EXPLAİNİNG ENERGY PRİCE BUBBLES İN THE EUROPEAN UNİON: COMMON EXTERNAL SHOCKS OR NATİONAL ENERGY MİX?

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Abstract: This study examines whether electricity price bubbles in European countries are driven primarily by common external shocks or by structural differences in national energy systems. It focuses on the role of crisis-related factors and energy mix characteristics, including the shares of renewables, fossil fuels, and imported energy, as well as generation diversification and market integration. In the first stage, speculative bubble episodes are identified and date-stamped using recursive right-tailed Augmented Dickey–Fuller tests based on the flexible-window procedure developed by Phillips, Shi, and Yu (2015). In the second stage, cross-country differences in bubble intensity and persistence are analysed in relation to national energy structures. The findings indicate that external shocks are the main triggers of electricity price bubbles, while their magnitude and duration depend on domestic energy mixes. More diversified systems with higher renewable-energy shares appear more resilient to prolonged price distortions.

***Keywords*:** electricity markets, electricity price bubbles, energy mix, renewable energy sources, European Union.

INTRODUCTION

The sharp increase in European electricity prices following the COVID-19 pandemic and Russia's invasion of Ukraine has raised concerns about the formation and persistence of price bubbles. This paper examines whether such bubbles are driven primarily by common external shocks or whether their intensity and duration depend on national energy mixes. Previous studies emphasise geopolitical disruptions, fuel prices, financial turbulence, and electricity-market interconnectedness, but devote less attention to structural differences between national energy systems. We identify and date-stamp bubble episodes using recursive right-tailed Augmented Dickey–Fuller tests based on the flexible-window procedure developed by Phillips, Shi, and Yu (2015). We then analyse cross-country variation in relation to renewable-energy shares, fossil-fuel dependence, energy imports, generation diversification, and market integration. The results indicate that common shocks trigger electricity price bubbles, while diversified, renewable-based energy systems are more resilient and experience less persistent price distortions.

Price bubbles are particularly important in electricity and wider energy markets because explosive price movements can amplify volatility, distort investment and consumption decisions, generate financial losses, and threaten energy security. Using recursive right-tailed unit-root tests, Sharma and Escobari (2018) identify explosive episodes across several energy indices and spot prices, demonstrating that bubbles are not confined to individual fuels or markets. Khan et al. (2022) similarly document multiple energy-price bubbles and associate them with speculation, economic and political events, strong economic growth, financial crises, and supply imbalances, including oil oversupply. Focusing specifically on electricity, Doran et al. (2025) show that bubble formation may reflect both common shocks (such as the post-pandemic recovery and disruptions to Russian gas supplies) and country-specific characteristics, including financial development, market structure, and the energy mix. Finally, Iliyasu et al. (2025) demonstrate that geopolitical risk can trigger bubbles and strengthen their contagion from European natural gas to international energy markets, highlighting cross-market interdependence as an additional transmission mechanism.

METHODOLOGY AND DATA

The analysis covers European countries for which comparable wholesale electricity price and explanatory data are available. Daily country-level day-ahead wholesale electricity prices, expressed in EUR/MWh, are obtained from Ember's European Wholesale Electricity Price Data (see Figure 1 below). The determinants of bubble formation are drawn primarily from Eurostat and include the shares of renewable and fossil-fuel-based electricity generation, energy import dependence, diversification of the generation mix, and indicators of electricity-market integration. These variables are supplemented with the IMF Financial

Development Index, which captures the depth, access, and efficiency of financial institutions and markets (IMF Financial Development Index). This allows us to compare our findings with Doran et al. (2025), while extending their semi-annual analysis of Germany and Romania to a broader European sample and substantially higher-frequency price data.

The empirical analysis proceeds in two stages. First, electricity price bubbles are detected and date-stamped separately for each country using the recursive right-tailed ADF framework developed by Phillips, Shi, and Yu (2015). In particular, the generalised sup ADF (GSADF) test is employed because its flexible starting and ending points allow it to identify multiple explosive episodes within a single series. The null hypothesis of a unit-root process is tested against the right-tailed alternative of explosive behaviour. Country-specific test statistics are compared with finite-sample critical values obtained through Monte Carlo simulation, as implemented by Caspi (2017). Bubble origination and termination dates are determined from the backward sup ADF sequence whenever the statistic crosses its corresponding critical-value sequence.

In the second stage, the baseline specification will employ a panel logit model in which the dependent variable equals one if at least one electricity price bubble is detected in country $i$and year t, and zero otherwise. Country and year effects will control for persistent national heterogeneity and common shocks, respectively. A fractional logit model will then use the proportion of observed days classified as explosive, thereby exploiting variation in bubble frequency while accommodating values bounded between zero and one (Papke and Wooldridge, 1996, 2008). The explanatory variables will include national energy-mix characteristics, import dependence, financial development, and interactions between structural characteristics and common crisis-related shocks.

As a robustness check, the number of bubble days or episodes will be estimated using Poisson pseudo-maximum likelihood with country and year effects and the number of available observations included as an exposure term (Santos Silva and Tenreyro, 2006). An extension will examine bubble intensity, measured by the maximum or cumulative excess of the BSADF statistic over its simulated critical-value sequence. A two-part model may be employed to distinguish between the probability of observing a bubble and its intensity conditional on occurrence (Cragg, 1971).

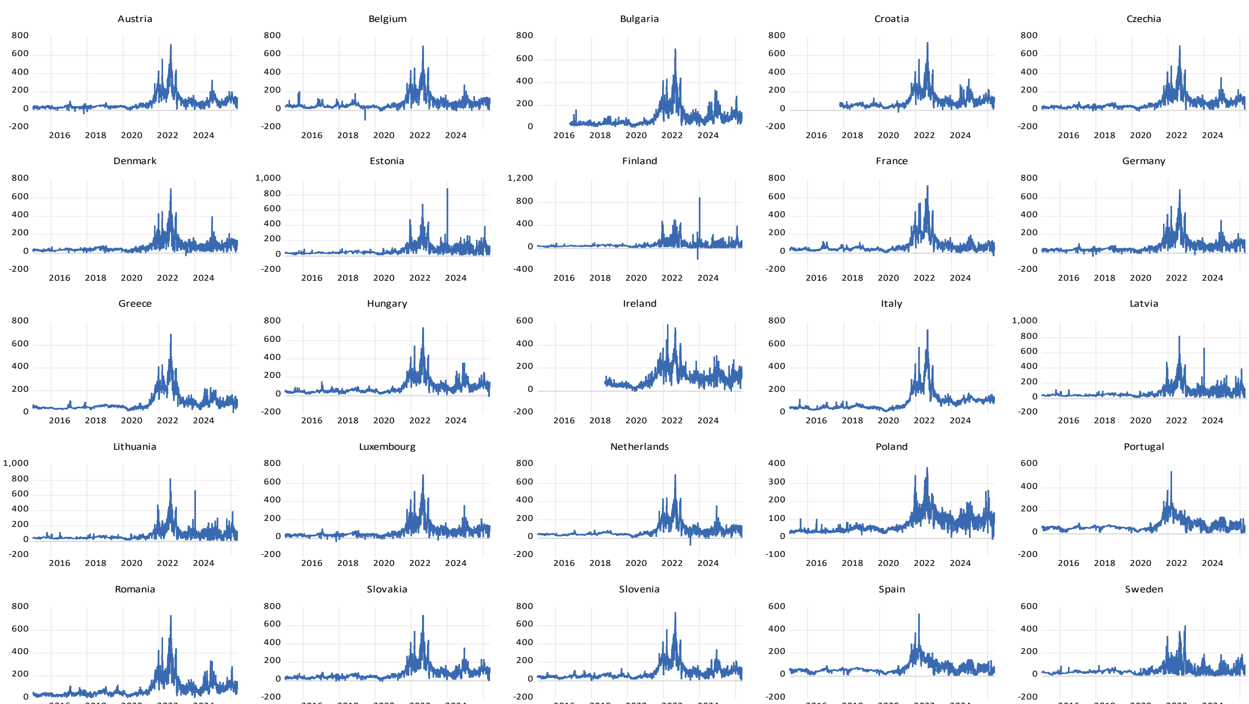

Figure 1. Daily wholesale energy prices in EU countries, 2015-2026.
Source: Own elaboration in E-views based on EMBER data (https://files.ember-energy.org/public-downloads/price/outputs/european_wholesale_electricity_price_data_daily.csv)

FINDINGS

The results provide evidence of multiple episodes of explosive behaviour in wholesale electricity prices in most of the countries examined, although their frequency, intensity, and duration vary considerably across national markets. Many episodes occur simultaneously, particularly during the post-pandemic energy crisis and following Russia's invasion of Ukraine, suggesting an important role for common external shocks. Nevertheless, substantial cross-country differences indicate that domestic structural factors also affect vulnerability to bubble formation. We hypothesise that dependence on imported energy and fossil fuels, limited diversification of electricity generation, stronger exposure to volatile natural-gas prices, and greater financial-market integration increase the probability and persistence of bubbles. Conversely, a diversified energy mix, a higher share of domestic renewable generation, stronger interconnection capacity, and greater energy efficiency may enhance resilience and limit prolonged price distortions.

CONCLUSIONS

The results indicate that electricity price bubbles across European markets are triggered primarily by common external shocks, while their frequency, intensity, and persistence are shaped by country-specific energy structures. Although multiple bubbles are identified in most countries, differences in their timing and duration suggest that greater diversification, higher shares of domestic renewable generation, and lower dependence on imported fossil fuels may strengthen resilience to price distortions. These generalisations should nevertheless be interpreted cautiously, as bubble identification is sensitive to the specification of the recursive tests, data availability differs across countries, and the second-stage analysis may not fully address endogeneity or distinguish speculative behaviour from sharp movements caused by fundamentals. The findings extend the literature by linking bubble formation to structural characteristics of national energy systems rather than treating explosive episodes solely as consequences of global crises. From a policy perspective, they support further diversification of generation, investment in renewables, storage and interconnection capacity, and closer monitoring of wholesale markets. Future research should incorporate higher-frequency determinants, alternative bubble measures, and causal methods to clarify the mechanisms through which external shocks interact with domestic energy structures.

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