Energy Price Shocks, Market Fragmentation, and the Macroeconomic Gains from Deeper Energy Market Integration in Europe

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Abstract

This project will examine how incomplete energy market integration in Europe may shape the macroeconomic effects of energy price shocks. If Europe continues to exhibit persistent cross-country price gaps, recurrent congestion, and uneven cross-border capacity, these features could influence how shocks propagate through electricity and gas markets and into real economic activity. The analysis will combine three empirical components: high-frequency evidence on the relationship between congestion and price dispersion; quasi-experimental estimates of how high voltage direct current interconnector openings affect wholesale prices and convergence; and panel-based estimates of how sectoral outcomes respond to exposure-weighted energy price shocks. A structural general equilibrium model will use these empirical magnitudes to explore counterfactual integration scenarios. Taken together, the project aims to provide a unified assessment of how deeper energy market integration could lower price volatility, improve resilience, and reduce the macroeconomic costs of energy shocks in Europe.

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Introduction

Over the past decade, Europe has experienced a persistent widening of energy price differentials both within the continent and relative to major peers, most notably the United States and China. The 2021–23 energy crisis exposed the structural fragmentation of European electricity and gas markets: cross country wholesale price gaps reached levels unseen since market liberalization, volatility surged, and physical bottlenecks in cross border networks repeatedly constrained the flow of energy across regions. Despite subsequent normalization in global commodity markets, intra-European price dispersion and congestion remain elevated. These developments raise fundamental questions about the macroeconomic implications of incomplete energy market integration at a time when Europe faces significant competitiveness challenges and a demanding decarbonization agenda.

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A large literature has documented the macroeconomic effects of energy price shocks, as well as the engineering drivers of electricity and gas market integration. However, much less is known about how physical congestion and cross border interconnection capacity shape the formation and transmission of energy prices, and how these market frictions translate into macroeconomic outcomes. Evidence linking infrastructure constraints to price volatility, the propagation of shocks, and downstream economic activity remains scarce. Similarly, while policy institutions have long emphasized the potential efficiency gains from deeper market coupling, there is limited causal evidence on how large-scale interconnector investments affect price gaps and volatility across countries.

This project examines the macroeconomic role of energy market integration in Europe through three complementary channels. First, it studies how congestion in electricity and gas networks affects price dispersion, volatility, and the transmission of shocks across European markets. Second, it exploits the quasi-experimental timing of major high voltage direct current (HVDC) interconnectors to estimate the causal effects of improvements in physical integration on wholesale prices and their volatility. Third, it assesses the macroeconomic consequences of energy price shocks across sectors and countries, and evaluates whether market fragmentation amplifies these effects. Taken together, the analysis provides new evidence on how the physical and institutional architecture of energy markets shapes macroeconomic performance in an era of heightened energy uncertainty and structural transformation.

Related literature

Recent work has renewed focus on the macroeconomic relevance of energy price shocks, particularly considering heightened volatility and structural energy transitions. Känzig (2023) shows that exogenous energy supply shocks—identified via high-frequency variation around OPEC announcements—have large and persistent effects on output, inflation, and asset prices. Baumeister and Hamilton (2019) look at oil supply and demand shocks in a Bayesian VAR framework and find that oil supply disruptions have substantial recessionary effects globally, whereas demand-driven oil price increases do not significantly dampen economic activity. In general equilibrium, Bachmann et al. (2022) use a multi-sector computable general equilibrium model to study Europe's 2022 gas crisis, finding that a complete Russian energy cut-off would reduce German GDP by only about 1% in their baseline (and at most ~2–3% in a worst case) due to firms' ability to reallocate and substitute energy inputs. Di Bella *et al.* (2024) similarly studies the economic impact of a full disruption of Russian pipeline gas flows to Europe and how pipeline bottlenecks affect output losses.

Another strand of research investigates energy market integration, price convergence, and infrastructure bottlenecks, often with empirical or quasi-experimental methods. Gonzales, Ito, and Reguant (2022) exploit a large-scale transmission expansion in Chile as a natural experiment and find that integrating previously separated electricity grids led to near elimination of regional price disparities, increased renewable generation investment, and lower overall generation costs and emissions. In natural gas markets, physical constraints can similarly impede price convergence: Avalos, Fitzgerald, and Rucker (2016) show that pipeline capacity congestion in U.S. gas networks raised gas prices, reflecting more severe bottlenecks in the latter. Likewise, Davis and Hausman (2016) document that the unexpected closure of a nuclear plant in California caused a $350 million increase in generation costs as gas-fired plants filled the gap, with transmission constraints limiting imports and creating short-run inefficiencies.

Taken together, these studies highlight how market integration and infrastructure investments can mitigate or exacerbate energy price shocks by influencing the degree of price convergence across regions. Our proposed project will build on and bridge these two literature strands by examining how the macroeconomic effects of energy price shocks depend on the extent of market integration and network capacity, thus contributing new evidence on the interplay between energy shocks and energy-market infrastructure.

Stylized Facts on European Energy Markets and Industrial Exposure

Preliminary evidence suggests three patterns that motivate the proposed analysis. First, Europe may continue to exhibit sizable differences in wholesale and industrial energy prices across countries. Even if benchmark prices normalize, cross-border dispersion could remain elevated due to heterogeneous fuel mixes, taxation, and network charges. Industrial users would likely continue to face substantial differences in effective input costs, implying that deviations from a single European energy price may persist.

Second, initial analysis of high-frequency flow and capacity data indicates that physical bottlenecks in electricity and gas networks could play an important role in sustaining these price gaps. Many interconnectors appear to operate near technical limits for extended periods, and such congestion episodes may coincide with wider cross-border price spreads. Directional patterns—for example, congestion from renewable-rich peripheries toward central Europe, or along west–east gas corridors following shifts in supply—suggest that network constraints could shape the spatial distribution of prices and the transmission of shocks. These observations point to incomplete market integration as a potentially central feature of European energy markets.

Third, sectoral data indicates that energy-intensive industries may be particularly exposed to these market characteristics. Historical patterns suggest that increases in energy prices are associated with declines in the share of energy-intensive value added, and the sharp rise in prices during 2021–23 may have accelerated pre-existing pressures. While some firms may adapt through efficiency improvements or product upgrading, the aggregate performance of these sectors could remain sensitive to structural differences in energy costs across countries.

Empirical Strategy: Congestion, Interconnection Investments, and Macroeconomic Effects of Energy Prices

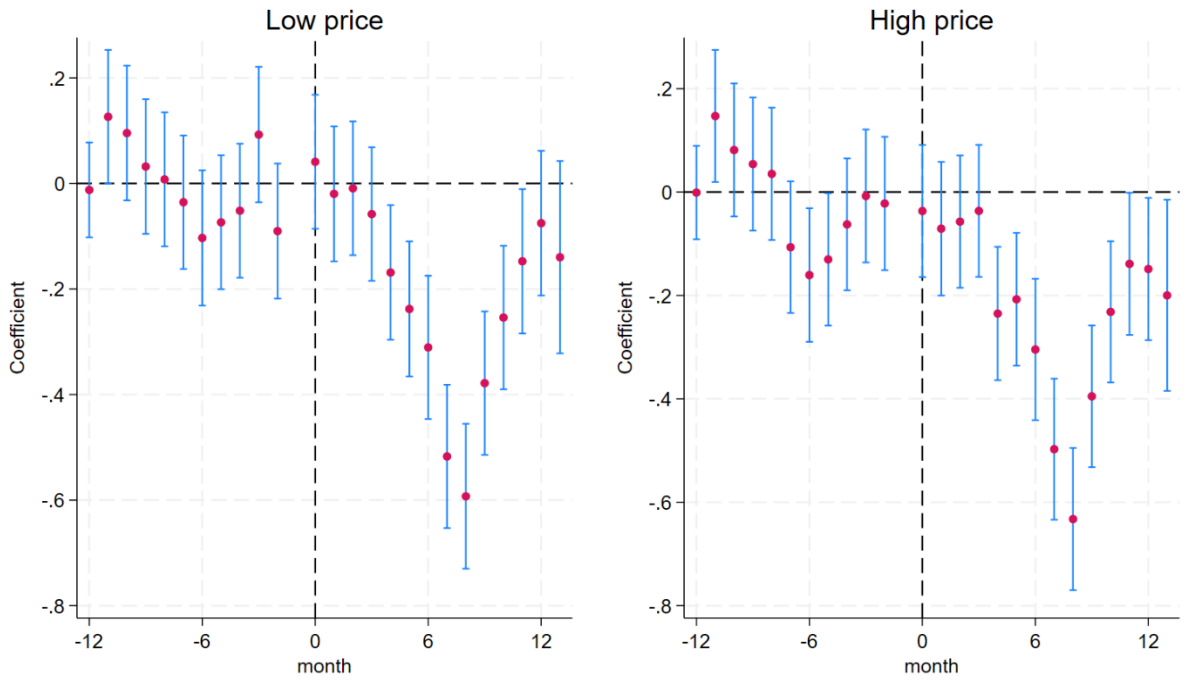
The empirical analysis will proceed in three modules that together aim to quantify how physical integration, cross border congestion, and energy price shocks shape macroeconomic outcomes. Each module relies on distinct data sources and identification strategies, but the three are designed to complement and reinforce each other.

The first module will examine the relationship between congestion in electricity and gas networks and patterns of price dispersion and volatility. Using high frequency flow and capacity data from ENTSO E and ENTSO G, we have constructed novel congestion measures that capture the frequency with which interconnectors operate near their technical limits. These measures will be combined with daily wholesale prices to assess whether periods of binding constraints coincide with larger cross-border price gaps, higher volatility, and stronger co-movement with regional benchmark shocks. This module is expected to

clarify whether and how network constraints may impede the law of one price and affect the transmission of energy shocks.

The second module will exploit the quasi-experimental timing of major high voltage direct current interconnectors entering commercial operation. Data on such projects has been assembled, with precise opening dates for both new links and major capacity upgrades. These events offer plausible exogenous variation in physical integration. The analysis will implement a difference-in-differences design, complemented by event study specifications, to estimate the causal effect of these investments on wholesale prices, cross-border price spreads, and price volatility. Treated country pairs will be compared with an appropriately defined control group consisting of unaffected European markets, accounting for common shocks and seasonality. The objective is to identify how marginal increases in transmission capacity affect price formation and whether physical integration delivers measurable improvements in market outcomes. Preliminary results suggest that, on average, market integration via high voltage lines do not increase prices for either country interconnected (Figure 1), although with relevant heterogeneity among countries. If confirmed, these results would challenge the notion that consumers in low price countries would necessarily see their prices increase.

Figure 1 - Effect of HVDC interconnection on log wholesale prices (PRELIMINARY – DO NOT CITE)



Note: Monthly coefficients estimated for an event-study. Treated group: countries that installed a high voltage direct country interconnector, classified as low and high price by average price in a two-year window around treatment; control group: net-yet-treated countries that did not install an interconnector in a two-year window around treatment. Newey-west standard errors at 95% confidence level.

The third module will study the macroeconomic effects of energy price shocks across countries and sectors, and examine whether differences in market integration alter these effects. The analysis will rely on an annual panel covering a broad set of European and advanced economies, matched with sector specific exposure to electricity, gas, and oil. Exposure weighted prices will be used to relate lagged energy cost movements to outcomes such as value added, employment, and capital formation. This module will provide an aggregate and long-term perspective on how energy price shocks influence the real economy and whether these effects are attenuated in more integrated markets.

Modelling Analysis: General-equilibrium Effects of Energy Price Wedges and Market Integration

In addition to our reduced-form empirical analysis, we use a structural general equilibrium model to provide a full macroeconomic assessment of the economic impact of low energy market integration and what could be gained by improving it. This approach enables a comprehensive assessment of the economic effects resulting from historical energy price trends. Furthermore, it quantifies the macroeconomic consequences of energy price differentials under various supply scenarios (such as the restoration of Russian gas flows) and demand scenarios (including increased demand driven by AI deployment), as well as to evaluate the extent to which deeper energy market integration could mitigate these impacts.

For this analysis with use the IMF-ENV model (Chateau, *et al.,* 2025). This is a multi-country, multi-sector computable general equilibrium model—calibrated to European supply-use tables and global trade data. The model will incorporate outputs from the econometric analysis to compare steady-state outcomes under alternative price-wedge and integration scenarios. The model yields a full general-equilibrium counterfactual that extends the partial-equilibrium findings of the econometric analysis and simulates how integration alters the propagation of energy-price wedges across sectors and countries.

Policy implications

The proposed project speaks directly to the macroeconomic and policy questions raised in the NBER call. If preliminary patterns hold, incomplete energy market integration may imply that Europe continues to face higher and more volatile energy prices than its peers, with consequences for competitiveness, industrial structure, and macroeconomic stability. The congestion analysis will show the role of physical bottlenecks on price dispersion and shock absorption, showing whether investment in cross border capacity could affect economic outcomes via energy prices. The macroeconomic analysis can further clarify the role of energy price shocks in affecting activity in energy intensive sectors, while assessing the effect of regional and global developments in energy markets, such as changes in natural gas supply, increased electricity demand from data centers associated with AI deployment. Together, these findings would help quantify the economic returns to integration and inform policy efforts in infrastructure planning, electricity market design, and cross-country coordination aimed at improving energy security, reducing volatility, and supporting industrial competitiveness during the energy transition.

Work plan and potential risks

The first module will construct and validate congestion indicators from high-frequency flow–capacity data, already collected from ENTSO E, ENTSO G and commercial sources for prices, followed by reduced-form estimations relating congestion to price dispersion and volatility. In parallel, the HVDC dataset will be finalized and used to implement event-study and difference-in-differences designs. The sector-level macro analysis will proceed once updated exposure-weighted energy price measures are incorporated into the country–sector panel. In parallel, the IMF-ENV model will be calibrated to reflect latest development in the European energy market and the inputs from the econometric analysis. A full draft integrating empirical and model-based results will follow, culminating in a paper suitable for NBER dissemination.

Some risks may affect the sequencing, including delays in harmonizing energy flow data, gaps in HVDC project documentation, or uneven availability of sectoral energy price series. These risks are modest and can be addressed through alternative data sources, robustness checks, and adjustments in module timing where needed.

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