Energy Shock and Firm-Level Decarbonisation

Did the Russia–Ukraine War trigger a change in GHG Intensity among European firms?

Data Group 2

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Big Picture

The context

Russia's 2022 invasion of Ukraine triggered the largest European energy supply disruption in decades, significantly increasing gas prices and forcing firms to rethink their energy sourcing overnight.

- Europe had built production models around cheap Russian pipeline gas
- The shock arrived as climate commitments tightened: EU Fit for 55, CSRD
- Energy-intensive industries (chemicals, metals, cement, paper) were hit hardest
- Yet the literature that combines geopolitical shocks with corporate environmental performance is thin

Why We Care

The gap

We know a lot about how geopolitical shocks affect investment and profitability. We know far less about their effect on **firm-level environmental performance**.

- Quantifying the firm-level GHG response is essential to evaluate whether energy-security shocks and climate policy *reinforce* or *undermine* each other
- Country-level energy infrastructure may become a *bottleneck* for decarbonisation, even when price incentives are strong
- Policy implication: energy-mix flexibility at the country level enables or blocks firm-level environmental adjustment

Research Question

Did the Russia–Ukraine war **trigger a change in firm-level GHG intensity** among European energy-intensive firms, and did this effect **vary** for firms operating in countries that were more or less dependent on Russian gas?

- **Outcome:** GHG Direct Intensity — Scope 1 emissions (tCO_2e) per \$1M revenue
- Measured by **TruCost (S&P Global)**: captures *operational* emissions efficiency, normalised for firm size, with lowest measurement noise across datasets (NGFS 2024)

Data

Panel dataset

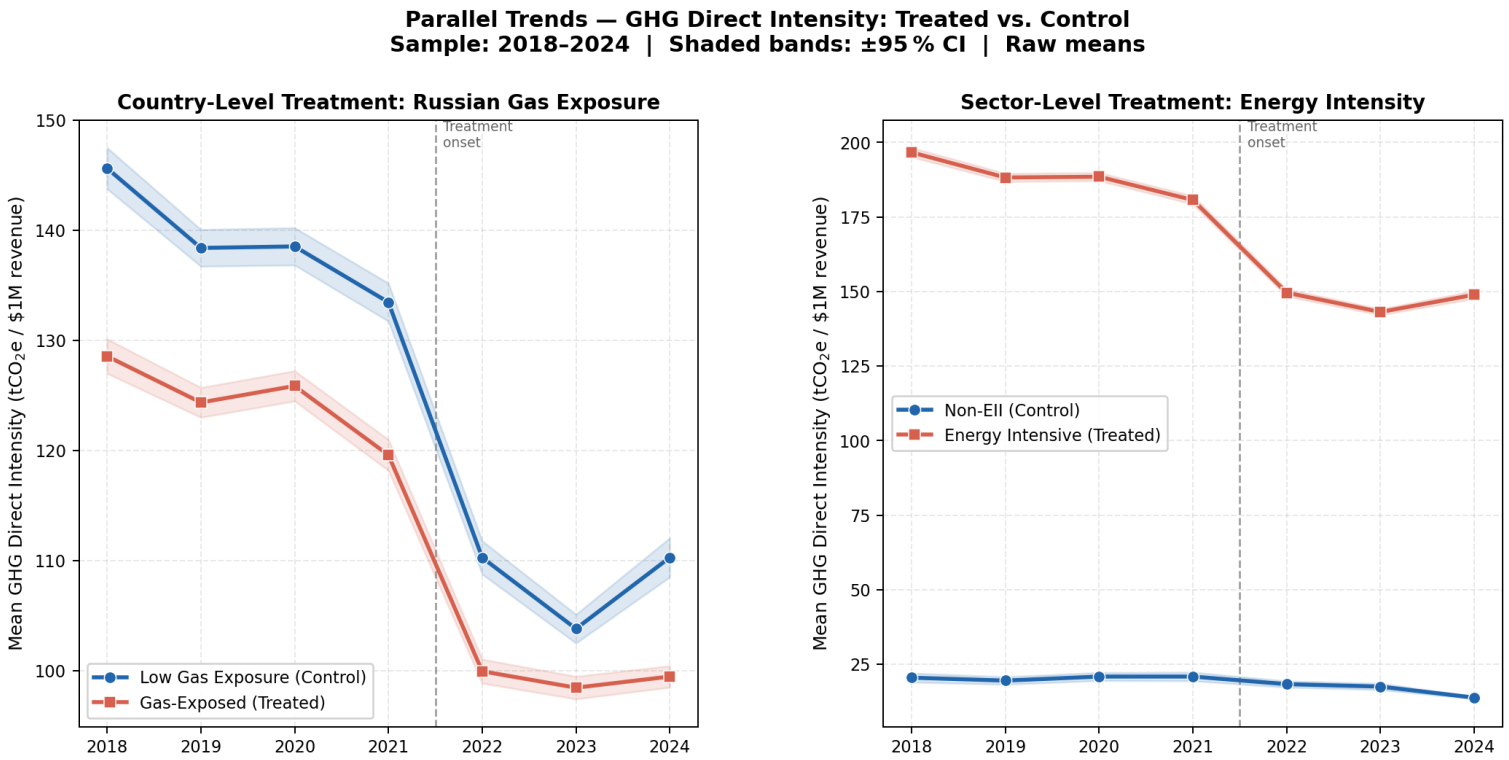
- ≈973,000 firm-year observations
- 30 European countries (EU-27 + NO, CH, UK)
- Years: 2018–2024 (pre-shock: 2018–2021; post-shock: 2022–2024)
- Publicly listed firms in manufacturing and resource sectors

Sources

- **TruCost (S&P Global)** — GHG Direct Intensity (Scope 1)
- **World Bank** — GDP per capita, CPI inflation
- **Eurostat** — Russian gas import shares (`nrg_ti_gas`, `nrg_bal_c`)

Identification Strategy: Difference-in-Differences

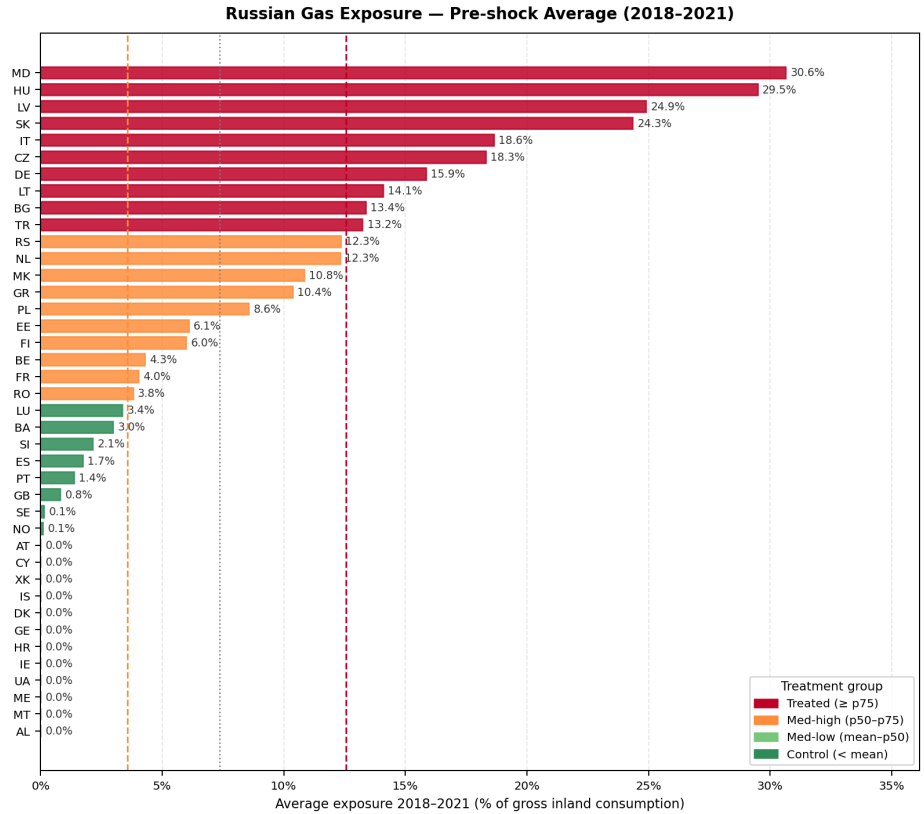
- **Core idea:** compare the change in GHG intensity for *treated* firms relative to *control* firms, before vs. after February 2022
- **Why the shock is exogenous:** the RU-UA war and energy disruptions were unanticipated by firms — no pre-announcement or anticipation bias
- **Parallel trends:** treated and control firms show broadly parallel GHG intensity trends in 2018–2021



Treatment 1: Country Gas Exposure

$$\text{Exp}_{c,t} = \frac{\text{RU gas imports}_{c,t}}{\text{Gross Inland Consumption}_{c,t}}$$

- Pre-shock average 2018–2021
- **Treated:** top quartile ($\geq$ p75 = 14.1%)
- 8 countries: HU, LV, SK, IT, CZ, DE, LT, BG



Avg. Russian gas exposure by country, 2018–2021. Red = treated ($\geq$ p75).
Source: Eurostat `nrg_ti_gas`, `nrg_bal_c`

Model 1: Gas Exposure Specification

$$Y_{i,t} = \alpha_i + \lambda_t + \beta_1 \cdot \text{Post}_t \times \text{GasExp}_i + \gamma' X_{c,t} + \varepsilon_{i,t} \quad (1)$$

- $Y_{i,t}$: GHG Direct Intensity (tCO_2e / \$M revenue)
- α_i: firm fixed effects λ_t: year fixed effects
- $\text{GasExp}_i = 1$ if firm's country is in the top-p75 exposure group
- $\text{Post}_t = \mathbf{1}(t \geq 2022)$
- $X_{c,t}$: GDP per capita + CPI inflation (country-year controls)
- SE clustered at the **country level**

Coefficient of interest

$\hat{\beta}_1$: avg. change in GHG intensity for gas-exposed countries vs. non-exposed, post-2022 vs. pre-2022

Treatment 2: Energy-Intensive Sectors (EII)

Treated (EII = 1)

OECD/EC official EII classification:

- C16 Wood products
- C17 Paper
- C19 Coke & refined petroleum
- C20 Chemicals
- C22 Rubber & plastics
- C23 Non-metallic minerals (cement, glass)
- C24 Basic metals

66% of observations in EII sectors (647K firm-years)

Control (EII = 0)

Comparable manufacturing, lower energy input share:

- C21 Pharmaceuticals
- C25 Fabricated metals
- C28 Machinery
- C29 Motor vehicles
- C31 Furniture
- C18 Printing

Model 2: Sector Energy Intensity Specification

$$Y_{i,t} = \alpha_i + \lambda_t + \beta_2 \cdot \text{Post}_t \times \text{EII}_i + \gamma' X_{c,t} + \varepsilon_{i,t} \quad (2)$$

- $\text{EII}_i = 1$ for energy-intensive sectors (C16, C17, C19, C20, C22, C23, C24)
- Same firm/year FE and country-clustered SE as Model 1

Coefficient of interest

$\hat{\beta}_2$: avg. change in GHG intensity for EII firms vs. non-EII, post-2022 vs. pre-2022

Final Model: Triple Interaction (Model 3)

$$Y_{i,t} = \alpha_i + \lambda_t + \beta_1 \, \text{Post}_t \times \text{GasExp}_i + \beta_2 \, \text{Post}_t \times \text{EII}_i + \beta_3 \, \text{Post}_t \times \text{GasExp}_i \times \text{EII}_i + \gamma' X_{c,t} + \varepsilon_{i,t} \tag{3}$$

- $\hat{\beta}_1$: standalone country gas-exposure effect
- $\hat{\beta}_2$: standalone EII sector effect
- $\hat{\beta}_3$: **additional** effect for firms that are *both* in gas-exposed countries *and* in EII sectors

Why triple interaction?

Allows us to decompose country- and sector-level channels separately, and test whether the two dimensions of treatment reinforce or offset each other.

Results: All Models

	(1) Gas Exposed	(2) Energy Intensive	(3) Triple
Post × GasExp	5.209^{***}	-38.461^{***}	-2.611
	(1.089)	(2.209)	(2.498)
Post × EII			-43.480^{***}
			(1.643)
Post × Both			9.863^{***}
			(2.543)
Observations	972,979	972,979	972,979
Firm / Year FE	Yes	Yes	Yes
SE clustered	Country	Country	Country

Dep. var.: GHG Direct Intensity (tCO_2e / $1M revenue). SE in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

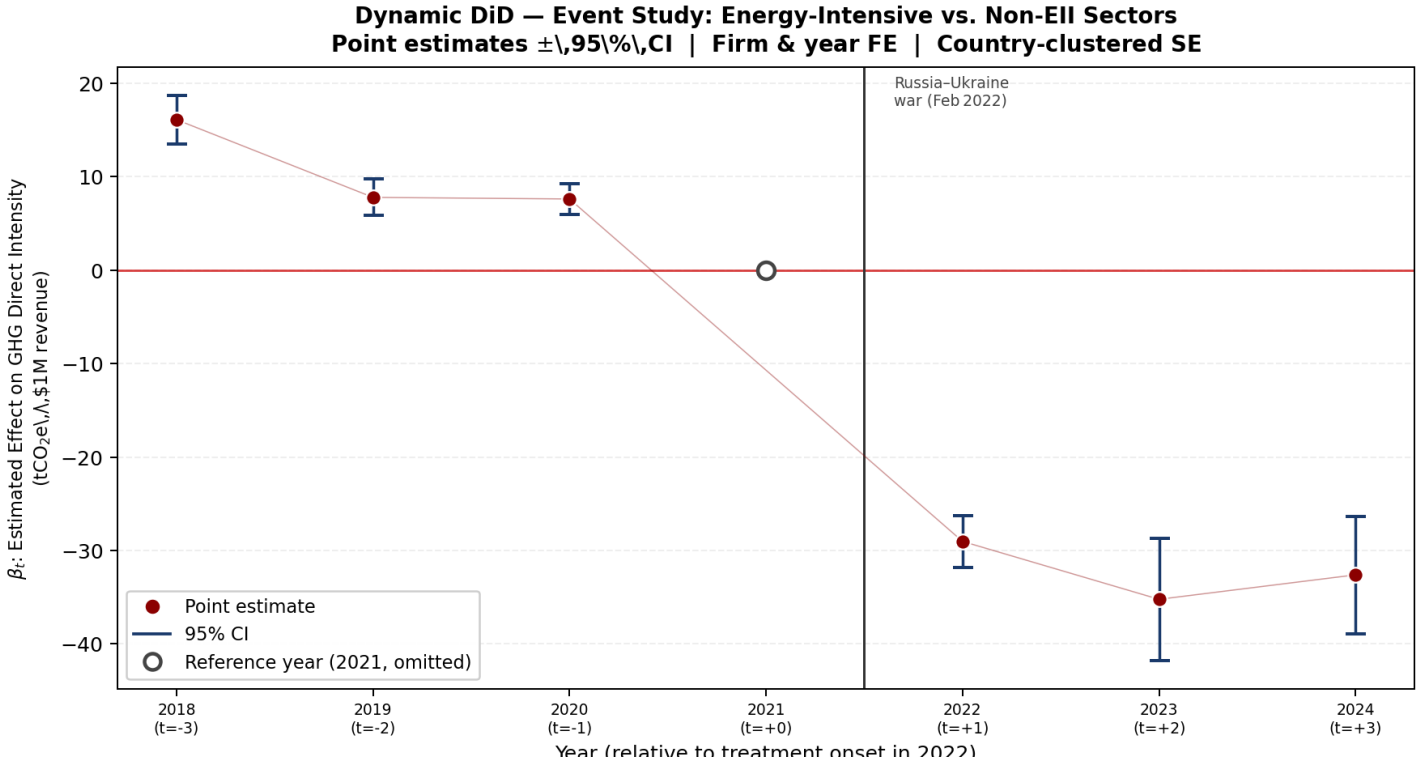
Finding: EII Firms Reduced GHG Intensity

Model 2

EII firms reduced GHG Direct Intensity by $\approx$ **38.5** tCO_2e/\$M post-2022 vs. non-EII firms

($p < 0.01$; $\approx$32% of sample mean of 121 tCO_2e/\$M)

- $\nearrow$ energy prices forced diversification away from gas $\rightarrow$ Scope 1 falls
- Effect is sustained across 2022–2024, not a one-off adjustment

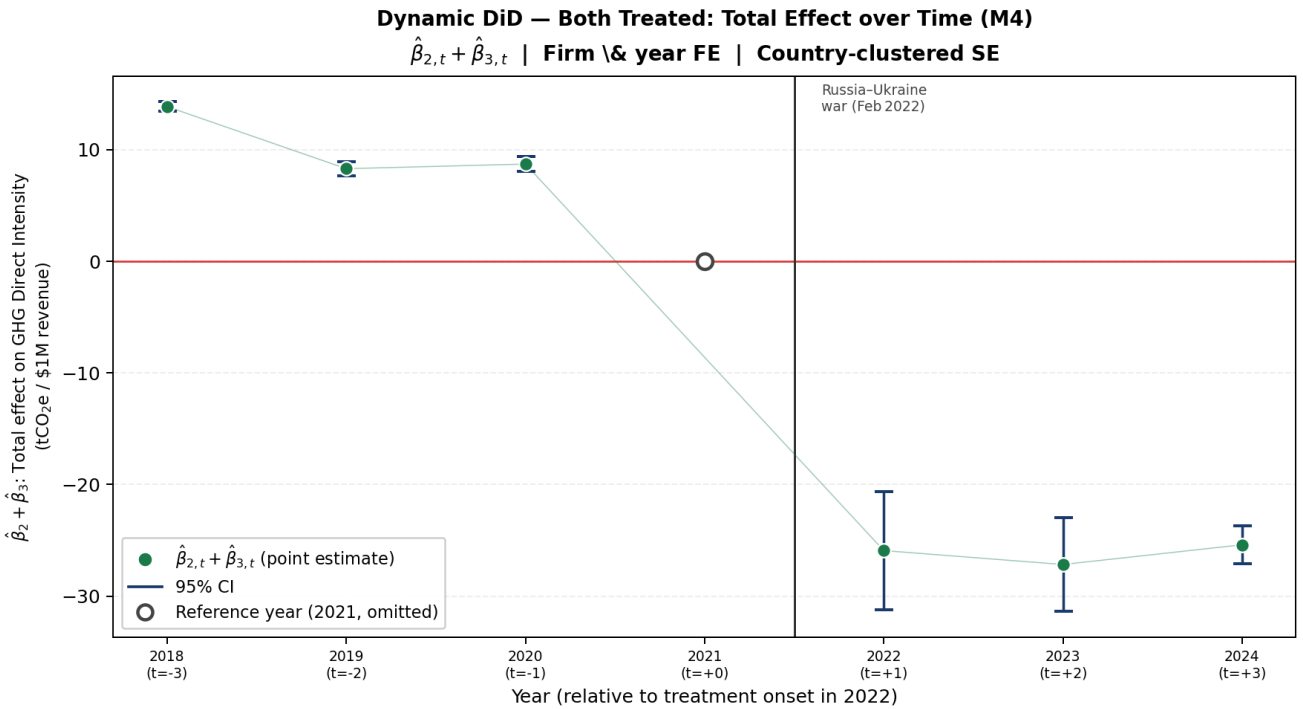


Finding: Gas Dependency Attenuates Decarbonisation

Model 3

$\hat{\beta}_2 = -43.5^{***}$, $\hat{\beta}_3 = +9.8^{***} \Rightarrow$ net effect (doubly treated): $-\mathbf{33.7}\,\mathrm{tCO_2e/\$M}$

- Gas-dependent countries faced **constrained transition paths** (LNG bottlenecks, long renewable lead times)
- Standalone gas-exposure effect: $+5.2$ in Model 1 $\rightarrow$ indistinguishable from zero (-2.6, $p = 0.30$) in Model 3



Discussion: Mechanism

1. Energy price shock → strong incentive to cut gas consumption
2. Firms diversify: energy efficiency, lower-carbon electricity, supply-chain changes
3. Gas is itself a GHG fuel → diversification *mechanically* reduces Scope 1

Country	Energy endowment	Adjustment capacity
France	Nuclear flexibility	Higher
Germany	Coal fallback + renewables	Moderate
Italy	LNG ramp-up constrained	Lower
HU / SK	High pipeline dependency	Lowest

Firm-level decarbonisation and **country-level energy infrastructure** are deeply complementary.

Limitations

1. **HQ $\neq$ operations for MNEs**
   A German-registered firm producing in Poland faces the Polish energy mix. Facility-level data would be needed to correct this.

2. **Carbon leakage not identified**
   Firms may have outsourced emission-intensive steps abroad. Scope 3 or trade-adjusted accounting required.

3. **Pre-trend caveat (EII treatment)**
   2018 pre-period coefficient elevated ($\approx +16$); results capture *acceleration* of a divergence, not its initiation. Post-shock drop (-25 to -35) is an order of magnitude larger.

4. **Short post-shock window**
   Panel ends in 2024 — only two full post-shock years. Full trajectory may materialise as renewable capacity investments complete.

Conclusion

Main finding

The RU-UA energy shock **significantly reduced GHG intensity** among European EII firms: -38–$43\,\mathrm{tCO_2e/\$M}$ (32–36% of sample mean). Effect is **smaller** in gas-dependent countries ($\approx -10\,\mathrm{tCO_2e/\$M}$ attenuation).

Policy implications

Country level

Energy diversification (interconnectors, LNG, renewables) is both an energy-security *and* decarbonisation imperative.

Firm level

Prioritise energy-mix flexibility and long-term power-purchase agreements to decouple GHG performance from host-country endowments.

Conclusion II

Thank you for your attention!

Questions and comments are very welcome :)