Productivity Effects of Production Reallocation from Electricity Price Dispersion

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--- Disclosure of Interests and Relationships for Paula Patzelt ---

Paula Patzelt is a graduate student at LSE. She has completed paid internships at the Norges Bank and the Bank for International Settlements, and she was an intern at the Bundesbank and ECB in the past. She continues to be a guest researcher at Norges Bank. As central banks, they are users of this research, but have not interfered with or dictated this research in any way. She is currently partially funded by the LSE Centre for Economic Transition Expertise CETEx, a specialised research and policy centre hosted by the Grantham Research Institute on Climate Change and the Environment at LSE. She has no ties to the energy industry.

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Abstract

Electricity prices vary significantly even across European countries despite grid interconnection, reflecting policy choices rather than natural resource endowments. This paper examines whether these price disparities distort production allocation and impose macroeconomic costs through reduced aggregate productivity. I will provide causal evidence on how electricity prices affect firm location decisions along different margins, exploiting solar cost shocks for identification. A structural model translates these microeconomic responses into macroeconomic productivity consequences. Counterfactual exercises evaluate alternative policy scenarios of deeper market integration and alternative renewable trajectories. The findings will reveal productivity consequences of energy policy divergence, informing ongoing debates on policy coordination and electricity market integration during the green transition.

JEL codes: Q43, Q41, E23, O47, R32.
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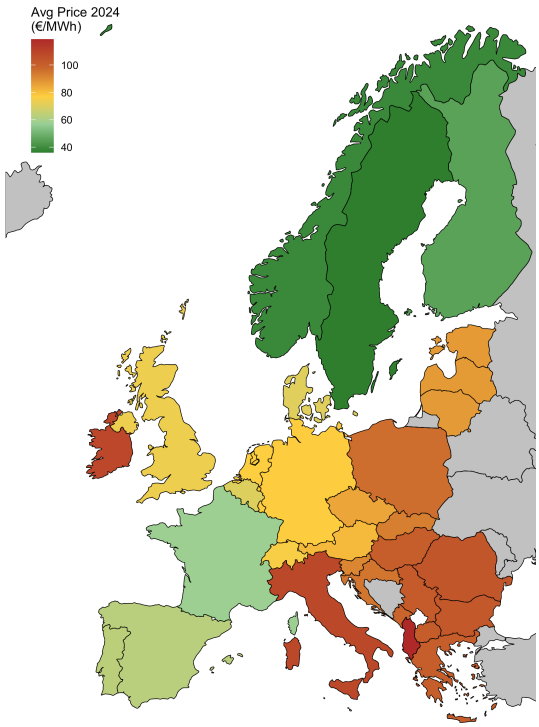
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1 Introduction

Motivation

Electricity prices show large and persistent disparities between countries, even within closely interconnected economies such as within the EU (see figure 1). The geography of energy has proven important for the location of production activity historically, for example in the form of coal availability leading to industrial clusters around coal fields.[1] In the 21st century, with accelerating electrification and new electricity-intensive industries, could policy-driven electricity price fragmentation reduce aggregate productivity by distorting where production locates?

Figure 1: Average annual wholesale electricity prices by country



Notes: The figure shows the annual average of daily wholesale electricity prices in 2024 in euros per MWh from Bloomberg, aggregated across zones within countries. Wholesale markets are split into mostly national bidding zones with a common price, with some exceptions: combined zones DE-LU; practically integrated ES & PT; split zones IT (6), NO (5), SE (4), DK (2), FR/Corsica.

[1]Consider for example large coalfields in the German Ruhr area with steel and chemical industry, or in the Welsh valley producing iron and textiles.

Three factors explain these persistent price differences: generation mix, market segmentation, and cross-border transmission. National prices are largely determined by the electricity generation mix, which is in part due to natural resource advantages (sun, wind, and hydro resources), but largely shaped by policy choices such as subsidies and regulations. Generation mix varies widely across countries even within the EU.[2] The segmentation of markets into zones with a common price further determines to what extent the price reflects local conditions. Lastly, limited cross-border transmission capacity and a degree of electricity nationalism lead to low electricity trade between pricing zones ($\approx 10\%$ within the EU), allowing price differences to persist. These differences in generation costs are then further amplified by taxes and regulations reflected in consumer retail prices.

When energy-intensive production reallocates in response to these policy-induced price disparities rather than to genuine comparative advantages, the resulting misallocation may impose macroeconomic costs, reducing aggregate productivity growth. This project addresses two related questions: First, how much do electricity price differentials affect the spatial allocation of production across countries, and what are the aggregate productivity implications? Second, to what extent do divergent renewable energy policies and limited market integration create misallocation relative to more aligned or integrated markets?

Conceptual framework

Lower electricity prices may attract electricity-intensive production, potentially leading to industrial clustering in low-price locations reinforced through agglomeration economies such as thick labor markets and specialised supplier networks. This creates path dependence, as early adopter countries of low-cost electricity generation attract industries, potentially establishing persistent comparative advantages.

Policy-induced price differences cause production to locate based on artificial rather than fundamental comparative advantages. While the efficient allocation would follow fundamental productivity advantages (technology, skills, infrastructure) and natural resource endowments, agglomeration effects can make initially inefficient locations become locally efficient, yet globally suboptimal. This misallocates energy-intensive production away from locations with genuine resource advantages, thereby generating aggregate

[2]Take for example the large price difference between France and Germany with similar natural resources. France continues to rely heavily on nuclear electricity with a share of over 70% in generation since the 1980s, Germany decided to exit nuclear energy in 2011.

productivity losses.

Changes in relative prices across countries might lead to limited reallocation in the short run given high adjustment costs, leading to output losses in high-price locations. If price differences are large enough or persist over time, they can trigger reallocation of activity with potentially permanent effects if they generate agglomeration externalities.

Methodology

This paper will provide a theoretical framework to illustrate competing mechanisms in production location choice and their implications for aggregate productivity. To inform and estimate the model, I will derive causal empirical evidence on how much energy price differentials drive production locations along different margins (within-firm reallocation, entry/exit, relocation) and across contexts (EU cross-country, EU within-country, US). Identification will be achieved by relying on a shift-share instrumental variable strategy exploiting a persistent exogenous technology shock to the cost of solar generation with different regional exposures, relying on solar potential and pre-existing policy commitments. Although solar generation is rarely the marginal price-setting source, it drives wholesale electricity prices inframarginally by displacing more expensive sources.

Counterfactual exercises quantify the productivity implications of alternative electricity policies. The estimated model evaluates projections of countries on different renewable trajectories and generates counterfactual scenarios with different levels of energy market segmentation across countries, comparing the status quo to a hypothetical full electricity union and a physically constrained version. The paper therefore aims to bridge the gap between microeconomic location responses and macroeconomic productivity consequences, informing ongoing policy decisions on the green electricity transition, market integration, and transmission investment.

Expected results

Several patterns in the data are consistent with electricity prices driving production reallocation. EU energy-intensive manufacturing employment and output declined following the 2021 energy crisis in line with electricity price increases. Preliminary evidence from the European Restructuring Monitor (ERM) data on announced firm restructuring events also shows a negative correlation between electricity price changes and cumulative job changes across countries. Recent prominent examples of production relocation

provide further anecdotal evidence of firms citing electricity costs as a primary location choice factor. For example BASF closed its ammonia production in Germany following the 2022 price spike, and Liberty Steel moved its UK plants to Czechia in 2024 due to lower electricity prices.

Descriptive evidence will be complemented by the reduced-form empirical analysis identifying electricity price elasticities across multiple margins of adjustment. Results will show how much production responds to electricity price changes on aggregate, and separate within-firm reallocation (intensive margin) from firm entry/exit and relocations (extensive margin). The analysis will reveal differential responses by electricity intensity, with larger effects in energy-intensive sectors (such as chemicals, metals, and data processing), and compare short-run responses with limited adjustment to long-run responses with endogenous location choices. Additional exercises using within-country electricity price zones for Italy and the US will show to what extent national borders are important, and how generalisable this mechanism is beyond Europe.

A structural model will quantify the aggregate productivity implications of electricity price-driven misallocation, informed by the causal empirical estimates. The model will quantify where production should locate based on fundamental comparative advantages (technology, skills) independent of electricity price distortions. It will then be used to compare the actual allocation to an efficient benchmark of full price equalisation across countries, quantifying the impact of price dispersion on productivity differences and aggregate productivity losses. Counterfactuals will further evaluate feasible gains that respect physical constraints for interconnection expansion and simulate consequences of continuing divergent electricity policy choices across countries.

The results will have direct implications for ongoing energy policy decisions that currently prioritise energy security and climate objectives without fully accounting for productivity considerations. More broadly, the analysis will clarify that the energy transition does not just imply a transformation of the energy sector itself, but reshapes comparative advantage with first-order implications for aggregate productivity.

Contribution

This paper combines causal microeconomic evidence on production location responses with a theoretical framework to quantify the aggregate productivity implications of electricity price differences driven by policy choices and market fragmentation. It thereby contributes to several strands of literature.

First, it extends the literature discussing the role of energy resources for economic geography. Related papers study, for example, oil reserves and infrastructure (Michaels, 2011, Greenspon and Hanson, 2025), coal (Gutberlet, 2014) or hydroelectric power (Fiszbein et al., 2020, Severnini, 2023). These papers examine how resource availability shapes economic outcomes in respective locations, mostly evaluating historical contexts without explicitly examining production relocation responses. Unlike this historical work, this paper examines contemporary policy-induced price variation with endogenous firm location responses, providing causal estimates of production reallocation effects.

Second, this paper extends the literature on the spatial economics of electricity markets beyond the energy sector. Recent work by Arkolakis and Walsh (2023) on clean energy investment and Gonzales, Ito and Reguant (2023) on electricity market integration in Chile focuses on outcomes in the energy sector (renewable investment, grid optimisation) and limited macro implications, but ignores production responses in other sectors. This paper focuses on implications for final goods producers and aggregate productivity through the reallocation of production across countries and sectors.

Lastly, the empirical approach of the paper advances existing studies using micro data to explore the role of energy prices for firm activity. For example, Kahn and Mansur (2013) study manufacturing firms' location choices across US states, and Saussay and Sato (2024) analyse manufacturing FDI and M&A at the extensive margin. These papers each focus on a single margin and are subject to some unresolved identification challenges (prices correlated with unobservables). This paper overcomes these challenges through a novel identification strategy exploiting solar cost shocks, estimates effects across multiple adjustment margins simultaneously, and uses these estimates to inform quantitative welfare analysis.

2 Theory: production location choices with local electricity

Setup

The theoretical framework builds on spatial and trade economics literature, adapting the approach of Arkolakis and Walsh (2023) to focus on electricity price differentials as a source of spatial misallocation of production activity. The model treats countries as distinct locations in a trade framework rather than implementing a full spatial model with land markets. Countries $j \in \{1, ..., J\}$ are endowed with fixed labor supply $\bar{L}_j$ and face

country-specific electricity prices p_j^E determined by their generation mix and energy policies.

Firms

Firms produce differentiated varieties within sectors under monopolistic competition, charging constant markups over marginal cost. They face nested CES demand within and across sectors with respective elasticities σ_s and μ. Production combines labor and electricity with sector-specific intensities: $y_{fjs} = \phi_f A_{js} L_{fjs}^{\alpha_s} E_{fjs}^{\beta_s}$, where sectors $s \in \{1, ..., S\}$ vary in electricity intensity β_s. Within each sector-country pair, firms draw heterogeneous productivity ϕ from a (Pareto) distribution following Melitz (2003). The model incorporates agglomeration externalities through $A_{js} = \bar{A}_s N_{js}^{\gamma_s}$, capturing productivity gains from sectoral clustering such as thick labor markets and specialised supplier networks. Labor market clearing determines wages, providing a congestion force that prevents all activity from concentrating in low-price locations.

Firm profits in location j and sector s take the form $\pi_{js}(\phi) = B_s \phi^{\sigma_s - 1} \Psi_{js} - F_{js}$, where $\Psi_{js} \equiv A_{js}^{\sigma_s - 1} w_j^{-\alpha_s(\sigma_s - 1)} (p_j^E)^{-\beta_s(\sigma_s - 1)}$ summarises location attractiveness, increasing in agglomeration and decreasing in input costs. The term B_s captures sector-level demand conditions. Firms face fixed operational costs F_{js} that vary by location and sector, reflecting regulations, real estate, and infrastructure requirements.

Location choices

Location decisions incorporate both entry and relocation margins. After paying entry cost F_s^e and drawing productivity, new entrants choose the profit-maximising location. Incumbent firms face one-time moving costs F_s^M when relocating. To avoid having to specify a fully dynamic model, firms make relocation decisions by comparing current profits to alternative locations net of annualised moving costs rF_s^M. This generates location-sector-specific productivity cutoffs: firms exit when profits are negative everywhere net of moving costs, and relocate when profit gains in alternative locations exceed the moving cost threshold. These decision rules allow the model to capture both sticky short-run responses when moving costs bind and flexible long-run reallocation when persistent price differences justify relocation.

Electricity markets

Electricity markets are segmented across countries, with prices determined by the local generation mix according to a two-component structure similar to Arkolakis and Walsh (2023). First, natural resource endowments (solar radiation, wind and hydroelectric potential) represent fundamental comparative advantages in low-cost generation that are exogenous to policy choices. Second, accumulated generation capacity capital by technology type reflects historical policy decisions (nuclear development, renewable subsidies, and fossil fuel reliance).

The model treats accumulated capital stocks $\{K_j^R, K_j^F\}$ as predetermined state variables in each period. This simplification allows the analysis to focus on production allocation responses to electricity price differentials, abstracting from the dynamics of energy sector investment decisions. Within a given period, these capital stocks determine electricity production: renewable capital produces $Y_j^R = \theta_j^R K_j^R$ at zero marginal cost (where θ_j^R captures generation potential), while fossil capital requires fuel inputs with production $Y_j^F = G(K_j^F, F_j^E)$ where fuel use F_j^E is chosen optimally given fossil fuel prices p^F. Electricity prices in each location are then determined by the merit order dispatch. This structure allows for realistic modelling of electricity price (supply) shocks, for example akin to the Russian gas shock, that have asymmetric effects across countries depending on their generation mix.

Accumulated capital can create additional path dependence: countries that invested early in low-cost generation technologies benefit from sunk capital that continues producing cheaply, while countries with predominantly fossil fuel capacity face higher marginal generation costs.

The model allows for bilateral electricity trade subject to transmission capacity constraints between country pairs, enabling partial price equalisation when grid infrastructure permits, while maintaining realistic market fragmentation.

Equilibrium

An equilibrium consists of firm location decisions, wages, sectoral price indices, entry masses, and agglomeration levels such that firms optimise given prices, labor and goods markets clear, free entry holds, and agglomeration updates according to the mass of firms in each location-sector cell. Equilibrium existence requires positive fixed costs, bounded agglomeration externalities, and sufficient productivity heterogeneity. The equilibrium is

unique when agglomeration forces are relatively weak.

Micro mechanisms

The model generates several key mechanisms through which electricity price differentials affect production allocation and aggregate productivity. First, threshold effects in firm relocation decisions create discontinuous responses: firms relocate only when profit differentials exceed annualised moving costs, leading to concentrated reallocation episodes rather than smooth adjustments. This generates state dependence where the existing distribution of firms affects marginal location choices through agglomeration. Second, heterogeneous responses by firm productivity create selection effects: within energy-intensive sectors, the most productive firms are most likely to relocate to low-cost locations since they have the most to gain in absolute terms, potentially amplifying productivity losses in high-cost regions. Third, sectoral composition shifts as energy-intensive industries concentrate in low-price locations while less electricity-dependent sectors remain more evenly distributed, altering the industrial structure of both gaining and losing regions.

Macro mechanisms

These microeconomic mechanisms aggregate to macroeconomic productivity effects through two competing forces. Reallocation toward low-cost locations can improve allocative efficiency by reducing input costs for energy-intensive production. However, this beneficial reallocation can be diminished when price differentials reflect policy distortions rather than fundamental comparative advantages. The model distinguishes these cases through the decomposition of profits: fundamental advantages enter through base productivity parameters (estimated from pre-divergence data), while policy-induced advantages operate through the electricity price term in location attractiveness. If a country achieves low electricity prices through subsidies despite lacking genuine productivity advantages in energy-intensive sectors, the resulting spatial allocation becomes inefficient.

Second, agglomeration externalities create path dependence. Countries that attract firms due to temporary price advantages may retain them even after those advantages dissipate, locking in inefficient patterns. The loss of agglomeration in high-price regions compounds output losses, as departing firms reduce productivity for remaining ones. The framework captures both short-run dynamics, where high moving costs freeze lo-

cations and only intensive margin adjustments operate, and long-run equilibria where endogenous relocation and agglomeration-driven clustering reshape industrial geography.

Estimation

The model structure enables estimation using a combination of calibration and reduced-form moments from the empirical analysis. Standard parameters, such as the productivity distribution, sector intensities, and demand elasticities, can be calibrated from input-output data and the observed firm size distribution. Estimated production elasticities to electricity prices identify technology and adjustment costs, while the decomposition across margins informs the relative magnitude of operational versus moving costs. Agglomeration strength can be identified from how responses vary with pre-existing sectoral concentration, and moving costs from the frequency and timing of observed relocations. Generation capital is calibrated to observed installed capacity by country and technology type. The efficiency benchmark requires estimating fundamental sector-country productivity independent of electricity prices, using either pre-divergence period data adjusted for any price contamination, or synthetic comparative advantage measures based on skill endowments and technological capabilities.

3 Empirical identification: reallocation margins

Strategy

The empirical analysis addresses the question of how much electricity price differentials affect the spatial allocation of production across countries. The central identification challenge is that electricity prices correlate with numerous country-specific factors (including demand shocks, labor supply conditions, regulatory environments, etc.). Moreover, reverse causality is a concern when large firms' electricity demand can influence local prices. Third, classic price shocks are usually temporary, but location decisions across countries are sticky with large fixed costs which temporary shocks are unlikely to outweigh. To overcome these challenges, I employ a shift-share instrumental variable strategy that exploits plausibly exogenous variation in electricity prices driven by large, persistent, and unexpected solar technology cost reductions interacting with differential country exposure.

Production reallocation can occur along multiple margins with different adjustment costs, and the empirical strategy is designed to separately identify these responses. At the intensive margin, firms can adjust production within country, and multinational firms can reallocate production across existing locations without paying full relocation costs. At the extensive margin, incumbent firms face moving costs when relocating production to new countries, while new entrants make initial location choices without this friction. These different cost structures generate heterogeneous responses across margins, which the empirical specifications will separately identify to inform the structural model parameters.

European data

The baseline sample focuses on European countries from 2005 onward, exploiting the combination of integrated goods markets and segmented electricity markets within the EU. EU countries have high generally high renewables shares, but significant cross-country variation in generation mix and approaches for how to meet future green energy targets, with differences likely to persist. For robustness, I will incorporate within-country variation using Italian price zones and US regional electricity markets.

The analysis combines several data sources to construct a comprehensive picture of firm responses. Firm-level financial data comes from Orbis, supplemented with Revelio Labs employment data that tracks effective firm locations through job postings and worker histories. These micro data are matched with sector-level electricity intensity measures from Eurostat. Electricity prices are obtained from ENTSO-E (European Network of Transmission System Operators) and Bloomberg, providing daily wholesale prices by bidding zone.

Firm-level specification

The baseline specification estimates the elasticity of firm activity with respect to electricity prices using cross-country variation in prices over time. For firm f in sector s and country c at time t, the estimating equation is:

$$\log(Y_{f,s,c,t+h}) = \alpha^h + \beta_1^h \log(P_{c,t}^E) + \beta_2^h \left[\log(P_{c,t}^E) \times \frac{E_{s,c,t-1}}{Y_{s,c,t-1}}\right] + \eta_{s,t}^h + \mu_{f,s}^h + \delta X_{c,t} + \epsilon_{f,s,c,t+h}$$

where $Y_{f,s,c,t+h}$ measures firm activity (employment, production, or investment) at horizon h, $P_{c,t}^E$ is the instrumented electricity price, and $E_{s,c,t-1}/Y_{s,c,t-1}$ is the lagged electricity

intensity of sector s (electricity expenditure relative to output).

The interaction term captures differential responses across sectors: energy-intensive industries should respond more strongly to price changes than sectors where electricity represents a small share of costs. $\eta^h_{s,t}$ are sector-time fixed effects absorbing common sectoral shocks, $\mu^h_{f,s}$ are firm-sector fixed effects controlling for permanent firm characteristics, and $X_{c,t}$ includes country-level controls such as wages. The coefficients β^h_1 and β^h_2 jointly identify the overall production elasticity to electricity prices, with β^h_2 capturing the amplification effect for energy-intensive sectors. Estimating at various horizons h allows me to distinguish short-run responses with largely fixed production structures from longer-run adjustments, incorporating potential firm relocations.

To distinguish short-run from long-run responses, I estimate this specification at multiple horizons h. Short-run estimates capture immediate adjustments when production structures are largely fixed, while long-run estimates capture the full adjustment including potential firm relocations. Additionally, I implement a long-difference specification in both prices and outcomes, which focuses identification on persistent rather than transitory price variation and better captures the cumulative effects of sustained price differentials that are most likely to trigger location decisions.

To isolate the intensive margin, I focus on multinational firms with establishments in multiple countries and exploit within-firm price differentials. The specification compares activity at a given location to the firm's activity-weighted average price across all other locations, controlling for firm-time fixed effects that absorb any firm-level shocks. This within-firm variation identifies how multinationals reallocate production across existing locations in response to relative price changes, abstracting from entry and exit decisions. The coefficient on the price differential quantifies the intensive margin elasticity, which directly informs the model's operational cost parameters and captures adjustments that can occur relatively quickly.

The extensive margin combines relocations by incumbent firms and location choices by new entrants. For incumbents, I estimate the likelihood of relocation events, identified from employment shifts in Revelio data, as a function of longer-horizon price differentials between current and alternative locations. For entrants, I employ a conditional logit framework where new firms choose among countries, with electricity prices (interacted with sector electricity intensity) entering as a location attribute. The extensive margin elasticities inform the model's moving cost and entry cost parameters, distinguishing between the high adjustment costs facing incumbents and the location choices of new

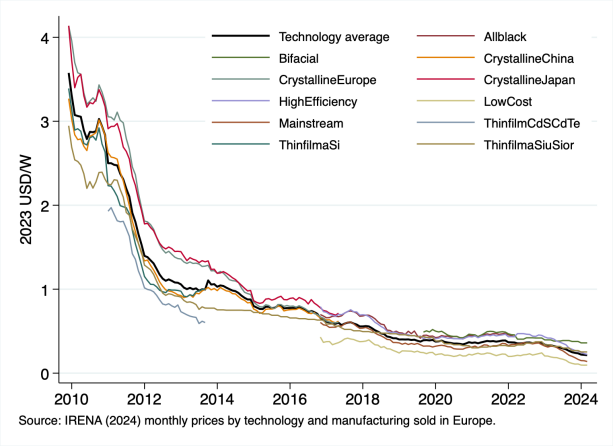
entrants.

Identification

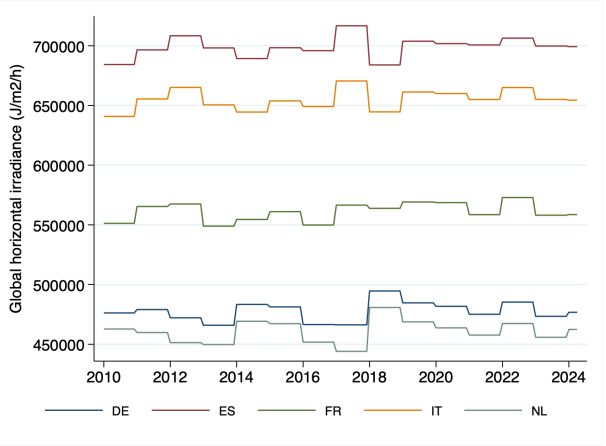
The shift-share instrumental variable $\mu_t \times \omega_{c,t-1}$ exploits a large, persistent shock to solar generation costs, μ_t, combined with differential country exposure to this technology, $\omega_{c,t-1}$. The shift component uses the average price of solar photovoltaic modules sold in Europe, which fell by over 90% between 2008 and 2020, driven by technological innovations and economies of scale in Chinese manufacturing (see Figure 2a). China's majority share of global production, supported by substantial subsidies and large-scale factories, generated cost reductions that were plausibly exogenous to European electricity demand conditions and unexpected by industry and forecasting institutions. The share component reflects countries' differential ability to exploit this technology, measured either by solar radiation intensity, capturing natural resource advantages (Figure 2b), or by pre-existing renewable policy commitments from binding EU-level targets.

Figure 2: Shift-share IV components: solar generation cost reduction

(a) Solar PV module prices



(b) Annual solar radiation by country



Note: Panel a) shows monthly prices of PV modules sold in Europe by technology and manufacturing provided by IRENA. The black line shows average of all solar PV modules sold in Europe at the time. Panel b) shows Global horizontal irradiance (GHI) by country from the IEA, which measures the density of solar resources available per horizontal surface area, including both direct and diffuse radiations.

Although solar rarely sets the marginal price in wholesale electricity markets, it affects prices inframarginally by displacing more expensive generation sources. Preliminary first-stage estimates confirm the instrument's strength, estimating that a one stan-

dard deviation shock to solar costs reduces electricity prices by 15-20% over a year, with F-statistics well above conventional thresholds across various fixed effect specifications. The instrument satisfies the exclusion restriction provided that Chinese solar manufacturing innovations do not directly affect European firm production or location decisions except through their impact on electricity prices. This seems a plausible assumption given the supply-driven nature of the cost reductions and China's strategic industrial policy objectives.

Within-country evidence: Italy and the USA

I plan to use two cases of within-country price variation to examine whether results on the reallocation margins are robust to non-price cross-country differences and valid outside of the European context.

Within Europe, Italy is the country split into the most within-country bidding zones with six zones between which prices can vary (Nord, Centro-Nord, Centro-Sud, Sud, Sardegna, Sicilia). Price variation between these zones is not as high as between countries, but reallocing production across them will likely come at a lower cost. A specification will then be indexed by zone z within country c, instead of c itself. Time fixed effects will absorb any national confounders such as policy, regulation, or demand shocks, which are absorbed when focusing on cross-sectional variation across zones.

$$\log(y_{f,s,z,t}) = \beta \log(p^{elec}_{z,t}) + \theta_{f,t} + \alpha_{z,s} + \delta X_{z,t} + \varepsilon_{f,z,t} \tag{1}$$

The US also has regional differences in electricity prices due to segmentation into several largely distinct markets (ERCOT, PJM, CAISO, etc.). Using data on US firms will allow me to test for price elasticity at different margins across these markets to determine whether price differences also lead to changes in production allocation within the US.

Linking empirical estimates to the model

The empirical estimates will serve to discipline the model's key parameters and validate its core mechanisms. The overall price elasticity from the baseline specification identifies the combined effect of production technology and adjustment frictions. The intensive margin estimates isolate within-firm reallocation responses, which inform the ratio of operational fixed costs to the gains from relocating production across locations. Extensive

margin estimates separately identify moving costs F_s^M from the frequency and magnitude of incumbent responses and entry costs F_s^e from new firm location patterns. The heterogeneous responses across sectors by electricity intensity provide variation to estimate sector-specific parameters, while the differential dynamics across short-run and long-run horizons help calibrate the moving costs.

4 Policy scenarios

The estimated model enables evaluation of several policy-relevant counterfactuals that assess the productivity implications of alternative electricity market configurations and renewable transition paths. The analysis will focus on three main scenarios that inform ongoing European energy policy debates.

4.1 Efficient benchmark: electricity union

The first counterfactual considers a hypothetical fully integrated European electricity market where prices equalise across countries, eliminating the current price dispersion driven by national bidding zones and limited transmission capacity. This scenario provides a benchmark for production allocation if electricity costs no longer influenced firm location decisions across countries.

Implementing this counterfactual requires constructing a measure of where production should efficiently locate absent price distortions. The challenge is that industry locations reflect many factors beyond electricity prices (e.g. sector-specific productivity, skill availability, infrastructure, and existing agglomeration economies). Equalising prices in the model without a clear efficiency benchmark might conflate beneficial reallocation when moving production to fundamentally productive locations with welfare-reducing disruption of existing efficient clusters.

The approach will use pre-divergence sector-country productivity measures to identify fundamental comparative advantages. Using data from the pre-period, I will estimate sector-country TFP from sources such as CompNet, adjusting for any contamination from electricity prices by controlling for sectoral electricity intensity. This provides a measure of which countries have genuine advantages in energy-intensive sectors, independent of current electricity cost advantages. An alternative approach would be to use skill composition and R&D intensity by sector-country, which should predict sectoral productivity

independent of input prices. The model can then simulate equilibrium firm locations under equalised electricity prices, with production allocating according to these fundamental productivity measures. The gap between this efficient allocation and the current distorted allocation quantifies the total productivity costs of electricity market fragmentation.

4.2 Constrained electricity integration

The electricity union scenario represents an ideal but potentially infeasible benchmark, as fully equalising prices would require transmission capacity far beyond what is physically or politically achievable. A more policy-relevant counterfactual respects actual grid constraints while exploring realistic transmission investments.

This scenario will model the effects of expanding cross-border transmission capacity, for example by doubling current interconnection capacity on key corridors, or implementing planned infrastructure projects like additional France-Germany or Spain-France connections. The model incorporates bilateral transmission constraints, allowing prices to partially equalise where infrastructure permits, while maintaining segmentation where capacity restrictions bind.

4.3 Divergent renewable transitions

The final exercise examines the productivity implications of countries following different renewable adoption trajectories. Using announced national energy policies, such as Germany's coal phase-out by 2030, France's nuclear expansion plans, and varying renewable energy targets across countries, I will project forward the evolution of electricity prices under these divergent paths.

The counterfactual compares this divergent transition scenario to an alternative coordinated path where countries synchronise their renewable adoption to limit price divergence. This quantifies the costs of uncoordinated green transitions generating aggregate productivity losses through spatial misallocation.

5 Plan ahead

I am planning to use this project as a job market paper, and hence will spend most of my time over the next year on it. See below a planned schedule of completion over the next year.
Completed

- European cross-country data assembled
- Solar IV constructed and first stage tested
- Theoretical framework specified with equilibrium characterisation

By end of 2025

- Solving the model analytically
- Refine productivity measurement and decomposition
- Firm-level empirical estimates for EU

By spring 2026 (pre-conference)

- Model estimation complete
- Policy counterfactual simulations (announced renewable paths, market integration scenarios)
- Preliminary draft

By fall 2026 (conference)

- Incorporate feedback from pre-conference
- Firm-level empirical estimates for US and Italy
- Full edited draft

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