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BUILDING ENERGY PERFORMANCE AND HOUSING MARKET REGIMES: EVIDENCE FROM EU COUNTRIES

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DOMINYKAS LINKEVIČIUS 
LAIMA OKUNEVIČIŪTĖ NEVERAUSKIENĖ 

ABSTRACT

In assessing developments in the real estate market, the energy efficiency of buildings is increasingly considered important from an environmental and economic perspectives. However, empirical evidence on the relationship between energy performance indicators and house price dynamics at the macro level remains mixed, suggesting that this relationship may vary across countries and contexts. This article examines whether and how building energy performance indicators are related to house price dynamics across European Union countries, focusing on short- and long-term relationships and cross-country heterogeneity. The study is based on panel data for 2010-2023, using house price indices as the dependent variable and several energy efficiency indicators, including final energy consumption in buildings and the share of renewable energy sources. Various econometric methods were applied, including panel cointegration analysis (FMOLS and DOLS), dynamic panel models (Arellano-Bond GMM), Granger causality tests, impulse-response analysis, quantile regression, threshold models, and exploratory country clustering. The results show that energy efficiency indicators are not strongly associated with house prices at the aggregate EU level, and their short-term effects are generally weak. Instead, the findings reveal significant heterogeneity across countries and income regimes, suggesting that the capitalisation of energy efficiency in house prices is highly context-dependent. By combining econometric analysis with exploratory segmentation approaches, the study helps structure heterogeneous energy housing interactions into distinct market environments relevant for investment and policy analysis. These results highlight the limitations of uniform macro-level approaches and underline the importance of differentiated market analysis.

KEY WORDS

energy efficiency, housing prices, panel analysis, market heterogeneity, energy-housing linkages

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Laima Okunevičiūtė Neverauskienė*
Vilnius Gediminas Technical University,
Saulėtekio eiv. 11, LT-10223, Vilnius, Lithuania
ORCID 0000-0002-7969-3254

Corresponding Author:
e-mail: laima.okuneviciute.neverauskiene@vilniustech.lt

Dominykas Linkevičius*
Vilnius Gediminas Technical University,
Saulėtekio eiv. 11, LT-10223, Vilnius, Lithuania
ORCID 0009-0001-4134-6425
e-mail: dominykas.linkevicius@vilniustech.lt

* Both authors are co-first authors

INTRODUCTION

Energy efficiency is one of the recent priorities for the sustainable development of the European Union (Okunevičiūtė Neverauskienė, 2025). Reducing energy consumption is directly linked to climate

change mitigation, reduced fossil fuel imports, and stronger energy independence (Bakhsh et al., 2024). This issue particularly affects the construction and energy sectors, as they account for more than a third of total energy consumption in the EU (González-Torres et al., 2022). Therefore, the European Green Deal includes retrofitting of buildings as one of its key

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measures to mitigate climate change (Ma et al., 2021). Energy consumption is not only an environmental issue, but also an economic and social one, as it directly affects household spending, energy security, and the sustainability of investments (Chen et al., 2024).

Energy efficiency is promoted by measures such as large-scale building renovation, energy performance certificates, and financial incentives for consumers choosing efficient solutions (Anarene, 2024). In recent years, the European Union has been strengthening legislation in this area, obliging Member States to introduce energy performance certificates and to move towards the nearly zero-energy building standard (Zangheri et al., 2021). These regulatory changes are increasingly affecting market behaviour as information on energy performance becomes an integral part of housing market transactions rather than just a formal requirement. Such measures and legislative changes alter market standards as consumers no longer evaluate only location, size, or infrastructure, but also the energy value of housing (Olasolo-Alonso et al., 2023).

The energy efficiency issue is not only environmental (Chen et al., 2024). It is increasingly linked to the financial sector, as energy-efficient buildings are the standard and are considered a more attractive investment due to lower operating costs and greater liquidity (Okunevičiūtė Neverauskienė et al., 2025). Therefore, energy efficiency is often discussed as a potential factor influencing housing prices and investment dynamics, especially in markets with developed credit systems and higher income levels. However, the extent to which energy efficiency is capitalised in housing prices may vary depending on broader macroeconomic and institutional conditions. Consequently, energy efficiency is becoming a strategic financial factor, affecting the energy, economic, and social sectors and shaping new and progressive standards (Durmus Senyapar, 2024).

More researchers are studying the relationship among energy efficiency, housing prices, and investment dynamics in different countries. However, comprehensive empirical research is still lacking to substantiate this link (Kholodilin, 2024). Existing studies provide mixed results, particularly in cross-country analyses, where estimated effects often differ in size, significance and even direction. Such discrepancies suggest that average correlations may mask fundamental structural differences between markets, and that the relationship between energy efficiency and housing prices may depend on the broader eco-

nomical and institutional context rather than follow a single uniform model.

This article aims to fill the existing gaps, including econometric models that analyse the lagged effects and assess the impact of energy efficiency indicators on real estate prices in the EU region (Baležentis et al., 2021). Rather than focusing solely on the average effect size, the article particularly centres on the stability and heterogeneity of the relationship between energy efficiency and housing price dynamics across countries. To support a more structured interpretation of these differences, the analysis incorporates cross-country segmentation as a complementary analytical perspective. Thus, it not only expands the academic discussion on the role of energy efficiency in the real estate market but also provides valuable insights for investors and policymakers making complex decisions. The novelty of the article lies in its systematic assessment of cross-country differences and the structural limitations of macro-level approaches, which helps to explain why empirical evidence in this area often remains inconclusive.

1. LITERATURE REVIEW

Changes in the real estate market are a complex phenomenon influenced by many fragile, interrelated components (Montvydaitė, 2024). Traditionally, the real estate market is influenced by various macroeconomic factors, demographic changes, and other economic and social trends (Stan, 2022; Ginevičius et al., 2025). However, in recent years, a newly emerging effect has also been observed due to changing legislation and requirements, i.e., environmental protection and energy efficiency (Wu & Tham, 2023). As energy-related regulations become more binding, energy efficiency indicators are increasingly incorporated into housing market assessments, and public expectations and standards are growing; therefore, energy efficiency indicators are becoming a significant component of the real estate market (Mugarra et al., 2025).

Macroeconomics is among the most critical aspects when analysing the real estate market (Okunevičiūtė Neverauskienė, Linkevičius et al., 2025a, 2025b). Higher incomes and employment are usually positively correlated with growth in energy-efficient housing, as residents who earn more tend to invest in long-term value and lower operating costs (Lee, 2023). Urbanisation also contributes to this

process, as growing cities and populations increase the demand for housing, and energy efficiency indicators are used as additional value points when looking for new housing (Ascione et al., 2024). Conversely, in regions with lower incomes, energy-efficiency methods can appear burdensome rather than beneficial, since renovation increases current costs and does not consider the future value of the housing (Özdemir & Koukoufikis, 2025). These differences suggest that the capitalisation of energy efficiency is highly context-dependent and unlikely to follow a uniform pattern across countries.

Real estate and financial markets are equally closely linked (Alqaralleh et al., 2023). Preferential interest rates, credit availability, and government subsidies determine the extent to which residents can become interested and afford to purchase energy-efficient housing (Carozzi et al., 2024). Sustainable financing options, such as green loans, further emphasise the relevance of this issue (Kwilinski et al., 2025). Thus, energy efficiency becomes an integral part of the real estate sector, and its integration into analyses enables the assessment and understanding of real estate price formation processes across different economic environments (Walacik & Chmielewska, 2024). Concurrently, these mechanisms imply that the observed impact of energy efficiency may depend on credit conditions and the institutional environment, rather than being universal.

The integration of energy efficiency into the housing assessment and investment decision-making processes is the most crucial development in recent years (Blomqvist et al., 2022). The energy efficiency certificate has become mandatory in Member States. It informs market participants about a building's energy consumption before they make any decision (Khazal & Sønstebo, 2023). Such information is not only a legal obligation, but also an element of market competition. Studies show that a high-energy class usually correlates with higher housing prices, and the sales period is significantly shorter than for other market objects (Taruttis & Weber, 2022). However, this evidence is largely based on micro-level or country-specific analysis and therefore has limited direct applicability to macro-level circumstances.

The emergence of energy efficiency criteria encourages the financial market to develop new products that link the real estate market to various sustainability aspects, such as green bonds, preferential renovation loans, and more favourable interest rates for energy-efficient buildings (Cara et al., 2025). The financial sector uses such products to signal that

energy efficiency is not only an essential environmental requirement but also an economic advantage (Zhang et al., 2024).

It is worth noting that research encounters issues, especially at the methodological level, as differences in countries' economic levels, regulatory systems, and consumer behaviours can affect the impact of energy efficiency on housing prices (Sun et al., 2022). It is also sometimes challenging to distinguish how much of the increase in housing prices is due to energy efficiency and other factors, such as population growth, geographical location, or simply the quality of construction (Galster & Lee, 2021; Cordeiro et al., 2023). As a result, estimates based on aggregated data may mask substantial heterogeneity and lead to inconclusive or contradictory conclusions.

As mentioned earlier, the importance of energy efficiency for the real estate market is acknowledged. However, there are still significant gaps in empirical research, which are limited to specific regions and are difficult to generalise in the broader European Union context. Similarly, some studies assess the direct link between energy efficiency and housing prices without considering the potential lagged effects of multiple other relevant factors (Farhaoui & Slimani, 2022; Wilhelmsson, 2023). This situation highlights the need for analytical approaches that explicitly address cross-country heterogeneity, dynamic adjustment processes, and market regimes when examining energy efficiency and housing price dynamics.

2. RESEARCH METHODS

This study's methodology is based on panel data analysis, which enables the assessment of short- and long-term relationships between energy efficiency and housing price dynamics in European Union countries. The data sample covers 2010-2023, and countries are selected based on their level of economic and social development, allowing for the identification of potential heterogeneity in effects across different economic contexts. The study uses data from Eurostat and national statistical offices.

The dependent variable is the house price index, denoted by Y_{it} , where i is the country and t represents the period. The primary independent variable is energy efficiency, measured by final energy consumption in the buildings sector, the structure of energy performance certificates, and the share of renewable energy sources. Control variables include GDP per

capita, unemployment rate, population density, interest rates, and average income.

First, stationarity tests are performed using the Im-Pesaran-Shin and Levin-Lin-Chu unit root tests. If the data are non-stationary, cointegration is assessed using Fisher-type panel cointegration tests based on the Engle-Granger framework. This step is necessary to ensure that the regression analysis is not misleading due to long-term non-stationary processes. Once cointegration is detected, the long-term relationship between the variables is assessed using the panel FMOLS (fully modified ordinary least squares) and DOLS (dynamic ordinary least squares) methods, which correct for endogeneity and autocorrelation problems. The form of the long-term model is written as follows (Formula 1):

$$Y_{it} = \alpha_i + \beta_1 EE_{it} + \beta_2 GDPpc_{it} + \beta_3 UNEMP_{it} + \beta_4 DENS_{it} + \beta_5 IR_{it} + \beta_6 INC_{it} + u_{it} \quad (1)$$

Where α_i denotes individual country effects, and u_{it} is the error term. This model enables the identification of the extent to which energy efficiency indicators are related to housing prices in the long run.

To analyse the short-term impact, a dynamic panel model with a lagged dependent variable is applied, which allows capturing the inertia of housing prices (Formula 2):

$$Y_{it} = \alpha_i + \rho Y_{i,t-1} + \beta_1 EE_{it} + \beta_2 GDPpc_{it} + \beta_3 UNEMP_{it} + \beta_4 DENS_{it} + \beta_5 IR_{it} + \beta_6 INC_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

The parameter ρ reflects the inertia in housing prices, and the model is estimated using the Arellano-Bond GMM estimator, which addresses endogeneity in dynamic panels.

To verify the direction of the relationships, Granger causality tests are additionally performed in a panel context, the logical form of which is as follows (Formulas 3 and 4):

$$Y_{it} = \sum_{k=1}^p \alpha_k Y_{i,t-k} + \sum_{k=1}^p \gamma_k EE_{i,t-k} + \varepsilon_{it} \quad (3)$$

$$EE_{it} = \sum_{k=1}^p \phi_k EE_{i,t-k} + \sum_{k=1}^p \theta_k Y_{i,t-k} + v_{it} \quad (4)$$

These models allow for testing whether energy efficiency drives changes in housing prices, or vice versa - higher housing prices encourage greater investments in energy conservation.

Dynamic relationships are also investigated using local projection methods in a panel setting, which allow tracing impulse-response functions without imposing the full structure of a panel VAR. This approach is particularly suitable in heterogeneous panels and enables the assessment of how an energy consumption shock affects housing prices over multiple horizons.

To assess differences in impact between different market segments, quantile regression is applied in a panel context. It allows testing whether the effects of energy efficiency are uniform across the entire distribution of housing prices or are more substantial only in the cheaper or more expensive segments. The model is written as follows (Formula 5):

$$Q_\tau(Y_{it}|X_{it}) = \alpha_\tau + \beta_\tau EE_{it} + \gamma_\tau Z_{it} \quad (5)$$

Where $Q_\tau(Y_{it}|X_{it})$ denotes the conditional quantile function at quantile τ , X_{it} is the primary variable, and Z_{it} are the controls.

In addition, to assess possible marginal effects, Hansen panel threshold models are used to test whether the impact of energy efficiency on housing prices changes when a country's GDP per capita or population density reaches a certain threshold.

Additional robustness tests are performed: the Breusch-Pagan heteroscedasticity test, the Wooldridge autocorrelation test, and a multicollinearity check using the VIF indicator. Finally, countries are grouped using a cluster analysis based on Euclidean distance to identify more homogeneous groups based on energy efficiency and housing market indicators. Finally, countries are grouped using cluster analysis based on Euclidean distance as an exploratory tool to structure cross-country heterogeneity in energy efficiency and housing market characteristics, rather than to infer causal relationships.

3. RESEARCH RESULTS

In 2011-2023, a clear trajectory of house price (HPI) growth was recorded after 2014 in all countries: it was the most pronounced in Poland and Germany, and the slowest in Italy. Temporary "pit-rebound" episodes in the early years, followed by accelerating growth later, indicate a strong trend and characteristic I(1) behaviour in the levels. These facts are essential for further tests and models: they explain why simple level comparisons are misleading, and panel tests and dynamic specifications are necessary (Fig. 1). Importantly, the acceleration after 2016 varies

considerably across countries, reflecting the heterogeneous dynamic and distributional effects identified in later sections.

The dynamics of final energy consumption in households (by fuel) in most countries are moderately decreasing, but with short-term spikes (especially in Germany and Poland), which reflect both price/climate and policy effects. There is no precise movement with the HPI here, so it would be a mistake to conclude from flat correlations alone (Fig. 2). This weak

visual association encourages the use of dynamic and nonlinear methods rather than static correlation-based inference.

The share of renewables is consistently growing in all countries, with the sharpest increases in Sweden and Spain. This structural trend is essential for interpretation: growing “green” energy can operate through price, income, or expectation channels, but does not necessarily explain changes in the housing price by itself if other macro factors change at the

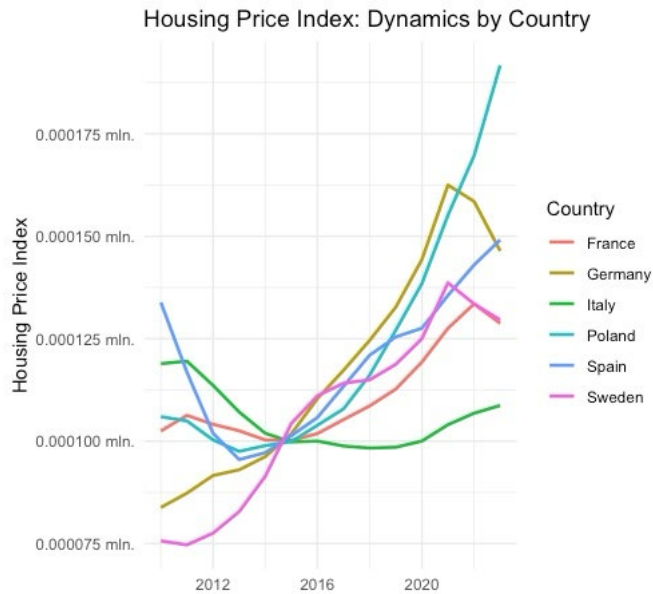


Fig. 1. Housing Price Index: dynamics by country

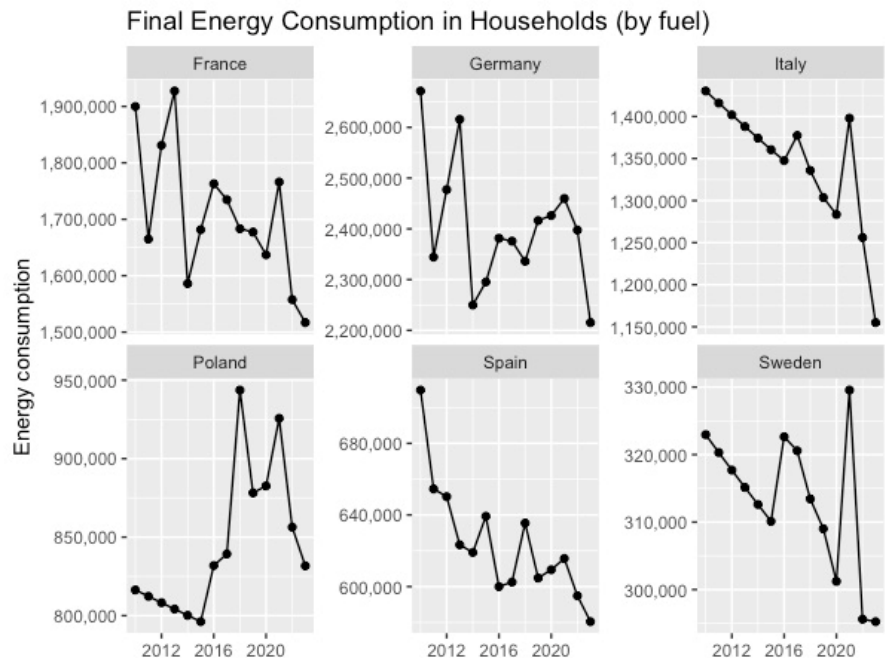


Fig. 2. Final energy consumption in households (by fuel)

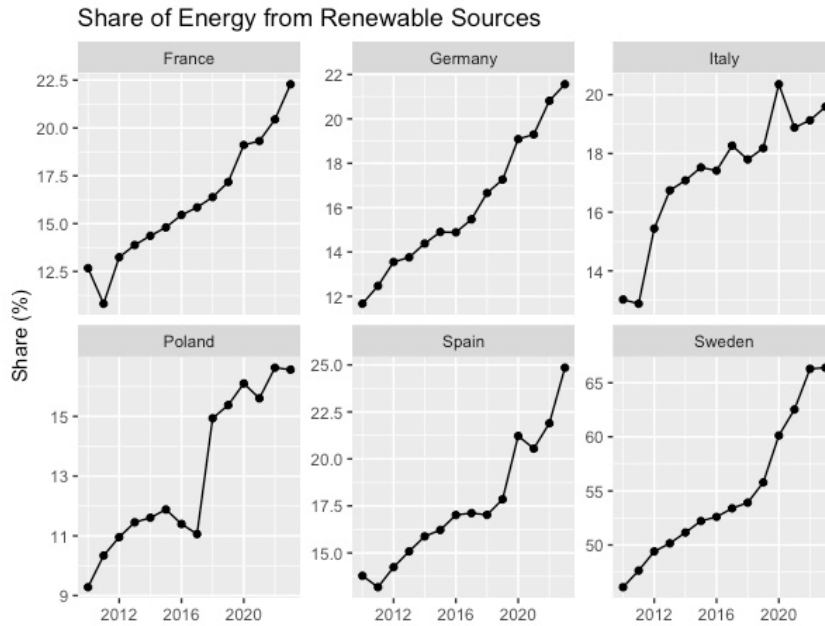


Fig. 3. Share of energy from renewable sources

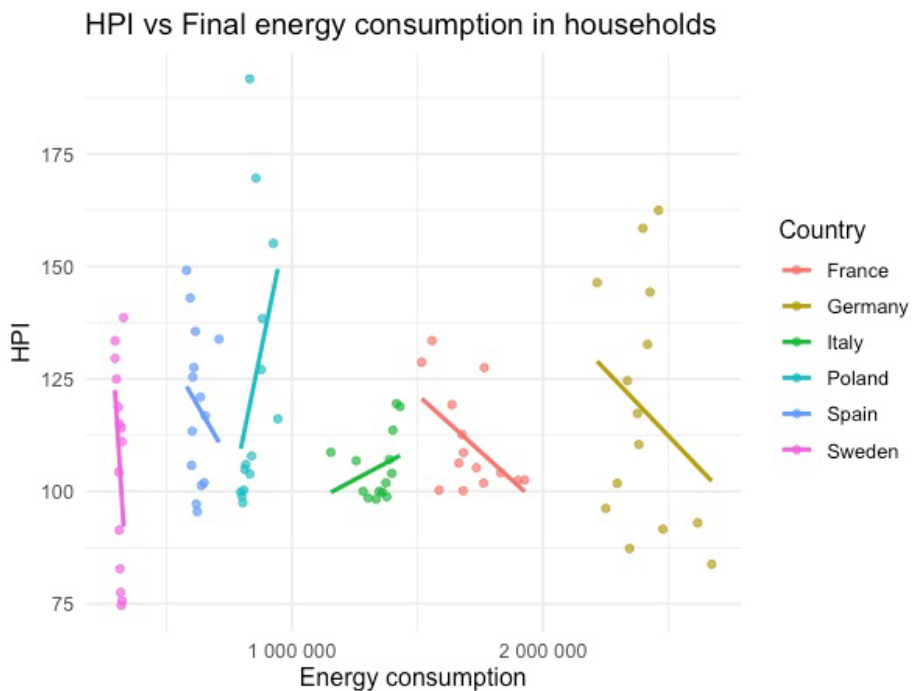


Fig. 4. HPI vs final energy consumption in households

same time (Fig. 3). Its steady trajectory suggests that any impact on housing prices is more likely indirect and subject to time lags.

The scatter plot with country OLS lines shows a heterogeneous HPI-energy relationship: negative in

France and Germany, weakly positive in Poland and Spain, and close to zero in Sweden and Italy. The small slopes and large dispersion suggest that the energy variable will have little explanatory power in dynamic/fixed effects specifications (Fig. 4). This

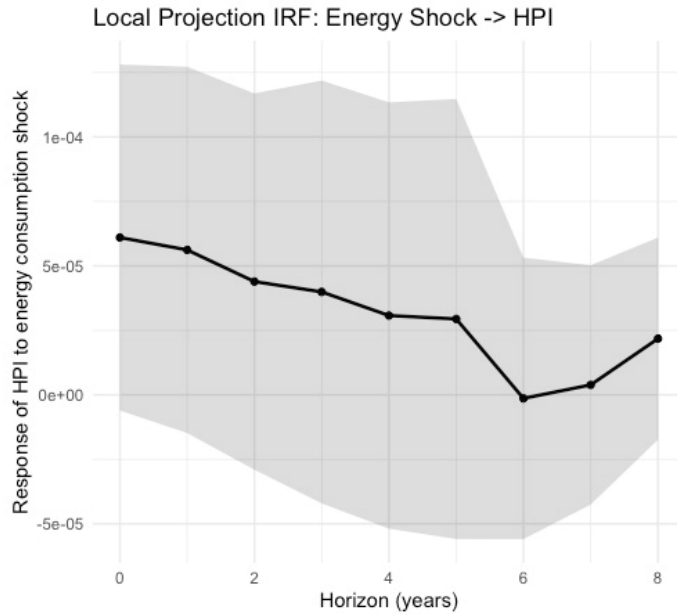


Fig. 5. Local projection IRF: energy shock -> HPI

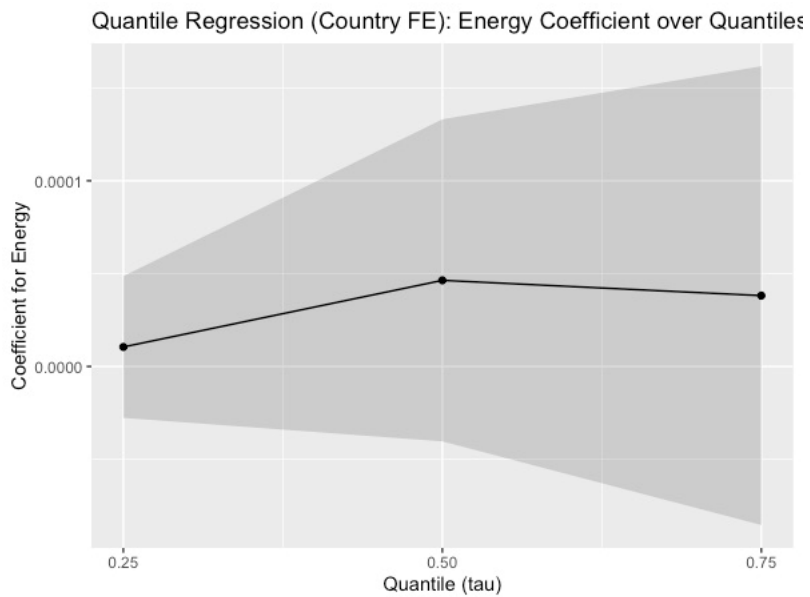


Fig. 6. Quantile regression (country FE): energy coefficient over quantiles

heterogeneity reinforces the need for country-level dynamics, fixed effects, and regime-dependent modelling.

Panel unit root tests (IPS/LLC) confirm that most series are non-stationary in levels (I(1)). The Fisher-type combined Engle-Granger cointegration test yields a marginal result (overall p-value ≈ 0.07), suggesting that a common long-run equilibrium relationship between housing prices and energy indicators is weak at the aggregate EU level. Conse-

quently, long-run effects should be interpreted with caution, and analytical emphasis is placed on dynamic responses and cross-country heterogeneity rather than on a single shared trend.

The dynamic response estimated using Jordà's local projection method shows that a unit shock to household energy consumption generates minimal and statistically insignificant responses of the HPI over a 0-8-year horizon. The median impulse-response trajectory remains close to zero, and the 95

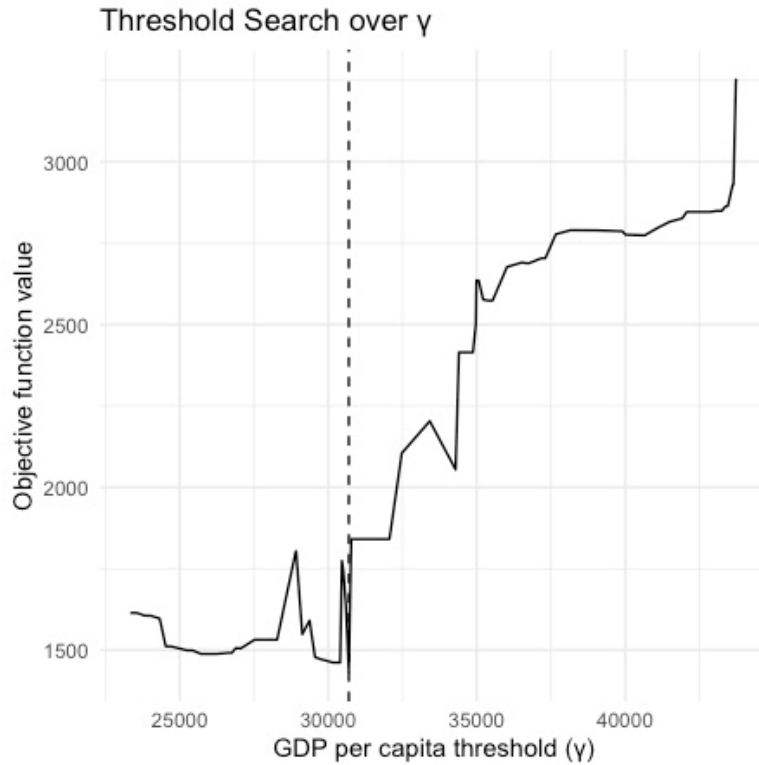


Fig. 7. Threshold search over gamma (objective function value)

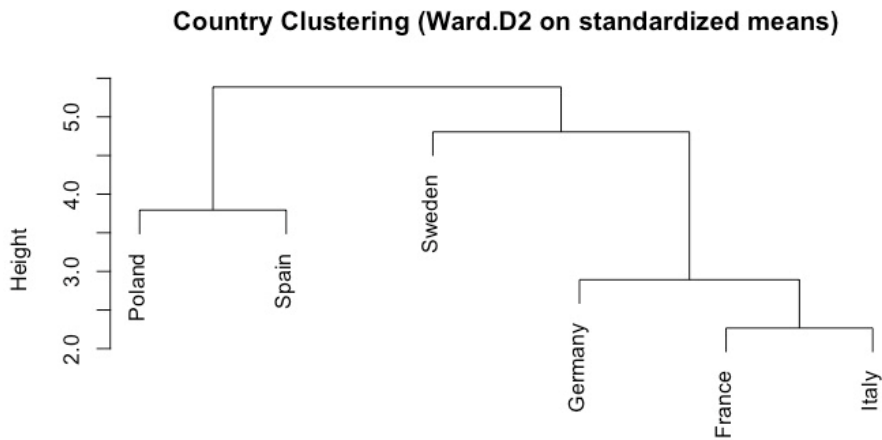


Fig. 8. Country clustering (Ward.D2 on standardised means)

% confidence bands consistently include zero, indicating that this channel-absent additional transmission mechanisms are secondary to broader macroeconomic (Fig. 5).

Quantile analysis with country fixed effects ($\tau = 0.25; 0.50; 0.75$) and cluster bootstrap by country shows only weak heterogeneity: the energy coefficient

is highest at the median ($\tau = 0.50$), but the confidence intervals for all τ intervals overlap with zero. Thus, the effect of energy efficiency on housing prices does not differ significantly across lower and higher-priced market segments (Fig. 6).

The threshold analysis by GDP per capita allows the energy coefficient to vary below and above a data-

selected threshold $\hat{y} \approx 15890$. The Wald test rejects the hypothesis of equal slopes in both regimes ($p < 0.01$). While this indicates income-dependent transmission mechanisms, the estimated coefficients remain economically small in both regimes, suggesting that energy effects on housing prices are context-specific rather than uniformly strong (Fig. 7).

Finally, hierarchical clustering using the Ward. D2 method and standardised variables identifies distinct country profiles. France clusters closely with Italy, Germany with Spain, while Poland and Sweden form separate branches. These groupings reflect differences in housing price dynamics and energy profiles, providing an additional structural perspective for interpreting cross-country heterogeneity (Fig. 8).

4. DISCUSSION OF THE RESULTS

This study aimed to assess whether and how building energy efficiency indicators are related to housing price dynamics at the macro level in EU countries, distinguishing between short- and long-term relationships and assessing heterogeneity between countries and price distribution segments. Rather than focusing on determining a single average effect size, the discussion emphasises the stability and variability of the estimated relationships across different economic contexts.

First, the main context should be highlighted: after 2014, a clear HPI growth trajectory was recorded in all analysed countries (the fastest in Poland and Germany, and the slowest in Italy), which immediately signals a strong inertial nature of $I(1)$ levels and prices. Later, it was also captured by dynamic models. Meanwhile, the trajectories of household final energy consumption in most countries are declining moderately, though with episodic spikes (especially in Germany and Poland), while the share of renewable resources is consistently growing. These visual observations alone show that comparing levels and simple correlations would be misleading, since individual links move under the influence of different structural factors, which encourages the use of panel and dynamic methods.

From a long-run perspective, unit root tests for the IPS/LLC panel confirmed the level non-stationarity of most series. At the same time, the Fisher-type combined Engle-Granger cointegration test yielded a marginal result (overall p -value ~ 0.07), which is closer to the 10 % threshold, but does not reach the 5 % level. This result is particularly important, as it

indicates that the capitalisation of energy efficiency in housing prices cannot be assumed to follow a uniform long-run pattern at the EU level. Importantly, this suggests that any long-term relationship, where present, is conditional rather than universal.

The practical conclusion is that the evidence for a general sustainable long-run level relationship between the HPI and energy indicators is weak for the entire sample, so FMOLS/DOLS interpretations must be treated with caution. Even when estimated coefficients point in a direction consistent with rising energy costs, such patterns cannot be interpreted as a general macroeconomic rule (Bashmakov et al., 2024). In other words, certain macroeconomic factors, such as income, cost of credit, urbanisation, or the labour market, are likely to overshadow the impact of energy efficiency. As a result, models calibrated solely on levels may fail to capture regime shifts and heterogeneous adjustment paths (Blažun Vošner & Završnik, 2023). This weak evidence of cointegration is consistent with visual observations (scatterplots show different directions of country-level slopes and large variance) and reinforces the argument that searching for a single average elasticity across the EU is unlikely to be valuable.

The dynamic (Arellano-Bond GMM) specification with a lagged dependent variable logically captures the slow changes in house prices — a typically positively significant parameter of price inertia driven by transaction expectations and financing conditions. In this study, energy indicators have low predictive power for short-term changes in HPI, and their coefficients are economically insignificant. This finding reinforces the view that short-term housing price dynamics are primarily driven by macro-financial conditions rather than energy-related signals alone.

This finding is consistent with the observed fact that short-term changes in energy consumption are often driven by price shocks or temporary policy measures that, when controlling for general macro variables, do not translate into a systematic increase in house prices (Bednář et al., 2022; Ciccarelli & Marotta, 2024; Qi et al., 2025). In practice, this means that, in the short term, energy transformation signals in the market can be “drowned out” by the noise of the credit cycle, labour income, and demographic flows. Methodologically, the choice of AB-GMM is appropriate: it suppresses endogeneity across instruments, but marginal cointegration and heterogeneity still reduce the stability of the values of energy variables (Khatib, 2025).

Impulse-response analysis based on local projection methods shows that a single shock to household energy consumption yields minimal, statistically unreliable HPI responses over a 0-8-year horizon; the median trajectory is close to zero, and the 95 % intervals are wide and include zero. This finding is consistent with the scatterplots' heterogeneity and the small coefficients in the dynamic models. This result further supports the view that energy-related shocks, isolated from additional transmission channels, have limited overall pricing power. From an economic perspective, a change in energy consumption alone, without additional channels (e.g., changes in the EPC level strictly related to housing quality, targeted subsidies, or changes in credit conditions), is not sufficient to create a sustainable, noise-free effect on house prices. From a policy perspective, this statement comforts the debate on affordability: improvements in energy efficiency do not systematically lead to "renovation-driven inflation" at the aggregate market level. Capitalisation effects are not precluded at the micro level, but rather tend to dissipate in macro-level panels (Balsiūnaitė et al., 2025).

Quantile panel regression: searching for distributional heterogeneity. Quantile BE regression ($\tau = 0.25; 0.50; 0.75$) with the cluster bootstrap method by country revealed only weak heterogeneity: the energy factor is highest at the median, but the confidence intervals of all quantiles coincide with zero. This indicates that distributional position alone does not substantially modify the energy-housing price relationship at the macro level.

This model shows that distributional differences do not substantially change the overall relationship between energy efficiency and housing prices. Consequently, at the macro level, the energy factor is not "particularly important" in the dynamics of either the cheaper or the more expensive housing segments: its "price" is capitalised heterogeneously and most likely more through a project/facility-based channel (Energy Performance Certificate level, building type, local micro-characteristics), which this panel does not reveal (Birch & Muniesa, 2020). A practical signal for policymakers: general, "one-size-fits-all" measures may be of limited effectiveness; instead, targeted interventions (e.g., by building age, urban density, and access to credit) should be applied where the probability of capitalisation is higher.

Regime (threshold) analysis by GDP per capita. The Hansen panel threshold model allows the coefficient to vary above and below a data-based threshold; the Wald test rejected the hypothesis of equal slope

($p < 0.01$), allowing the energy coefficient to differ across income levels. While income acts as a conditioning variable, the estimated coefficients remain economically small in both regimes, indicating that income moderates rather than amplifies energy-related price effects.

The interpretation is that in higher-income countries, energy efficiency is more easily recognised in the market and "priced in" (through discounting of operating costs, access to "green" loans, and expectations), while in lower-income countries, pure affordability and credit constraints become more critical in the short term, relegating the energy factor to the background (Landis et al., 2021). This conclusion is in good agreement with the findings of the IRF and dynamic models: the effect exists in some regimes, but at the macro level, it is not large.

Country clustering using the Ward.D2 method identifies natural groupings: France with Italy, Germany with Spain, and Poland and Sweden forming separate branches. These clusters reflect differences in housing price trajectories and energy profiles and provide a contextual framework for interpreting cross-country heterogeneity. Importantly, clustering is used here as a descriptive rather than causal tool, highlighting structurally distinct market environments. For instance, higher renewable energy penetration and urban density may enhance the visibility of energy-related signals in some markets, without necessarily producing a stronger aggregate price response if macro-financial conditions change simultaneously (Ang et al., 2022; Gayen et al., 2024; Zach et al., 2019).

Robustness checks and limitations. Diagnostics for heteroscedasticity, autocorrelation, and multicollinearity (Breusch-Pagan, Wooldridge, and VIF) reduce the risk that the result is "engineered" due to technical discrepancies, but two critical limitations remain. First, the macro indicators (final energy consumption, renewable energy share) are far from corresponding to micro-EPC levels and building quality; therefore, capitalisation may be distorted. Second, 2010-2023 includes multi-regime shocks (COVID-19 and 2021-2022 energy crisis) that are difficult to capture using average coefficients alone. These limitations support interpreting the findings as evidence of structural constraints rather than model misspecification. Further research directions include micro-level data (EPC, sales transaction prices), natural experiments (subsidy/standard changes), DiD models, and a more precise identification of credit supply and interest rate regimes.

CONCLUSIONS

At the macro-level EU panel, the energy consumption and “greenness” indicators of buildings are not strongly cointegrated with the house price index: the combined Engle-Granger test yields a marginal result ($p \approx 0.07$), so a single stable long-term relationship cannot be claimed across all countries. This finding shows that the long-term capitalisation of energy efficiency is structurally heterogeneous rather than uniform across the European Union. The evidence for long-term capitalisation remains weak and context-dependent.

The dynamic specifications reveal strong price inertia, and the short-term impact of energy variables is statistically and economically small; in the short term, house price trajectories are mainly determined by income dynamics, credit conditions, and demographic factors. The impulse-response functions show a near-zero response of the HPI to an energy consumption shock over the 0-8-year horizon, suggesting that the “pure” energy channel at the macro level is secondary, unless it operates jointly with financial, regulatory, or market-specific transmission mechanisms.

The quantile analysis does not reveal significantly different effects of energy factors in the cheaper and more expensive housing segments, as the confidence intervals of the coefficients overlap with zero across the quantiles. At the same time, threshold analysis shows that income level modifies the effect: the hypothesis of different slopes is rejected ($p < 0.01$), but the coefficients themselves remain small. Capitalisation is therefore more likely to occur in higher-income countries, whereas in lower-income contexts it is constrained by affordability and credit limitations.

These results emphasise that the observed effects are regime-dependent rather than universal. The structure of country clusters confirms that one-size-fits-all solutions are unlikely to be effective; instead, differentiated analytical and policy approaches tailored to specific credit, income, and urban contexts seem more appropriate.

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