variables (dark blue line) in the model along with the 68 percent confidence interval and the observed values of these variables (dotted grey line). The results reveal substantial heterogeneity in the long run behaviour of the macroeconomic and housing market indicators, highlighting the importance of allowing for time variation in the unconditional mean. Across variables, the estimated trends exhibit significantly lower volatility than the corresponding observed series, confirming that the proposed specification successfully isolates persistent structural movements from short run cyclical dynamics.

More specifically, the trend in real GDP growth ( $\tau_t^{gdp}$ ) displays a gradual but persistent decline from the early 2000s until the aftermath of the sovereign debt crisis, followed by a modest recovery and subsequent stabilisation. This reflects the long recession but also the recovery of the Greek economy, which has underpinned improved housing market prospects. Moreover, the trend in foreign direct investment in the real estate sector ( $\tau_t^{fdi}$ ) is particularly noteworthy, as it remains subdued for most of the sample before rising sharply after 2017. This pronounced upward shift is consistent with the surge in foreign demand for Greek residential property, facilitated, among other factors, by residency-by-investment programmes, and suggests that higher investment demand from abroad has become an important structural driver of housing demand in Greece. This rise in housing demand post-pandemic is also observed in many advanced economies and is associated, among others, with a change in housing preferences amid telework schemes, but also an increased search-for-yield during an era of still low interest rates (Di Casola et al., 2022).

On the supply side, the trend in building permits ( $\tau_t^{bp}$ ) indicates a prolonged contraction

during 2008–2016, exceeding the depth of the observed cyclical decline in economic activity. This suggests a structural weakening of construction activity that only partially reverses after 2017. Meanwhile, the trend in real construction costs ( $\tau_t^{cc}$ ) follows a relatively stable path until 2017, after which it increases markedly, mainly reflecting cost-push pressures associated with global supply-chain disruptions, the energy crisis and domestic input-cost inflation.

Credit conditions also display distinct long run patterns. The trend in the stock of housing loans ( $\tau_t^{cr}$ ) decreases steadily during the deleveraging phase of 2015–2021 and begins to stabilise thereafter, though it remains well below the pre-crisis levels. The latter suggests that, while credit supply has normalised, it has not regained the central role it played in the pre-2008 expansion. By contrast, the trend of the lending rate on new housing loans ( $\tau_t^{lr}$ ) exhibits a persistent downward path until mid-2010s, showing a sharp upward correction thereafter. This pattern highlights a long period of accommodative financing conditions, driven largely by the low interest rate environment in the euro area, that likely supported housing demand.

Overall, assessing the long run patterns of these structural drivers offers early insights into how closely they align with the long run trend in house prices. As discussed in the previous Section, the trend in real house price growth displays a clear structural break. From 2004 to 2016, the trend remains low and relatively stable, consistent with a period of subdued underlying price dynamics. From 2017 onward, however, the trend rises sharply and stabilises at a level substantially above its pre-2016 values. This significant upward shift seems to be the combined effect of renewed domestic and foreign demand and tightened house supply conditions. The visual comparison of trends across variables underscores the interplay of these forces: on the one hand, demand and credit structural factors, such as rising FDI in the housing sector, low lending rates, modest credit growth and macroeconomic recovery, and on the other hand, supply-side constraints, such as weak construction

activity and elevated construction costs, have led to structurally higher house prices over the past decade.

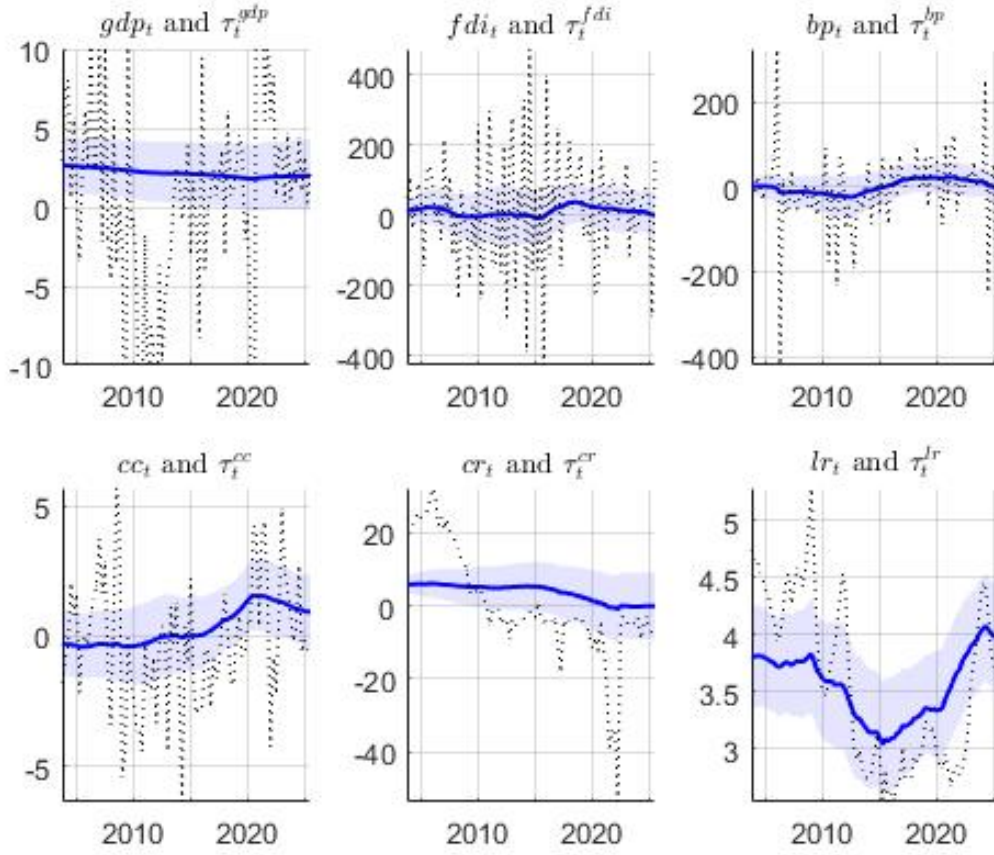
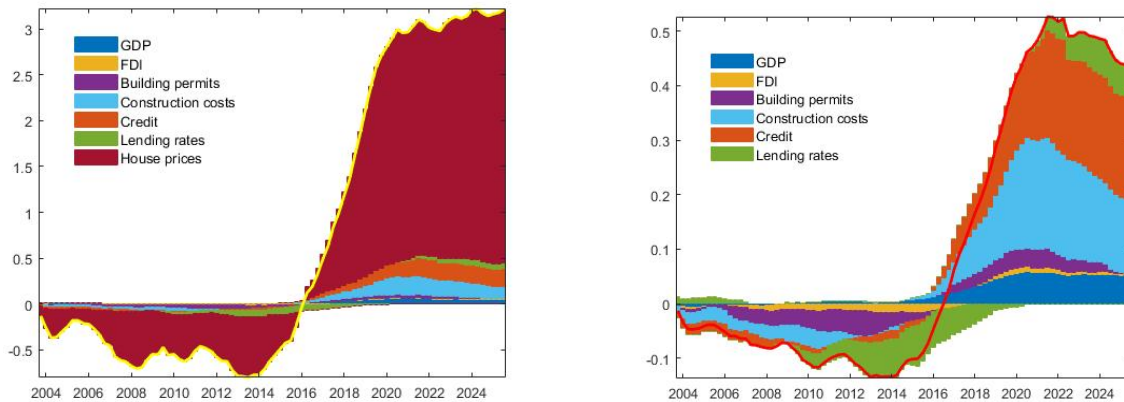


Figure 2: Endogenous variables and the corresponding estimates of their trends. All variables are annualised growth rates ( $x_t = 400 \times \log\left(\frac{X_t}{X_{t-1}}\right)$ , where  $X_t$  is the corresponding endogenous variable) except for lending rates,  $lr_t$ . Light blue shaded areas denote the 68% confidence intervals

Figure 3a decomposes the evolution of the trend component of real house price growth,  $\mu_t$ , into the contributions from the full set of structural shocks identified through the Cholesky factorisation of the trend covariance matrix, as discussed in Section 3.3. The estimates highlight the changing sources of long run house price dynamics in Greece and provide insight into the relative importance of demand, supply, and credit factors over time.

More specifically, the decomposition reveals that the persistence of house price shocks is a major driver of the house price trend in Greece. The contribution of house price shocks

is especially pronounced during the sharp rise of the house price trend observed after 2017, when it accounts for approximately 83 percent of the variation in the house price trend. This finding is in line with the euro area house price cycles (see Ott, 2014). In addition, no single shock is solely responsible for the large upward shift in the house price trend. Instead, the trend reflects the combined effect of several structural forces whose impacts become increasingly aligned in recent years.



(a) Shocks contribution to house price trend.

(b) Non-Housing shocks contribution

Figure 3: Structural shock contributions to Greek house price trends. The light yellow line in (a) shows the posterior mean of  $\mu_t^{hp}$ , while the red line in (b) represents the combined contribution of all structural shocks excluding the house price shock.

Figure 3b decomposes the contributions of all non-housing shocks and provides a clearer picture of the structural drivers behind the recent house price trend acceleration. Interestingly, the set of structural shocks that determines the time-varying house price trend appears to have become substantially different broadly after 2017.

Specifically, shocks in lending rates, partly reflecting the role of policy interest rates on residential property prices, seem to have the largest contribution to the decline in house price trend during the global financial crisis and the sovereign debt crisis. The role of monetary policy for house price cycles has also been corroborated in other empirical studies (see e.g. Nocera & Roma, 2017). Moreover, shocks in building permits exert a contractionary impact during the crisis years, underscoring the structural weakness of housing investment

activity and its contribution to the tightening of housing supply conditions.

By contrast, shocks originating from real construction costs and credit and to a lesser extent, domestic macroeconomic conditions appear to play a dominant role in the upward shift in the time-varying house price trend after 2017. Positive contributions from shocks in construction costs reflect persistent cost pressures from global supply disruptions, the 2022 energy crisis in Europe, geopolitical tensions and rising trade protectionism. Moreover, the gradual relaxation of credit constraints in Greece after 2018 and the long period of exceptionally low lending rates supported a favourable financing environment, amplifying the effects of both high domestic and foreign demand in the Greek housing market. That said, while the contribution of foreign investment shocks is smaller compared to other structural shocks, it is consistent with the strong post-2017 inflows into the Greek housing market.

Taken together, the evidence in Figure 3 indicates that the pronounced increase in the trend of real house price growth in Greece since 2017 is driven by both self-sustaining house price dynamics and underlying structural forces. The latter mainly include higher construction costs, constrained building permits and housing investment activity, gradually improving credit and financial conditions as well as domestic economic recovery.

## 5 Conclusions

This paper proposes a Bayesian VAR framework with time-varying unconditional means for the analysis of house price dynamics. Unlike standard VAR or cointegration-based approaches that typically evaluate house price misalignments relative to a fixed long-run equilibrium, the proposed empirical framework allows the steady state of house prices to vary over time and identifies its structural drivers. This distinction is central for assessing housing market imbalances, particularly in economies that have experienced structural

breaks, financial instability and major shifts in demand and supply housing conditions.

Taking the Greek housing market as a highly informative case, our empirical results show that the assessment of house price overvaluation depends critically on how the long-run equilibrium is modelled. For Greece, a constant steady state benchmark implies large deviations of actual house price growth from trend, notably in the post-pandemic era. By contrast, the time-varying framework shows that part of the recent rise in house prices is in line with changes in fundamentals and the structural equilibrium of the Greek housing market. In particular, from 2017 onwards, the house price trend has increased sharply and stabilised at a level well above its earlier historical average, implying smaller deviations of actual house price growth from its long run trend. The historical decomposition of the structural shocks of the house price trend indicates that this upward shift was mainly driven by self-reinforcing house price dynamics, but also by the joint effect of stronger demand and tighter housing supply conditions. Overall, the present analysis showcases that the strong house price growth observed in Greece in recent years is largely in line with the upward shift in the long run equilibrium of house prices, though the need for close monitoring of housing market risks remains imperative.

Our analysis has important policy implications. In economies undergoing large macro-financial and institutional transformations, empirical models that impose a fixed steady state for house prices may provide misleading signals of systemic risks. Macroprudential policy tools should therefore account for time variation in house price trend and its structural drivers, while remaining attentive to the possibility that persistent supply constraints and demand pressures in the housing market may generate vulnerabilities over the medium term.

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