Electricity Prices and Inflation: Pass-Through and the Renewable-Generation Question in a European Panel

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ABSTRACT

This paper asks whether electricity price growth passes through to inflation across a panel of five European countries (Germany, Italy, Norway, Poland, and Sweden) from January 2021 to July 2026, and whether that pass-through is shaped by how the electricity itself is generated. Using a country fixed-effects specification, electricity price growth passes through to inflation, at a magnitude of roughly 0.037 to 0.041 points of inflation per point of price growth, holding stable before and after the 2022 energy crisis. However, the effect is no larger than what you would expect simply because electricity is one of the things consumers pay for, and electricity prices do not raise core inflation (inflation excluding energy and food). This suggests the relationship is largely mechanical rather than evidence of broader, economy-wide cost-push inflation. A second, finer zone-level panel of Norway's and Sweden's electricity bidding zones then tests whether renewable generation share lowers wholesale electricity prices, the "merit-order effect". Here the results are genuinely inconclusive: fixed-effects models find no significant moderating relationship, though this likely reflects the panel's limited independent variation in renewable share rather than the absence of a true effect.

1. INTRODUCTION

The winter of 2021-2022 brought an electricity price shock unlike anything the EU had seen in decades. Already in the summer of 2021, energy prices began rising: lower-than-usual hydro and nuclear output pushed up gas use for electricity and tightened gas markets. The Russian invasion of Ukraine in February 2022 acted as another factor in the continuation of the increase of energy prices (Gil Tertre, Martinez, & Rivas Rábago, 2023). Most notably the invasion resulted in the decline of Russian piped gas supplies to the EU, on which much of Europe's power generation still depended (International Energy Agency, 2023). Headline inflation rose alongside, reaching record highs. The coincidence of these two events affected both the policy makers and the public, where electricity prices became one of the most economically and politically salient and central parts of the European economy.

This raises an obvious question: since these two variables (electricity price and headline inflation) experienced similar trends during the same time frame, was the inflation in Europe caused by electricity prices, and to what extent? Answering this question can be tricky since the correlation can conflate real transmission with "lucky timing" of shared trends. A way of disentangling these two is by tracking

variation within countries over a time frame after removing structural differences between them that are not relevant to the question.

This paper first estimates this relationship between electricity price growth and headline consumer price inflation (HICP). It does this by using a monthly panel of the five EU countries Germany, Italy, Norway, Poland, and Sweden. Here it is important to note that Norway is not a part of the EU, but its electricity grid remains both physically and economically connected to it, such as NordLink, a subsea cable that directly connects southern Norway (NO2) to Germany's electricity market (Bjørndal, Bjørndal, Hovdahl, & Tselika, 2025). These five countries were chosen with specific purpose, as the energy market structure differs across them: heavy fossil-fuel dependence (Poland), a diversified but gas-exposed system (Germany, Italy), and near-total renewable generation (Norway, Sweden).

This will be of importance further on as this paper also asks another question: what is the relationship between electricity price pass-through to inflation and countries' renewable share of energy. By utilising this monthly panel, a country-fixed-effects specification isolates the within-country co-movement of electricity prices and inflation from any permanent cross-country differences in price levels, energy mix, or consumption baskets. Four robustness checks, reported separately in Section 4.3, then test whether the originally analysed relationship is immediate or delayed, linear or crisis-dependent, and symptomatic of broader cost-push inflation.

The paper then turns to the renewable-energy question more directly. It does this by using a novel method that includes finer geographical resolutions than the conventional way of national aggregates. By using a zone-level panel of Norway's 5 bidding zones and Sweden's 4 bidding zones, where the markets are small enough that the renewable share can vary meaningfully even within a country itself, this paper tests the "merit-order effect". This according to conventional renewable-energy economics literature is the proposition that since wind, solar and hydro generation is near-zero-marginal-cost, it displaces other forms of conventional energy since they are more expensive marginal producers, which should result in lowering wholesale electricity prices (Clò, Cataldi, & Zoppoli, 2015; Patzelt, 2025). The zone-level data allow a more direct test of this mechanism than national averages can provide.

2. LITERATURE REVIEW

2.1 The 2022 European energy crisis

This paper does not treat the 2022 shock as having a single cause; rather it also acknowledges the political and economic climate predating the Russia–Ukraine war that started in February 2022. In the summer of 2021, gas markets had already begun tightening because hydro and nuclear output had fallen to below-average levels in Europe. This ended up pushing electricity generators towards gas-fired plants, simultaneously as the global demand was trying to recover from the COVID pandemic (International Energy Agency, 2023). Hence, when Russia invaded Ukraine in the month of February 2022, the war added to the current situation rather than causing the shock, by removing a large share of the pipeline gas

that Europe was now heavily dependent on (Alessandri & Gazzani, 2023). Furthermore, some other studies claim that in the years preceding the war, Europe's dependence on Russian energy exports had grown. Hence, the war can be seen as an added shock on top of a preexisting, slow-building structural exposure (Jegorow & Rubaj, 2026). Based on these views, this paper establishes an empirical basis for a post-war variable: the war in February-March of 2022 is a clear, major shock for the EU, but is treated as a robustness check that seeks to answer whether the relationship between electricity price and inflation remained the same or changed, rather than being the origin of it, since the shock's roots clearly predate it.

2.2 Energy price pass-through to headline and core inflation

The question of how much the increase in energy prices actually contributed to the 2022-2023 inflation surge (and whether that contribution remained only significant in headline inflation or was able to seep through into other metrics such as core inflation) is the closest body of work to this paper's central thesis. Neri, Busetti, Conflitti, Corsello, Delle Monache, and Tagliabracci (2023), writing for SUERF, estimate that energy price shocks accounted for nearly 60% of euro-area headline inflation, and roughly 20-30% real pass-through into core inflation. However this remained heavily concentrated in the direct, mechanical component of the price index. Also, López, Odendahl, Párraga Rodríguez, and Silgado-Gómez (2024), in their working ECB paper, test the pass-through of gas price shocks to inflation directly and reach the conclusion that the underlying source of the shock can be an important factor in the magnitude of the effect. When focusing on the pass-through size of energy prices into inflation, a related CEPR VoxEU column (Pallara, Rossi, Sfregola, & Venditti, 2023) reports that pass-through, normally small, roughly quadrupled during 2021–2022. Another study on the dynamic interactions between energy prices and CPI (Cavicchioli, Kyrtsou, & Papana, 2026) uses a time series approach, modelling energy-CPI co-movement as a dynamic rather than static relationship. This paper adopts a similar approach through its own distributed-lag models later on. Finally, the study closest to this paper's design asks directly whether renewable energy reduces the pass-through of energy costs into consumer prices (Altunöz, 2025). That study asks a very similar question but differs in the chosen country sample, hence serving as the most direct point of comparison available for this paper's results.

2.3 Renewable generation and the merit-order effect

The merit-order effect is the main economic rationale and reasoning for why renewable energy generation is expected to lower wholesale electricity prices. Because wind, solar and hydro generation in general tend to have near-zero marginal cost, their presence in the generation will naturally displace other forms of energy production (such as fossil fuel and conventional production) which eventually lowers the price that clears the market. Clò, Cataldi, and Zoppoli (2015) provide the foundational research of this mechanism, by studying the Italian power market. They find that solar and wind power generation does contribute to lowering the national wholesale prices. There is also comparable evidence from outside of the EU (Ajanaku & Collins, 2023, on the PJM market, and Quint & Dahlke, 2019, on the Midcontinent (MISO) market) that supports the same conclusion, which strengthens the statement that this is not merely an EU mechanism, rather that it holds across different regulatory and geographic settings. An extension of

the literature just mentioned and a more direct complication for this paper's specific setting comes from a seasonal, spatial-econometric study of wind and hydro interaction (Wen, Suomalainen, Sharp, Yi, & Sheng, 2022). This study models how only wind and hydro together affect price, rather than treating the entire spectrum of renewable generation as a single undifferentiated category, which is of significant relevance to Sweden's and Norway's different bidding zones that are primarily hydro-dominant. An interesting approach to this question (the relationship between renewable energy production and energy prices) can be found in an LSE CFM discussion paper, Patzelt (2025). The methodology here creatively uses the weather as an indicator of renewable energy production across 17 European countries rather than the systems themselves.

2.4 Norway's integration into the European electricity market

In this paper, Norway is included in the national-level analysis even though it is not a member of the EU. Hence, it is of importance to address that its inclusion in this study is defensible and based on solid ground, rather than arbitrary. The EEA Agreement incorporates EU energy legislation (including the Third Energy Package, a 2009 law designed to open up and connect gas and electricity markets across member states), directly into Norwegian regulation. Furthermore, Norway's regulator participates in ACER, the EU's energy regulatory coordination body (Norwegian Ministry of Energy, n.d.). This integration is not merely political and economic, but it is also physical: Bjørndal, Bjørndal, Hovdahl, and Tselika (2025) did a study on the NordLink subsea cable that connects Germany and Norway's southern bidding zone (NO2), and found that the interconnector integrated the two countries' prices together. Additionally, the study concluded that NO2's exposure to gas price movements and its price volatility both increased, while Germany's experienced the opposite. This can be seen as direct evidence that Norway's electricity prices are directly linked to those of the EU through actual physical infrastructure, rather than indirect correlation by means of coincidences. This is consistent with older literature on Nordic market integration: Amundsen and Bergman (2007) documented the earlier integration of the Norwegian and Swedish electricity markets, which preceded the broader European interconnection that followed. More recently, Silvester (2024) studied the current political and economic feasibility of Norway expanding this interconnection even further, showing that how far Norway's integration could go is still an open policy question. When diving deeper into the zone level of Norway, but also Sweden, a 2026 study of price forecasting across Norway's five bidding zones (Phan, Truong, Ha, & Nguyen, 2026) and an earlier study of Nordic area price spreads (Spodniak, Viljainen, Makkonen, & Jantunen, 2013) both argue that the two countries' bidding zones differ in price mainly due to transmission constraints and local supply-demand conditions.

2.5 The gap this paper addresses

Based on the literature above, this paper aims to establish three things: that energy price shocks passed through to headline inflation during the 2022 shock, and to what extent; whether core inflation was also affected; and whether renewable generation affects wholesale prices. What is new about this study is that it tests energy-inflation pass-through and the renewable-price mechanism together, using both a national

panel and, more importantly, a finer more detailed zone-level panel within the same framework. That combination (national pass-through evidence, a direct zone-level mechanism test, and an explicit accounting of where fixed-effects methods change the answer) is this paper's contribution.

3. DATA AND METHODOLOGY

3.1 National panel: data and construction

The national panel used in this paper covers Germany, Italy, Norway, Poland, and Sweden at monthly frequencies from January 2021 to July of 2026. Headline and core inflation are drawn from Eurostat's Harmonised Index of Consumer Prices database (Eurostat, 2026), which provides both the index levels and the derived series used here: the month-on-month percentage change in the headline and core inflation indices. Core HICP in the Eurostat database excludes energy and food, so it is a useful check since any relationship between electricity prices and Core HICP cannot be attributed to electricity's own presence in the index (as it might be with HICP).

The main regressor at the national level of this paper (the month-on-month percentage change in electricity prices) is also drawn from Eurostat's Harmonised Index of Consumer Prices database (Eurostat, 2026). Here it is important to note that this specific data is a consumer/retail electricity price series, rather than a wholesale market price. Because a part of HICP in itself consists of electricity, this may have direct methodological consequences which matters for interpretation in Section 3.6 below.

The national production mix data, which serves as the foundation for the national-panel renewable share variable, also comes from Eurostat, this time from the table that reports monthly generation by source (combustible fuels, hydro, wind, solar, nuclear, and other sources) for each country. The renewable share variable is constructed as renewable (hydro, wind and solar) generation divided by total generation across all listed sources. The post war indicator equals 1 for observations from March 2022 onward, marking the period following Russia's invasion of Ukraine, whilst the high shock indicator equals 1 for the top 10% of months by electricity price growth, which is used as a robustness check for crisis-interaction.

3.2 Zone panel: data and construction

The zone-level panel narrows the geographic entity from country to electricity bidding zone. This paper covers all four of Sweden's zones (SE1–SE4), but only three out of the five Norwegian zones (NO1, NO2, NO5). NO3 and NO4 are excluded because Statistics Norway withholds their hydro data for confidentiality reasons (1 of 68 possible months non-missing for NO3, 3 of 68 for NO4).

The production data of these two countries' zones comes directly from their specific national statistical offices: Statistics Sweden (SCB, 2026) for all Swedish bidding-zone production categories, and Statistics Norway (SSB, 2026, table 14093) for Norwegian bidding-zone production. However, these two sources label their categories differently; for example, Norway's and Sweden's raw files each used

country-prefixed category names rather than a shared naming convention. So, this paper made the categories into a common set (Hydro, Wind, Solar, Total Production, plus Sweden-only Nuclear and Conventional categories, zero-filled for Norway) before reshaping them from long to wide format. The monthly zone-level price data for Sweden comes from Elbruk (2026), and Norway's comes from Fraunhofer ISE's Energy-Charts platform (Fraunhofer ISE, 2026). This was because neither SCB nor SSB publish official zone-level price data. Similarly to the national panel level discussed above, the renewable share variable at the zone level is constructed by dividing renewable production (hydro + wind + solar) by total production.

Lastly, two data-cleaning decisions were made after inspecting the constructed panel for anomalies. August 2026 was dropped as an incomplete month still in progress at the time of data collection, and Norway's price data showed literal zero values in several 2025 months (March, April, June through September). Rather than treat these as genuine zero prices, they were recorded as missing, reflecting confirmed data unavailability for those months.

3.3 Descriptive statistics

Before turning to the actual regression results, summary statistics are firstly reported for both panels to explain the scale and spread of the underlying data. For the national panel, means, standard deviations, minimums, and maximums are computed for the variables: HICP_mroc, Core_HICP_mroc, Electricity_Price_mroc, and renewable_share, pooled across the full sample. For the zone panel, the same statistics are computed for the variables Price_EUR_Gwh, Price_mroc, renewable_share, and the underlying production components (hydro, wind, solar, nuclear, conventional, and total production), first pooled across all seven zones and then broken down by individual zone and by country. Reporting the zone-level statistics both pooled and by group is deliberate. Because the empirical strategy throughout this paper relies heavily on within-entity variation (Section 3.4), it matters not just what the sample looks like on average but how much genuine variation exists within each zone and country individually. The tables named above and short interpretations for each are presented alongside the regression results in the Results Section.

3.4 Empirical strategy

The core empirical challenge of this paper, as discussed in the introduction, is to try to separate genuine within-country transmission from electricity prices to inflation from confounding due to notable, permanent cross-country (or cross-zone) differences. This is achieved by running a fixed-effects panel regression:

$$HICP_mroc(i,t) = \alpha(i) + \beta \cdot Electricity_Price_mroc(i,t) + \varepsilon(i,t)$$

Where i indexes country (or zone, in the zone-level analysis), and t indexes month. α(i) is a full set of entity fixed effects, absorbing any time-invariant differences between countries (such as price levels,

energy mix, consumption basket composition, etc.) so that β is identified from within-country co-movement alone. Furthermore, given the panel's short cross-sectional dimension (5 countries nationally, 7 zones at the zone level), standard errors are clustered by entity throughout, following Cameron and Miller (2015).

3.5 Robustness checks

Four additional checks are included with the main purpose of testing the robustness and character of the baseline relationship. The first is timing: a distributed-lag equation tests whether the relationship is contemporaneous or delayed, by including electricity price growth (Electricity_Price_mroc) at the current month alongside its own values from each of its preceding six months:

$$HICP_mroc(i,t) = \alpha(i) + \beta0 \cdot Electricity_Price_mroc(i,t) + \beta1 \cdot Electricity_Price_mroc(i,t-1) + \beta2 \cdot Electricity_Price_mroc(i,t-2) + \beta3 \cdot Electricity_Price_mroc(i,t-3) + \beta4 \cdot Electricity_Price_mroc(i,t-4) + \beta5 \cdot Electricity_Price_mroc(i,t-5) + \beta6 \cdot Electricity_Price_mroc(i,t-6) + \varepsilon(i,t)$$

Two other models test the 6-month and 12-month lags in isolation instead, outside of the distributed structure above, to check whether either result holds up independently of the multicollinearity that may arise when correlated lag terms are estimated at the same time within the same equation:

$$HICP_mroc(i,t) = \alpha(i) + \beta \cdot Electricity_Price_mroc(i,t-6) + \varepsilon(i,t)$$
$$HICP_mroc(i,t) = \alpha(i) + \beta \cdot Electricity_Price_mroc(i,t-12) + \varepsilon(i,t)$$

The second check evaluates sensitivity to the 2022 crisis in two different ways. One is a crisis-shock interaction, which tests whether the relationship intensifies during extreme-shock months rather than holding uniformly, by interacting electricity price growth with the high_shock indicator (Section 3.1):

$$HICP_mroc(i,t) = \alpha(i) + \beta1 \cdot Electricity_Price_mroc(i,t) + \beta2 \cdot high_shock(i,t) + \beta3 \cdot [Electricity_Price_mroc(i,t) \times high_shock(i,t)] + \varepsilon(i,t)$$

In this model β3 is the coefficient of special interest, capturing whether the price-inflation relationship is steeper specifically during high-shock months, over and above the baseline relationship captured by β1.

The other is a pre/post-war split, which tests whether the relationship changed following Russia's invasion of Ukraine, by estimating the baseline specification from Section 3.4 separately on the subsample where post_war(i,t) = 0 and again on the subsample where post_war(i,t) = 1, treated here as a check on an already-existing relationship rather than as its origin, given that gas markets had already tightened in the summer of 2021 (Section 2.1).

The third check replaces headline inflation with core inflation. Here a Core HICP specification substitutes the core inflation measure for the dependent variable, testing whether the relationship extends beyond electricity's own direct presence in the headline index:

$$Core_HICP_mroc(i,t) = \alpha(i) + \beta \cdot Electricity_Price_mroc(i,t) + \varepsilon(i,t)$$

The fourth and final check tests whether a country's renewable generation share contributes to the price-inflation relationship, estimated both with fixed effects and, separately, without them, to show the effect of cross-country confounding on this particular test:

$$HICP_mroc(i,t) = [\alpha(i) +] \beta1 \cdot Electricity_Price_mroc(i,t) + \beta2 \cdot renewable_share(i,t) + \beta3 \cdot [Electricity_Price_mroc(i,t) \times renewable_share(i,t)] + \varepsilon(i,t)$$

Here β3 is again the coefficient of interest: it tests moderation directly, since it captures whether the slope of the price-inflation relationship itself changes as renewable share changes. The bracketed α(i) term is included in the fixed-effects version of this specification and omitted in the pooled version, which is what allows the comparison between the two to isolate the effect of cross-country confounding. The results of these four checks are reported in Section 4.3.

3.6 A note on interpreting the baseline coefficient

Because electricity's month-on-month change is itself a component of the HICP basket (Section 3.1), most likely any relationship between it and headline HICP will be mechanical. HICP is a weighted average of its sub-indices, and electricity's own movements are guaranteed to show up in headline HICP in nearly the same proportion to electricity's basket weight, independent of any broader economic transmission. To actually be able to tell and assess how much of the baseline coefficient reflects the honest relationship, rather than merely a co-movement with the rest of the basket, electricity's actual HICP weight for each country (Eurostat, 2026) is compared directly against the estimated coefficient (presented in Section 4.1.3).

4. RESULTS

4.1 National panel results

4.1.1 Descriptive statistics

Variable	N	Mean	SD	Min	Max
HICP_mroc (%)	332	0.387	0.694	−1.80	3.80
Core_HICP_mroc (%)	332	0.309	0.702	−2.20	2.40
Electricity_Price_mroc (%)	327	1.008	8.305	−27.50	59.20
renewable_share	328	0.542	0.268	0.109	0.993

Table 1. National panel — descriptive statistics

Electricity price growth is far more volatile than the other two variables, Core HICP and HICP (SD 8.3 versus roughly 0.7 for both HICP measures), serving as the first indicator of a large swing in electricity prices translating into a comparatively small, but consistent, swing in headline inflation, consistent with the basket-weight argument mentioned in Section 4.1.3. The renewable share, according to the table, ranges approximately from 11% (Min 0.109) to 99% (Max 0.993), which reflects the mix of countries included, from fossil/nuclear-heavy Poland and Germany to hydro-dominant Norway.

4.1.2 The baseline relationship

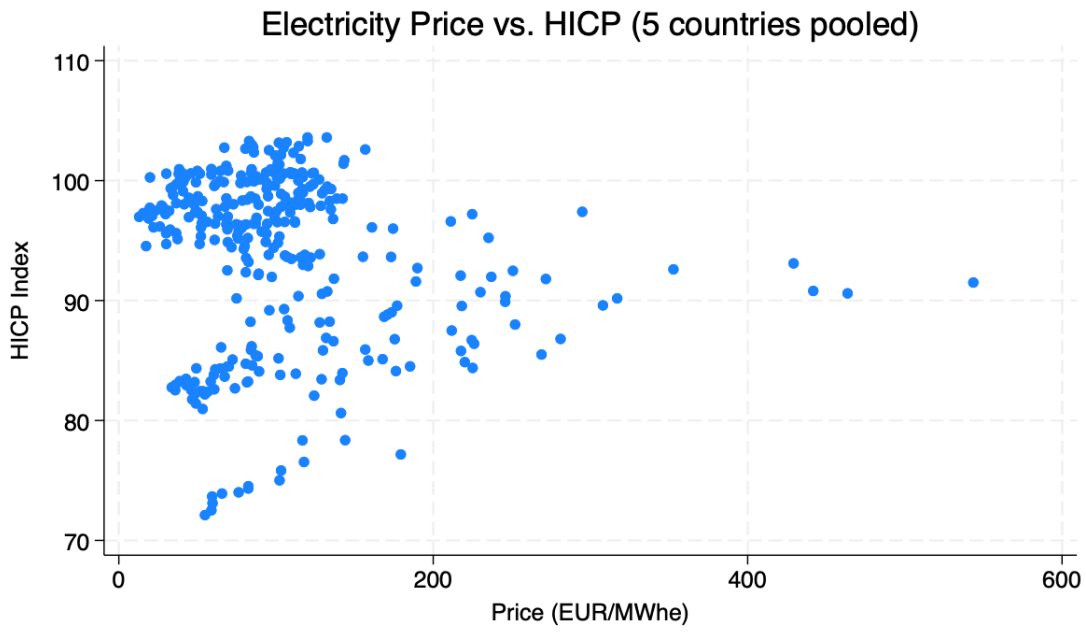
	(1) Pooled OLS	(2) Country FE
Electricity_Price_mroc	0.0372***	0.0374***
	(0.0055)	(0.0015)
	$p < 0.001$	$p < 0.001$
	$t = 6.71$	$t = 25.13$
	95% CI [0.0263, 0.0481]	95% CI [0.0333, 0.0415]
Constant	0.3518	0.3516
	(0.0341)	(0.0015)
corr(u_i, Xb)	—	−0.0134

	(1) Pooled OLS	(2) Country FE
rho	—	0.0263
Country fixed effects	No	Yes
Standard errors	Robust	Clustered (5 countries)
N	327	327
R^2	0.1985	0.2030 (within)

Table 2. National panel — baseline relationship*Standard errors in parentheses; p-values on the third line for the row of interest. *** p < 0.01, ** p < 0.05, * p < 0.10, read directly off the p-value row above, not off the standard error. The constant's p-value is omitted in this section: in the fixed-effects columns it reflects the demeaned intercept rather than any single country's actual level, so its statistical significance isn't of major significance here.*

The pooled OLS specification (Model 1), which does not pay attention to country identity at all, shows a strong association (Table 2, column 1): a coefficient of 0.0372 (robust SE 0.0055, p < 0.001), with electricity price alone accounting for roughly 20% of the variation in headline inflation across the pooled sample (R^2 = 0.1985). Figure 1 shows this relationship visually before imposing any country structure on it.

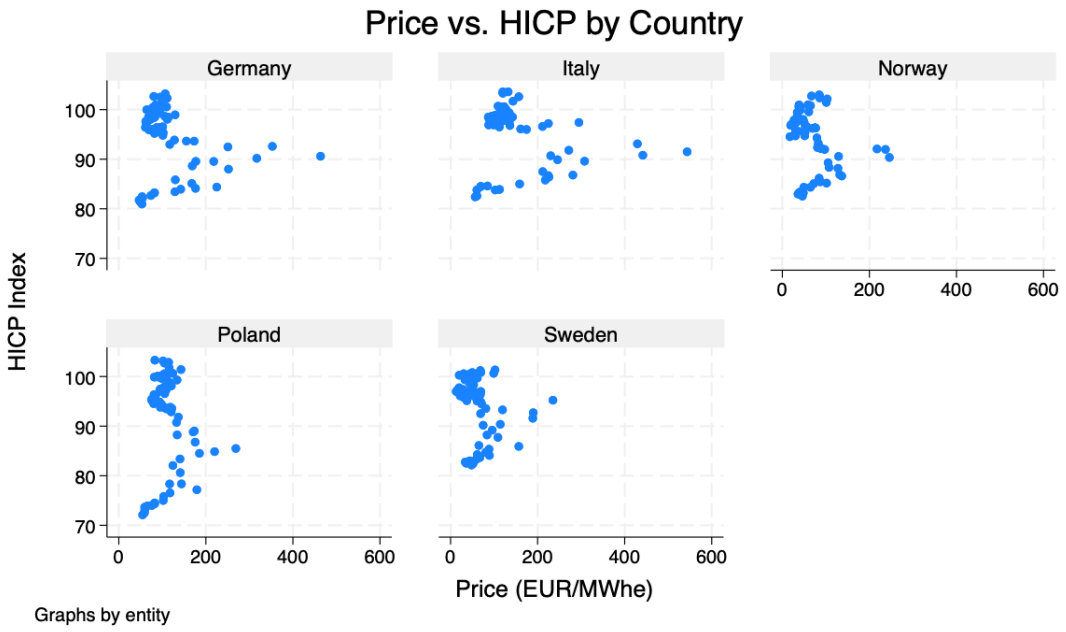
Figure 1: *Electricity Price and HICP Index, Pooled Across Five Countries*



Note. Author's calculations based on Eurostat (2026), table PRC_HICP_MINR. Each point is one country-month observation (N = 327).

There are permanent differences between countries that Model 1 is unable to separate. So, Model 2 adds country fixed effects to isolate the within-country effect from the between-country confounding present in Model 1 (Table 2, column 2). The coefficient barely moves compared to the pooled OLS specification (0.0374 versus 0.0372), but one thing that does see a difference is the standard error, which tightens sharply once clustered by country (0.0015 versus 0.0055). The t-statistic gets pushed from 6.71 to 25.13, and the 95% confidence interval gets narrowed down to [0.0333, 0.0415]. The corr(u_i, Xb) diagnostic (Table 2) is close to zero (−0.0134) and rho is just 2.63%, meaning almost none of the total variance is attributable to permanent cross-country differences, rather the relationship is carried almost entirely by within-country co-movement. Figure 2 shows this: all five nations see a near-identical slope, which is what a common, within-country relationship should look like.

Figure 2: *Electricity Price and HICP Index, by Country*



Note. Author's calculations based on Eurostat (2026), table PRC_HICP_MINR. Panels share axis scales to allow direct visual comparison of slope across countries.

4.1.3 Is the baseline relationship mechanical or economic?

Country	2021	2022	2023	2024	2025	5-year average
Germany	2.985%	3.000%	2.963%	3.318%	2.629%	2.979%
Italy	2.268%	2.387%	3.315%	2.902%	3.060%	2.786%
Norway	3.270%	5.825%	5.301%	4.064%	4.768%	4.646%
Poland	2.864%	2.807%	2.387%	2.679%	2.856%	2.719%
Sweden	4.337%	5.342%	7.050%	4.550%	3.846%	5.025%
Panel average						**3.631%**

Table 3. Electricity's weight in the national HICP basket (COICOP CP0451)

Source: Eurostat (2026), table prc_hicp_inw, COICOP category CP0451 (Electricity).

Table 4. Basket weight vs. Model 2 coefficient — statistical comparison

Quantity	Value
Model 2 coefficient (β)	0.0374
Model 2 clustered SE	0.0015
Panel-average electricity HICP weight	0.0363
Difference (β − weight)	0.0011
z-statistic	0.73
p-value	0.47

$z = (\beta - \text{weight}) / SE = (0.0374 - 0.0363) / 0.0015$. Not significant at any conventional threshold — the coefficient and the weight are statistically indistinguishable.

Electricity's average weight in the HICP basket across the five countries and the five years of the panel is 3.631% (Table 3). Model 2's coefficient (Table 2) is almost exactly the same as this figure (0.0374); a direct test (Table 4) confirms the fact that they are statistically indistinguishable. Simply put, the headline result is consistent with electricity prices moving headline HICP by roughly the same amount their own basket weight does, with no additional co-movement detectable beyond that. This does not imply that the relationship is only spurious, but electricity genuinely is part of the basket, and this is a real, correctly measured pass-through. However, it does mean Model 2 on its own cannot be read as evidence that electricity prices are driving broader, economy-wide inflation. That question is what Model 7 (Core HICP), in Section 4.3.3, tests directly.

4.2 Zone panel results

4.2.1 Descriptive overview

Table 5. Zone panel — descriptive statistics, pooled

Variable	N	Mean	SD	Min	Max
Price (EUR/GWh)	451	71,345	59,839	970	442,700
Price growth, mroc (%)	438	28.71	253.23	−94.48	3,659.79
Renewable share	454	0.841	0.246	0.198	0.999
Hydro (GWh)	460	1,953.8	1,319.8	18	5,984.8
Wind (GWh)	459	488.2	440.5	0	2,432
Solar (GWh)	465	39.5	85.7	0	489
Nuclear (GWh)	465	564.0	1,413.0	0	5,124
Conventional (GWh)	465	161.9	225.2	0	1,173
Total production (GWh)	469	3,222.0	1,926.3	454	8,255

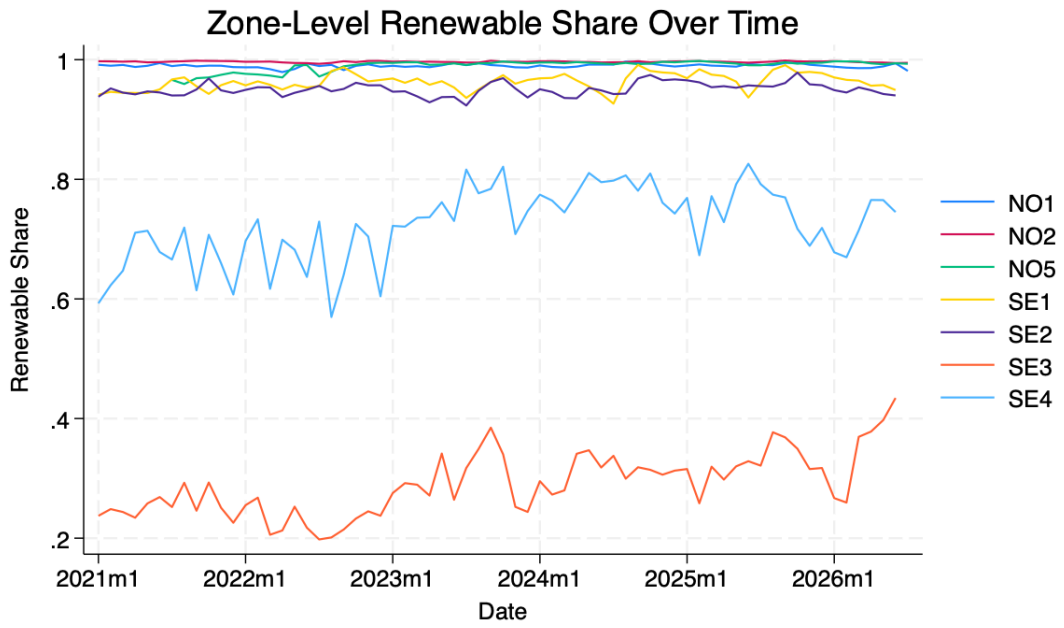
Pooled across all seven zones. Price is highly volatile at this level — its standard deviation (Table 5) is nearly as large as its mean — and the month-on-month growth rate is even more extreme. This is the reason the level variable (Price_EUR_Gwh) rather than the growth rate is used as the dependent variable in every regression below.

Table 6. Zone panel — price and renewable share, by zone

Zone	Price mean	Price SD	Price min	Price max	Renewable share mean	Renewable share SD	Renewable share min	Renewable share max
NO1	91,982	68,834	980	354,720	0.990	0.003	0.979	0.997
NO2	99,824	76,849	20,070	442,700	0.997	0.001	0.993	0.999
NO5	93,980	72,931	970	354,720	0.990	0.009	0.959	0.998
SE1	37,058	28,895	2,760	186,385	0.963	0.014	0.927	0.991
SE2	37,473	28,888	4,516	186,457	0.951	0.011	0.923	0.978
SE3	65,011	43,705	7,729	243,463	0.290	0.053	0.198	0.434
SE4	80,516	47,134	27,286	276,016	0.724	0.062	0.570	0.826

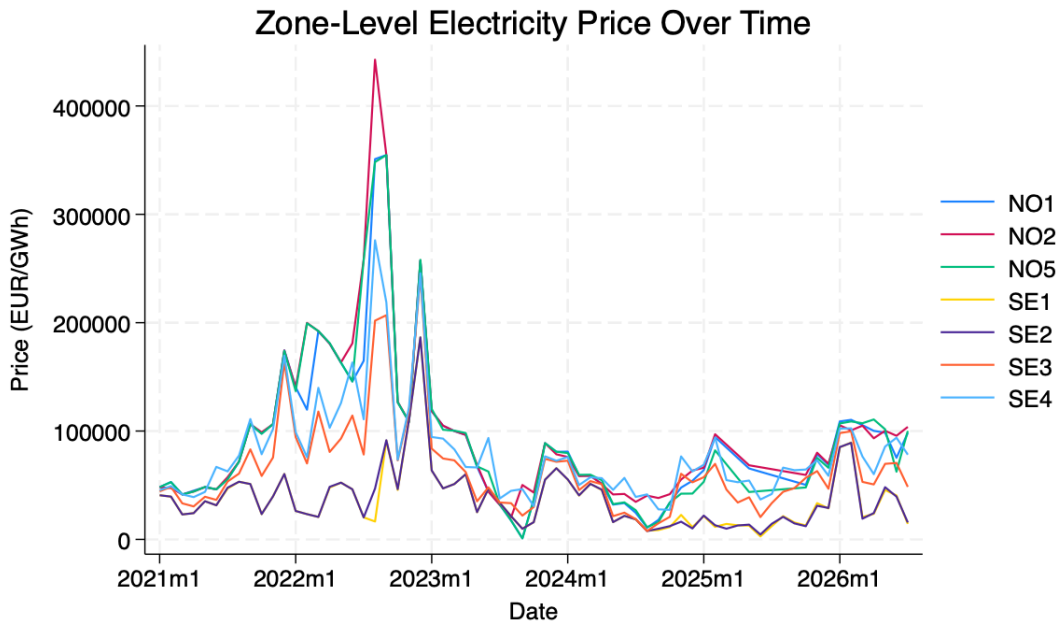
Renewable share is clearly split into three different groups (Table 6): Norway's three zones together with Sweden's SE1 and SE2 all sit roughly at 0.95–1.00, SE4 sits at 0.724, and SE3 sits markedly lower at 0.290. Figure 3 shows this separation directly, whilst Figure 4 shows their corresponding price paths, including the shared 2022 crisis spike, reaching the panel's maximum value of EUR/GWh, with Norway's NO2 zone at 442,700 EUR/GWh (Table 6).

Figure 3: *Zone-Level Renewable Share Over Time*



Note. Author's calculations based on Statistics Sweden (SCB, 2026) and Statistics Norway (SSB, 2026, table 14093).

Figure 4: *Zone-Level Electricity Price Over Time*



Note. Author's calculations based on Elbruk (2026) for Swedish zones and Fraunhofer ISE (2026) for Norwegian zones.

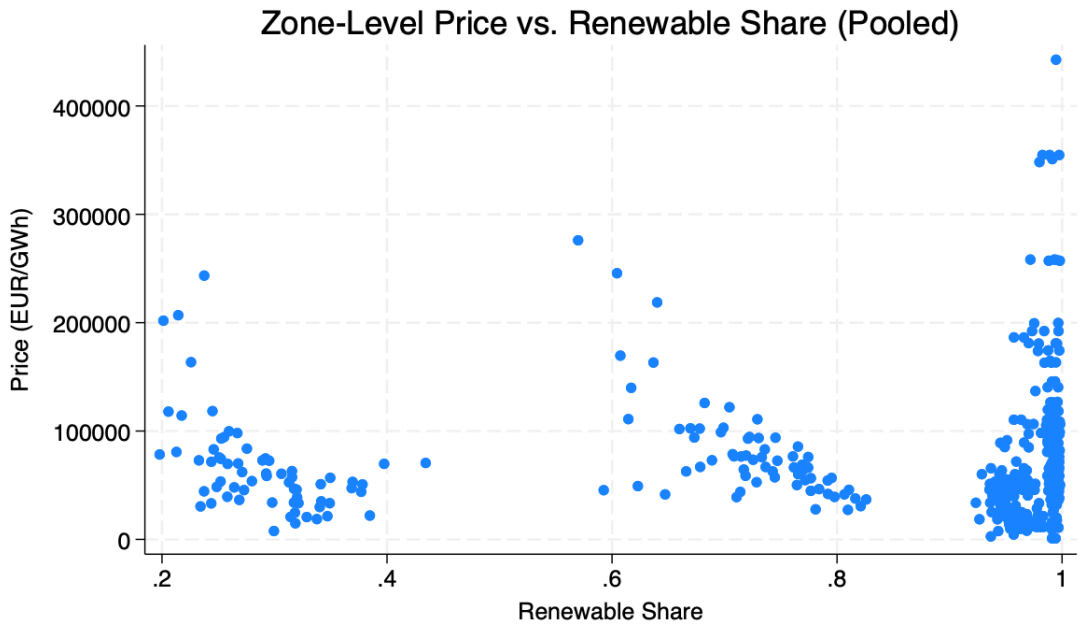
4.2.2 Renewable share and price: a Simpson's paradox

Table 7. Zone panel — correlation between renewable share and wholesale price

Sample	N	Correlation (r)	p
Pooled, all 7 zones	436	0.0152	0.752
Norway only (NO1, NO2, NO5)	172	−0.2402	0.0015
Sweden only (SE1–SE4)	264	−0.3403	<0.001

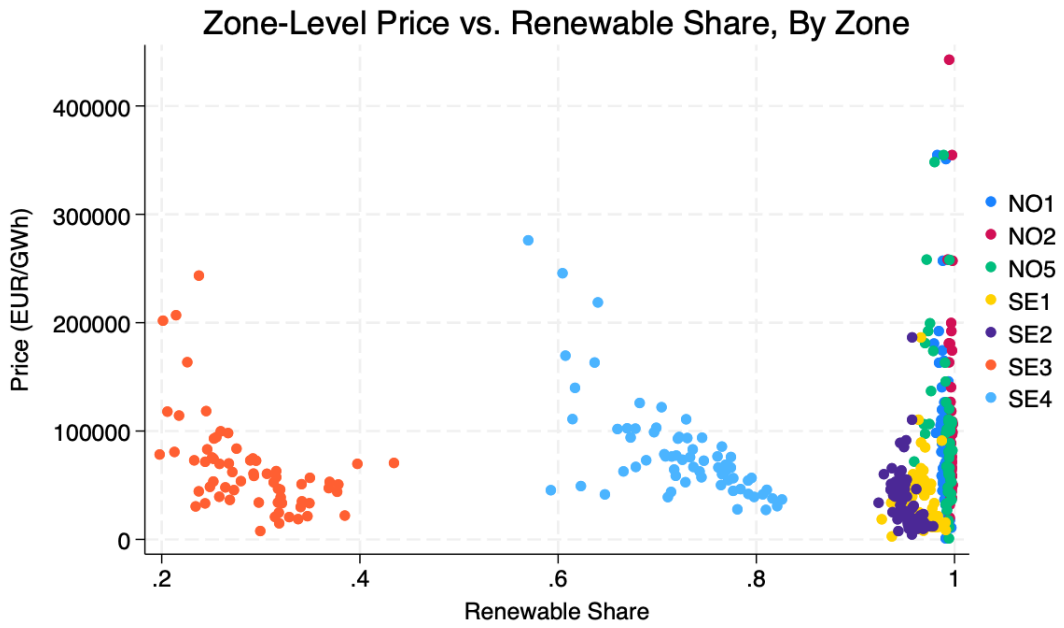
When all 7 zones are pooled together, one can clearly see that the correlation is basically non-existent, sitting at a mere value of 0.0152 (Table 7). However, when split by country, a clear negative relationship emerges in both Norway and Sweden (−0.2402 and −0.3403). Figures 5 and 6 visually present this, as when the zones are pooled one is unable to distinguish a clear pattern, while the by-zone version shows Norway and Sweden sitting as two separated clusters, each sloping downward on its own.

Figure 5: *Zone-Level Price vs. Renewable Share, Pooled*



Note. Author's calculations based on Elbruk (2026), Fraunhofer ISE (2026), Statistics Sweden (SCB, 2026), and Statistics Norway (SSB, 2026, table 14093).

Figure 6: *Zone-Level Price vs. Renewable Share, by Zone*



Note. Author's calculations based on Elbruk (2026), Fraunhofer ISE (2026), Statistics Sweden (SCB, 2026), and Statistics Norway (SSB, 2026, table 14093). NO1, NO2, and NO5 are Norwegian zones; SE1–SE4 are Swedish zones.

This is a striking example of Simpson's paradox: On average Norway's zones have higher renewable share as well as higher average prices than Sweden (Table 6). When these are pooled together, their between-country differences mask the within-country relationship, cancelling it out completely.

4.2.3 Fixed-effects regressions: Models A and B

Table 8. Zone panel — renewable share and wholesale price

	(1) Model A	(2) Model B (+ month FE)
renewable_share	−522,005***	−49,156
	(48,075.5)	(134,588)
	p < 0.001	p = 0.727
Month fixed effects	No	Yes
corr(u_i, Xb)	−0.9737	−0.0885
N	436	436
Within R^2	0.0947	0.7367

*Standard errors clustered by zone in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10. corr(u_i, Xb) is reported here because it is the diagnostic that explains why column 1 should not be read at face value.*

Model A, with zone fixed effects only, returns a strikingly large coefficient (Table 8, column 1) that is larger than nearly the entire observed range of the price variable (Table 5), and not a plausible marginal effect. corr(u_i, Xb) (Table 8) is close to −1, indicating the estimate is dominated by a small number of high-leverage observations rather than a general relationship, almost certainly the shared 2022 price spike visible in Figure 4 and in Table 6, which hit Norway's near-100%-renewable zones hardest.

Model B adds a fixed effect for every calendar month, which compares each zone's price only to other zones in that same month, stripping out the shared crisis shock before estimating renewable share's effect. Once that is done, the coefficient collapses and loses significance entirely (Table 8, column 2); corr(u_i, Xb) falls to a far more reasonable level, confirming that Model A's inflated estimate was substantially riding on the shared time trend.

Hence, these results indicate that this panel does not provide robust evidence that renewable share actually lowers wholesale electricity price (since Model A shows a correlation that is entirely dependent on a few values rather than the actual long-term trend). With only seven zones here (where only Sweden's SE3 and SE4 supply meaningful independent within-unit variation in renewable share), there is not enough independent variation within this panel alone to detect a moderating effect of energy mix with confidence.

4.3 Robustness checks

4.3.1 The timing of the pass-through

Table 9. National panel — distributed-lag specification (Model 3)

Lag	Coefficient	SE	p
Contemporaneous	0.0393	0.0030	<0.001
1 month	0.0033	0.0015	0.101
2 months	−0.0018	0.0046	0.710
3 months	0.0067	0.0039	0.164
4 months	0.0034	0.0052	0.550
5 months	0.0036	0.0033	0.341

Lag	Coefficient	SE	p
6 months	0.0086	0.0052	0.175
6 months, isolated (Model 4)	0.0057	0.0074	0.486
12 months, isolated (Model 5)	0.0001	0.0066	0.983

The first seven rows are all from Model 3's single distributed-lag regression (N = 294). The last two rows are separate, single-lag regressions (Model 4, N = 302; Model 5, N = 272) included to check the 6- and 12-month lags outside the distributed-lag structure, where multicollinearity among adjacent lag terms could otherwise mask a real effect.

The main purpose of the distributed-lag specification (Model 3) is to test whether the relationship is immediate or delayed, by including electricity price growth alongside its own values from the preceding six months (Table 9).

According to the results (Table 9), only the contemporaneous term is significant: it was the only one with a p-value below 0.001 (none of the six lags in Model 3 reach conventional significance, though the one-month lag comes closest with a p-value of 0.101). The two other isolated-lag specifications (Table 9) confirm the same conclusion: the six-month lag remains small and insignificant, and the twelve-month lag is indistinguishable from a value of 0 (non-existent correlation). Hence, electricity price growth passes through to headline inflation only the same month it occurs, and, according to these models, there is no evidence of either a delayed or a resurfacing effect at six or twelve months.

4.3.2 Crisis-shock and pre/post-war robustness

Table 10. National panel — crisis-shock interaction and pre/post-war split

	(1) Model 6: Crisis-shock	(2) Model 2a: Pre-war	(3) Model 2b: Post-war
Electricity_Price_mroc	0.0393***	0.0342***	0.0388***
	(0.0079)	(0.0048)	(0.0022)
	p = 0.008	p = 0.002	p < 0.001
High-shock (=1)	−0.1003	—	—
	(0.4559)		
	p = 0.837		
Electricity × High-shock	0.0010	—	—
	(0.0283)		
	p = 0.973		
Constant	0.3576	0.3625	0.3501
	(0.0092)	(0.0126)	(0.0013)
Country fixed effects	Yes	Yes	Yes
Sample	Full	Before Mar. 2022	Mar. 2022 onward
N	327	70	257
R^2 (within)	0.2036	0.2375	0.1995

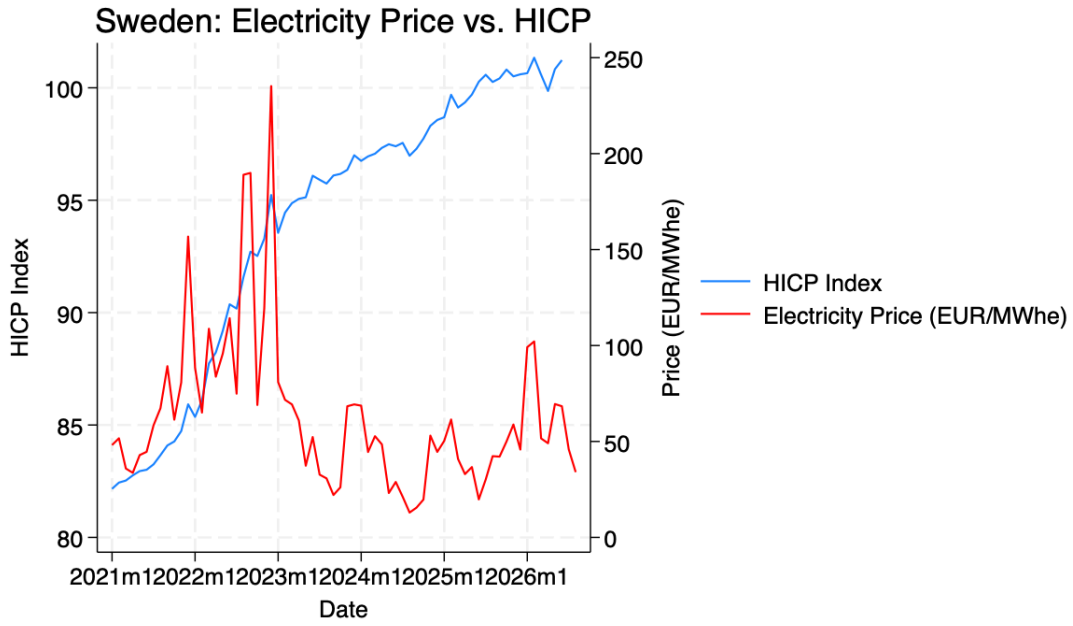
*Standard errors clustered by country in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10.*

Model 6 is a crisis-shock interaction that tests whether the price-inflation relationship intensifies specifically during extreme months, rather than holding at a constant rate throughout the sample (Table 10, column 1). Even though the baseline coefficient remains significant, the interaction term (Electricity × High-shock), the coefficient that actually tests this relationship, is close to zero and hence entirely insignificant. The relationship does not steepen during the top 10% of price-growth months; it appears to be linear and stable across the full range of observed price movements, not something that switches on only in a crisis.

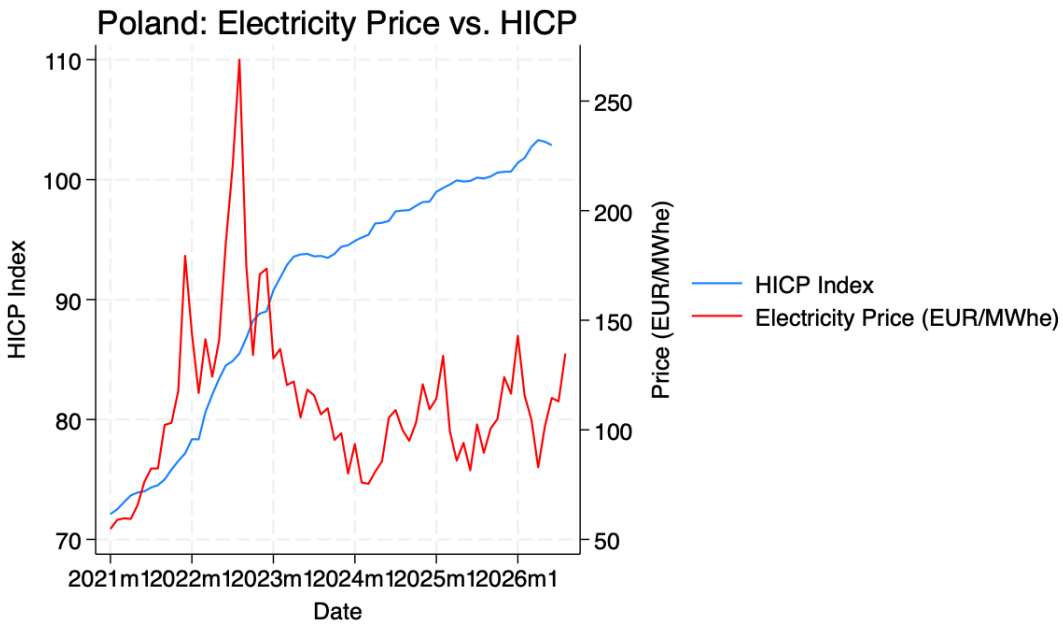
The two other columns (Table 10, columns 2–3) utilise a pre/post-war split and test the same question from a different angle: whether the relationship changed after Russia's invasion of Ukraine in February 2022. Three separate things are worth pulling apart here, all visible in Table 10. First, magnitude: the coefficient is 0.0342 before March 2022 and 0.0388 after; this is close enough that the relationship does not look meaningfully different in either period. Second, significance: both periods remain significant on their own ($p = 0.002$ pre-war, $p < 0.001$ post-war), so this shows that it is not a case of the effect existing in one period and not the other. Third, precision: the post-war estimate showed a considerably smaller standard error (0.0022 versus 0.0048); however, taking this at face value can be misleading since the two time frames have two different sample sizes. This mechanically tightens the estimate regardless of whether the underlying relationship changed at all. Figure 7 allows for the reader to see the crisis period directly rather than through the table coefficients present in Table 10.

Figure 7: *Electricity Price and HICP Index Over Time, Sweden and Poland*

(a) Sweden



(b) Poland



Note. Author's calculations based on Eurostat (2026), table PRC_HICP_MINR. Left axis: HICP index; right axis: electricity price (EUR/MWhe). Sweden and Poland are shown as a renewable-heavy and a fossil-heavy country pairing, respectively, both illustrating the same 2022 co-movement pattern.

So, all three models point towards the same conclusion: the relationship predates the 2022 crisis, persists throughout it without becoming steeper, and is not merely an artefact of that single episode.

4.3.3 The Core HICP test

Table 11. National panel — Core HICP specification (Model 7)

	Core_HICP_mroc
Electricity_Price_mroc	−0.0114*
	(0.0050)
	p = 0.084
	t = −2.29
Constant	0.3246
	(0.0050)
Country fixed effects	Yes
N	327
R^2 (within)	0.0185

*Standard errors clustered by country in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10.*

Model 7 substitutes Core HICP as the dependent variable, holding Electricity_Price_mroc as the regressor (Table 11). This is the paper's most direct test of whether electricity prices spread beyond their own accounting presence in the HICP index, since Core HICP is unable to capture the mechanical within-basket effect that is linked to HICP, as discussed in Section 4.1.3. The results show no real positive effect (only marginally significant at the 10% level and negative in sign; Table 11). However, given the small number of countries included in the panel, as well as the borderline p-value, the conclusion can be seen as a narrow one: no evidence of positive pass-through, rather than the negative correlation which claims that electricity prices reduce core inflation. Along with Section 4.1.3, this null result reinforces rather than merely accompanies the basket-weight comparison, both pointing to the same conclusion, that Model 2's headline coefficient is close to fully accounted for by electricity's own weight in the index, with little to no detectable spillover into the rest of the basket.

4.3.4 Does energy mix moderate the relationship? A Simpson's paradox

Table 12. National panel — renewable-share interaction, with and without country fixed effects

	(1) Model 8: Country FE	(2) Model 9: Pooled (no FE)
Electricity_Price_mroc	0.0407***	0.0424***
	(0.0035)	(0.0143)
	p < 0.001	p = 0.003
renewable_share	−1.2519	−0.2956**
	(0.6853)	(0.1312)
	p = 0.142	p = 0.025
Electricity_Price_mroc × renewable_share	−0.0073	−0.0084
	(0.0051)	(0.0186)
	p = 0.223	p = 0.651
Constant	1.0292	0.5136
	(0.3683)	(0.0862)
corr(u_i, Xb)	−0.6757	—
Country fixed effects	Yes	No
N	325	325
R^2	0.2211 (within)	0.2137

*Standard errors clustered by country in parentheses (column 1) or robust (column 2). *** p < 0.01, ** p < 0.05, * p < 0.10.*

The divergence between Models 8 and 9 on renewable share's main effect (renewable_share) (Table 12) is not a contradiction that has to be resolved, but rather informative. Without adding any fixed effects, a high-renewable country gets compared directly against a low-renewable one, and the resulting correlation is confounded by every other permanent difference between the two. Once the fixed effect is included, the differences are stripped out and the apparent effect disappears. Most importantly, however, the interaction term (Electricity_Price_mroc × renewable_share) is null in both models (Table 12).

There is a specific, diagnosable reason the interaction comes back null in Model 8 rather than just an absence of evidence. corr(u_i, Xb) (Table 12) is large in magnitude, in sharp contrast to its near-zero value in the baseline Model 2 (Table 2). Since energy mix shifts gradually over years, not month to month, most of its variation in the panel is between countries rather than within them. Fixed effects deliberately discard between-country variation, which means they also discard nearly all the variation renewable share actually has, leaving very little independent movement left to estimate an interaction from. Also, once again, the country panel consists of merely 5 countries, and hence this result should be read as being underpowered to detect moderation, rather than as an absence of it.

5. DISCUSSION

5.1 Returning to the hypothesis

The introduction asked two questions that the rest of the paper set out to figure out: does electricity price growth pass through to headline inflation, and if yes, then is that pass-through shaped by the electricity generation? The results are able to answer the first question with more confidence than the latter.

According to the results price growth does pass through to headline inflation immediately, at a magnitude of approximately 0.037 to 0.041 points of inflation per point of price growth (before and after the 2022 crisis, and without really intensifying or declining during the highest-shock months) (Sections 4.1.2, 4.3.1, 4.3.2). But this paper's main contribution is not the fact that this relationship is actually there, but rather, it is what constitutes the relationship. When electricity's own weight in the HICP basket is accounted for (Section 4.1.3), the estimated coefficient is basically the same as what the basic arithmetic would achieve. Additionally, the Core HICP test (Section 4.3.3) finds no actual evidence of spillover into the rest of the consumer basket. When both of these findings are analysed together, they reshape the earlier headline finding: this paper does not provide strong evidence that electricity prices influence broader, economy-wide cost-push inflation in the five chosen countries. Instead it provides evidence that electricity prices moved headline HICP by roughly the amount their own accounting weight implies.

The second question, however, did not receive an answer as straightforward as the first. At the national level, the interaction term is null with and without fixed effects (Section 4.3.4); at the zone level, the properly time-controlled specification (Model B) finds no significant relationship between renewable share and price at all (Section 4.2.3). However, neither result here should be taken as evidence that renewable generation does not affect price. Instead, they should suggest that the design (with five

countries and seven zones) does not have enough independent variation in renewable share to detect an effect if one actually exists.

5.2 A mechanical relationship, not a symptomatic one

Section 2.2 reviewed work on how far energy prices spread into inflation during 2022–2023. Neri et al. (2023) estimate that energy shocks accounted for roughly 60% of euro-area headline inflation but only 20–30% of core inflation. This paper's result for Core HICP does not align with that finding. Neri et al. found a somewhat meaningful, core contribution, this paper found essentially none. Two differences could explain this. One is a sample difference: this paper's five-country panel, of merely Germany, Italy, Norway, Poland, and Sweden, is not the same population as euro-area-wide aggregates, and includes two countries (Norway, Sweden) with very high renewable production, which in turn may cause their energy costs to differ compared to the euro area as a whole. Another is a specification difference: this paper's Core HICP test (Model 7) is a simple regression, while the CEPR VoxEU account, referenced in Section 2.2, finds the energy-to-core pass-through specifically concentrated in 2021–2022, a pattern a plain regression averaged across the full 2021–2026 window is not built to detect.

The distributed-lag results (Section 4.3.1) speak to a related question raised by the time-series work in Section 2.2: does pass-through happen all at once, or does it build up over several months? This paper's results point clearly to the former, with a strong same-month effect and no significant effect in any of the following six months, or at twelve months. That is itself informative about the two different mechanisms that could be at play here. Either there is a genuinely dynamic cost-push process, in which higher electricity costs gradually filter into other firms' pricing, which would plausibly show up with some lag. Or a mechanism that is purely mechanical, based on basket-composition as discussed in Section 5.1, where it would appear the same month electricity prices move, because that is definitionally when the index updates. The complete absence of any lagged effect is consistent with the latter and inconsistent with a slower-building cost-push channel.

5.3 The renewable-share result in the context of the merit-order literature

Section 2.3 referenced studies (Clò, Cataldi, and Zoppoli (2015), comparable studies of the PJM, and MISO markets in the United States) that brought up and analysed the "merit-order effect" as a real observable mechanism when it comes to renewable production and energy prices. This paper's zone-level test does not confirm that mechanism in the Norway/Sweden setting. However, this paper should not be read as contradicting the merit-order effect. Instead the more plausible explanation is a difference in what is actually being measured and the data sets.

The studies cited in Section 2.3 typically work with hourly or daily price and generation data, which is the frequency at which the merit-order mechanism actually operates. For example, a wind farm coming online at 2pm lowers the price for that specific hour, not for the month as a whole or later than that. This paper's zone panel does not work with hourly or even daily prices but rather a huge jump to monthly. This

most definitely diminishes the kind of within-day price variation the merit-order effect produces, particularly in Norway and Sweden's hydro-heavy systems, where hydro output (and therefore renewable share) can be managed strategically within a month even while the monthly average share stays fairly stable.

This paper's result is more comparable to Altunöz's 2025 study asking directly whether renewable energy reduces the pass-through of energy costs into consumer prices (Section 2.2), which is very close both methodologically and structurally to this paper's own Model 8/9 interaction test. Both papers reach a null conclusion on the interaction term specifically. It is also consistent with the more sophisticated pattern Patzelt (2025) discussed in Section 2.3, both pointing to the fact that even methodologically more sophisticated identification strategies reach the conclusion of the renewables-price relationship being a genuinely open empirical question. This paper's contribution to that conversation is modest but real. It demonstrates the same difficulty recurring in a fixed-effects panel design, using an entirely different country pairing than the studies cited above, which is some evidence that the difficulty is general rather than specific to any one dataset or method.

5.4 Limitations

Several limitations of this paper need their own discussion rather than a brief mention, because they strongly limit how much weight the results can bear.

The most important limitation of the entire paper is sample size. Five countries and seven zones is enough to estimate a fixed-effects baseline relationship (Model 2's confidence interval is narrow, Table 2), however, it is too small to test cross-section interaction, a test that, by construction, needs meaningful independent variation in the moderating variable (renewable share) across units. Sections 4.3.4 and 4.2.3 both state that their null interaction results are caused by the same underlying problem, the fact that renewable share barely moves within a country or zone over the sample period, so fixed effects leave very little independent variation left to estimate a moderating effect from. This is not a flaw of the analysis or methodology; it is a structural limit of the available data.

A second limitation concerns what Electricity_Price_mroc actually measures. As Section 3.1 and 4.1.3 establish, it is Eurostat's HICP electricity sub-index and not a wholesale market price. This is the right variable for the paper's actual question (how electricity prices move the consumer price index), but it means the national-panel results cannot speak directly to wholesale market dynamics or the merit-order mechanism in the way the zone-level analysis, using an actual wholesale price series, attempts to.

Finally, the zone-level panel's geographic coverage is narrow not by choice but because of availability of data. Three of Norway's five zones and all four of Sweden's, were chosen because they had usable data, not because they are representative of European bidding zones generally.

6. CONCLUSION

This paper had the goal of answering two questions. Whether electricity price growth passes through to headline inflation across a panel of European countries, and whether that pass-through is dictated or influenced by how the electricity itself is generated. The answer to the first question is a yes. Electricity price growth is associated with a stable, immediate increase in headline HICP inflation of roughly 0.037 to 0.041 points per point of price growth, a relationship that holds before and after the 2022 energy crisis. But the importance of this finding is not that it exists but instead what constitutes it. When electricity's own weight in the HICP basket is accounted for, the estimated coefficient is statistically indistinguishable from what arithmetic alone would predict. Furthermore, the effect does not extend to core inflation (Model 7). The evidence therefore does not support the stronger claim that electricity prices drove broader, economy-wide cost-push inflation in these five countries; it supports the narrower claim that electricity prices moved headline inflation by roughly their own accounting weight, and no more. The answer to the second question is not as straightforward: the national-level interaction test (Models 8/9) finds no evidence that renewable generation share moderates the price-inflation relationship, and the zone-level fixed-effects specification (Models A/B) finds no robust evidence that renewable share lowers wholesale electricity prices. However, this paper's design is underpowered to detect a moderating effect if one exists, and these null results should not be read as evidence against the merit-order mechanism as noted earlier in this paper.

Hence, these findings imply two things. For policy, they suggest that electricity subsidies aimed at headline inflation numbers will do roughly what basic arithmetic predicts and little more. For the renewable-energy question, this paper adds one more design to a list of papers and documents that have struggled to pin down a real traceable price effect of renewable generation, suggesting the difficulty is a genuine feature of the data available rather than a limitation of any single method. Future work could push on both fronts: extending the zone-level analysis to markets beyond Norway and Sweden, and moving to genuinely higher-frequency price and generation data (hourly or daily rather than monthly) would give the merit-order test the actual data it needs to detect the mechanism it is designed to find. Also a larger sample of countries, or a longer sample that lets renewable shares move further within a given country over time, would give the moderation question the statistical power this paper's design could not provide.

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