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Geopolitical shocks and **GHG EMISSIONS**

A DiD analysis of how the 2022 Russian invasion of Ukraine affected GHG emissions of global listed firms, conditional on their pre-war exposure to Russia and Ukraine

Data Group 3
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Contents

How geopolitical shocks reshape firm emissions

The Russia-Ukraine war was a global, exogenous shock to firms' operations and sustainability decisions

Energy markets disruption

- Sharp increase in **energy prices** and **volatility**
- **Supply disruption**, especially in natural gas
- Direct impact on firms' production costs and **profitability**
- Incentives to reduce energy use or **switch sources**

Investments delays under uncertainty

- Reduced **investment capacity**
- **Postponed** high CAPEX **projects** (e.g. green transition)
- Shift toward **short-term operational decisions**

Financial markets suffering

- **Credit tightening** and reduced bank lending
- **Investment cuts**, especially in long-term projects
- Asset write-downs and **forced divestments** (exit from Russia)

Heterogeneous firm exposure

- Exposure depends on : **Operations** in Russia/ Ukraine, **Energy dependency & Supply chain links**
- More exposed firms **react more strongly**

Geopolitical shocks may reduce emissions, but it remains unclear whether this reflects genuine decarbonisation or disruption-driven contraction

LITERATURE REVIEW

Geopolitical risk & emissions: what do we know?

	What the literature shows	*So what for this paper*
GPR & ESG Performance	GPR affects ESG, but evidence is **mixed across** firms and countries	ESG scores **do not necessarily capture** actual **environmental** outcomes
GPR & Carbon Emissions	GPR is linked to emissions, mostly at macro level or **through broad risk indices**	**Firm-level** Scope 1 and Scope 2 evidence is **still limited**
DiD Methodology	DiD has been **used for shocks** such as Russia–Ukraine and US-China tariffs.	The **method fits this setting**, but emissions are underexplored.
Firm-Level Exposure	**Exposure** is often **measured** with **country-level** GPR or text-based risk measures.	Commercial firm-level exposure has received limited attention, as **macro-level exposure** measures **are simpler** to construct and apply.
Ukraine War as a Sustainability Shock	The **war disrupted** energy, supply chains, financing and operations.	The shock affected multiple channels at once, making its **impact on emissions difficult** to isolate.

RESEARCH QUESTION

Research question & hypotheses

1

Research gap

Literature relies mostly on broad **ESG indices as proxies or word-based risk measures**. **Direct causal evidence** on how firms' actual **Scope 1 and Scope 2 emissions** respond to a specific geopolitical shock such as the Russian-Ukraine war **is still limited**.

2

Research question

Do firms with pre-war exposure to Russia and Ukraine exhibit a different change in emissions after the onset of the war compared to non-exposed firms?

3

Hypotheses

H1: Pre-war commercially exposed firms to Russia and Ukraine experienced a different change in Scope 1 GHG emissions after the onset of the Russia-Ukraine war compared to non-exposed companies.

H2: Pre-war commercially exposed firms to Russia and Ukraine experienced a different change in Scope 2 GHG emissions after the onset of the Russia-Ukraine war compared to non-exposed companies.

RESEARCH QUESTION

Why this research? The polycrisis perspective

From isolated shocks to polycrisis

- Geopolitical **conflicts** and **climate** crisis are increasingly **interdependent**
- Wars can **disrupt energy systems**, which are central to decarbonization pathways
- Climate policies depend on **stable global cooperation**, which conflicts undermine

Firms are no longer facing separate risks, but **compound** and **interacting shocks**

Tension for multinationals

- **Short-term survival pressure**: energy &, supply disruptions, financial constraints
- **Long-term climate** commitments: decarbonization, Scope 1 & 2 targets

Polycrisis creates a strategic trade-off: **resilience vs. sustainability**

What we still don't know

- Do firms **actually decarbonize**, or do emissions fall due to **economic contraction**?
- Does geopolitical exposure **accelerate** or **delay** climate transition

Our contribution

- Use the **RU-UA** war as a **natural experiment**
- Provide **causal evidence** on how geopolitical shocks affect **heterogeneously exposed firms**;
  - **Scope 1 emissions** (direct operations)
  - **Scope 2 emissions** (energy use)

Data Retrieval

Built a global firm-year panel by combining emissions data from Trucost Environmental with financial and geographic revenue exposure data from FactSet.

Trucost ESG Analysis / S&P Global

Emissions data: Trucost Environmental Dataset by S&P Global Sustainable1

Key variables: Scope 1 GHG emissions, Scope 2 location-based GHG emissions, Total revenues

Initial extraction: 21 million observations

Filters applied:

- ✓ Publicly listed firms only
- ✓ Firms with **at least 4 observations** for each emissions' measure

FactSet

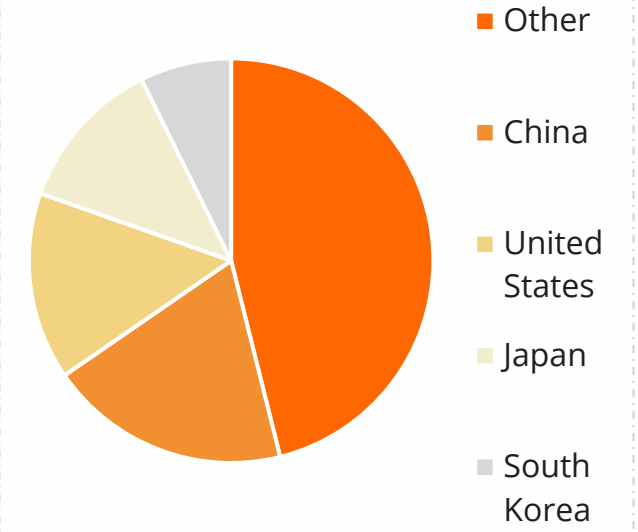
Financial & exposure data: retrieved through the FactSet API

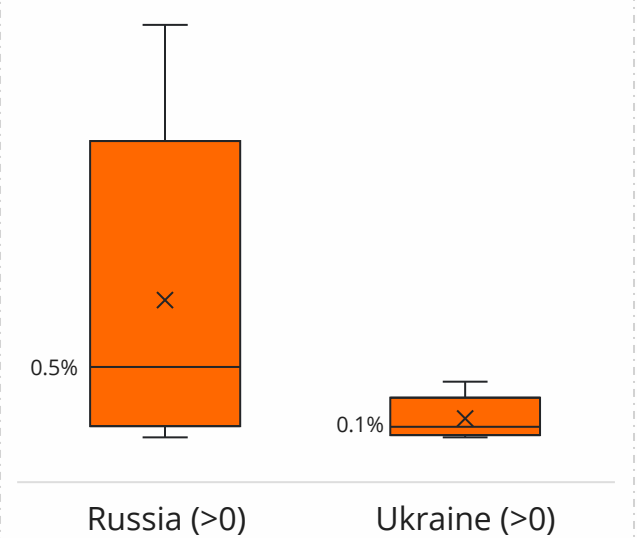
Key variables: % revenues from Russia, % revenues from Ukraine

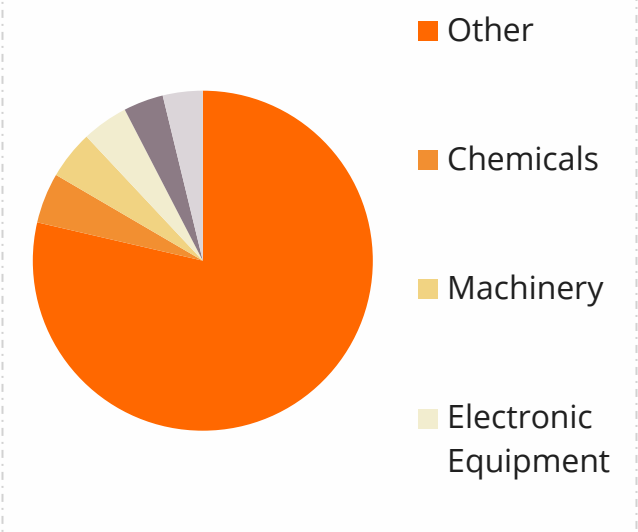
Final firm-year panel

- ➢ Global panel of **17,985 listed firms** from **104 countries**
- ➢ Period: **2018–2025**
- ➢ Final dataset: **143,880 firm-year observations**

Empirical Dataset: Composition and Exposure







Countries

Firms originate from a **wide range of countries**, with no single country accounting for a disproportionate share of the sample.

Revenues Exposure

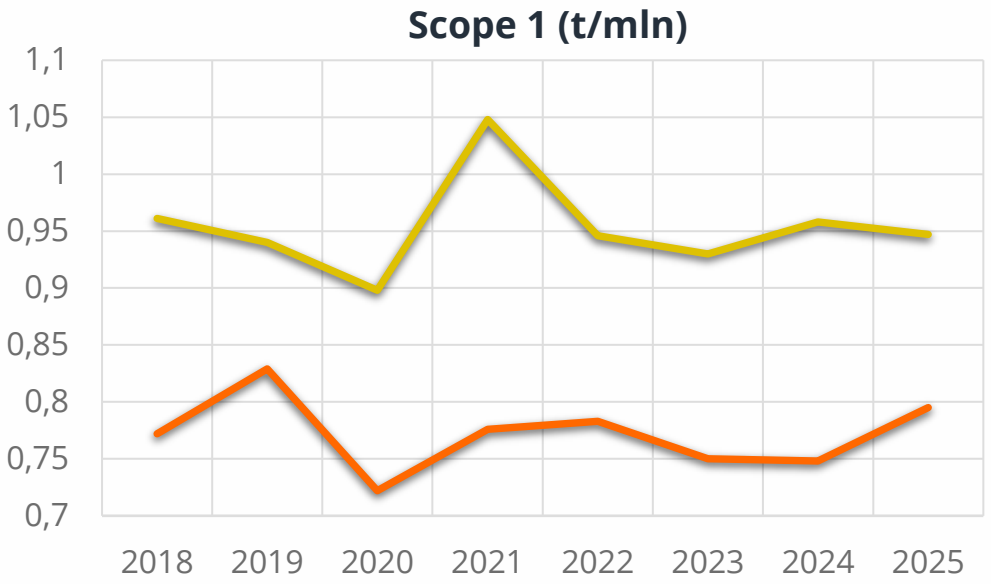
The average **pre-war exposure to Russia and Ukraine is modest**: across firms, the mean combined exposure is approximately 0.5% of their total revenues.

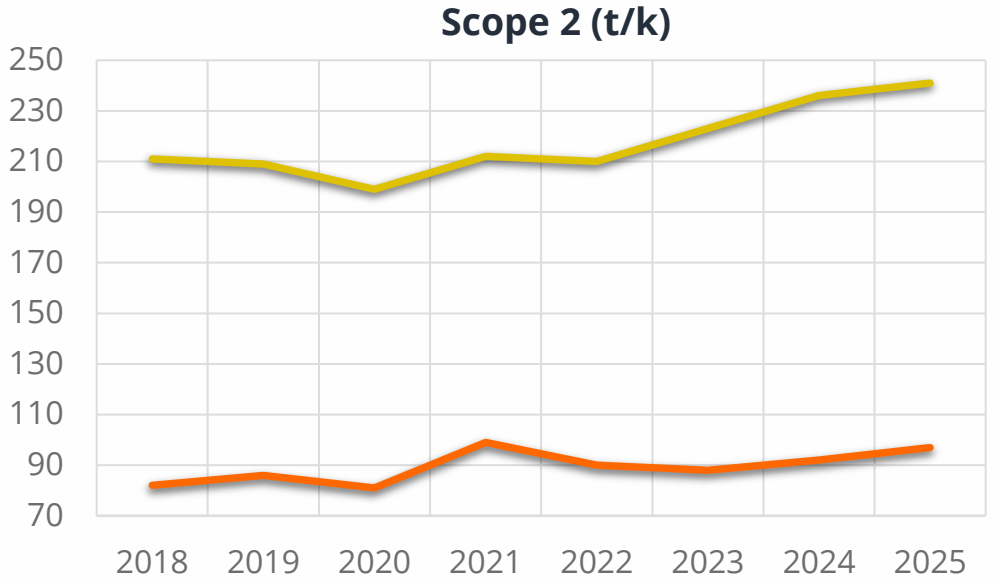
Industries

A **large residual category** ("Other") accounts for about 65% of firms, while the remaining observations are **spread across industries** such as chemicals, machinery and electronic equipment.

Empirical Dataset: Scope Emissions

Exposed firms show higher average Scope 1 and Scope 2 emissions (tCO2e) compared to **not exposed** ones throughout the entire period analysed.





Most firms report low emissions, while a few report extremely large values.

Because of this right skewness, **log(1 + x)** is used for the main emissions variables.

Median Scope 1 emissions (tCO2e)

6,503

Median Scope 2 emissions (tCO2e)

8,514

Diff-in-Diff framework

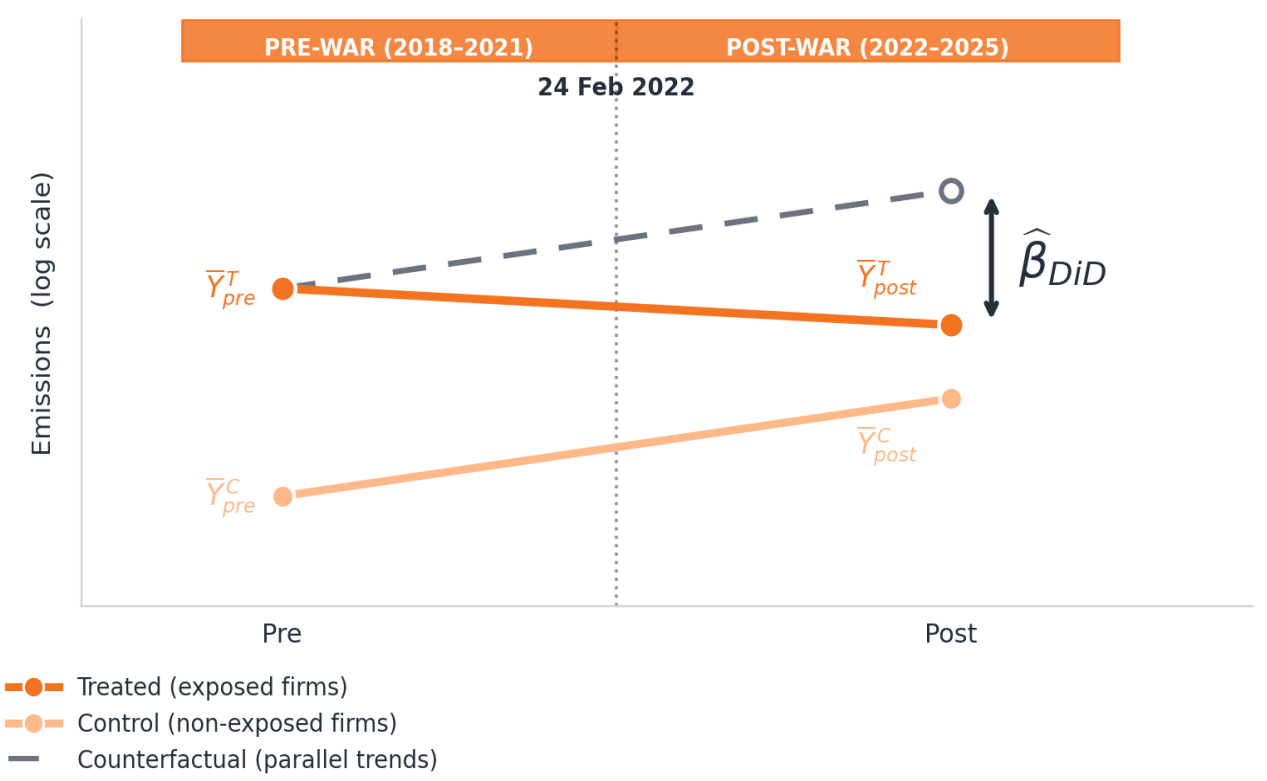
What DiD does in this project?

Compares the post-war change in emissions of firms with Russia/Ukraine exposure against the contemporaneous change of non-exposed firms.

DiD estimator

$$\widehat{\beta}_{DiD} = \left(\overline{Y}^{T}_{post} - \overline{Y}^{T}_{pre}\right) - \left(\overline{Y}^{C}_{post} - \overline{Y}^{C}_{pre}\right)$$

T = treated / exposed firms C = control / non-exposed firms



1 First difference

Before-after change within exposed firms - captures their own dynamics across the shock.

2 Second difference

Subtracts the contemporaneous change of non-exposed firms, removing common time shocks.

3 Identifying assumption

Parallel trends: in the absence of the invasion, treated and control would have moved together.

Baseline DiD specification

Equation used in the paper

$$y_{it} = \alpha_i + \lambda_t + \beta(Treat_i \times Post_t) + \varepsilon_{it}$$

Outcome: log(1 + Scope 1) or log(1 + Scope 2)

Treatment definition

$Treat_i$ = 1 for firms with positive pre-war RU/UA revenue exposure. **$Post_t$ = 1** from 2022 onward.

Coefficient of interest

β captures the differential post-invasion change in exposed firms relative to non-exposed firms - the average treatment effect on the treated.

Identifying assumption - parallel trends

Without the war, treated and control emissions would have followed the same trend. Tested via event-study pre-coefficients and a joint Wald test.

- $\mathbf{y_{it}}$ is $log(1 + Scope\ k_{it})$ for firm *i* in year t
- $\boldsymbol{\alpha_i}$ are firm fixed effects
- $\boldsymbol{\lambda_t}$ are the fixed effects (depending on the model)
- $\mathbf{Post_t}$ equals 1 for t ≥ 2022
- **β** (the coefficient of interest) captures the differential change in the outcome experienced by treated firms relative to controls in the post-invasion period.
- $\boldsymbol{\varepsilon\{it\}}$ is the error for firm *i* in year t

Treatment indicator from average pre-war RU/UA revenue share

$$Treat_i = \mathbf{1}\{Exposure_i > 0\}, \quad Exposure_i = \frac{1}{4}\sum_{t=2018}^{2021} \frac{Rev_{it}^{RU} + Rev_{it}^{UA}}{Rev_{it}}$$

Empirical strategy

1

Identification

The 24 February 2022 invasion is treated as an **exogenous shock. Treatment intensity** is based on each firm's **average pre-war share of revenues** originating from Russia and Ukraine over 2018–2021 period (any exposure considered).

2

Specifications

The empirical strategy is a **two-way fixed-effects DiD**. Treatment is a binary indicator equal to one for firms with any positive pre-war (2018–2021) revenue exposure to Russia and Ukraine. **Outcomes: log(1 + Scope 1)** and **log(1 + Scope 2).** Three nested specifications:

- Firm FE + Years FE;
- Firm FE + Country × Year FE;
- Firm FE + Industry × Years FE.

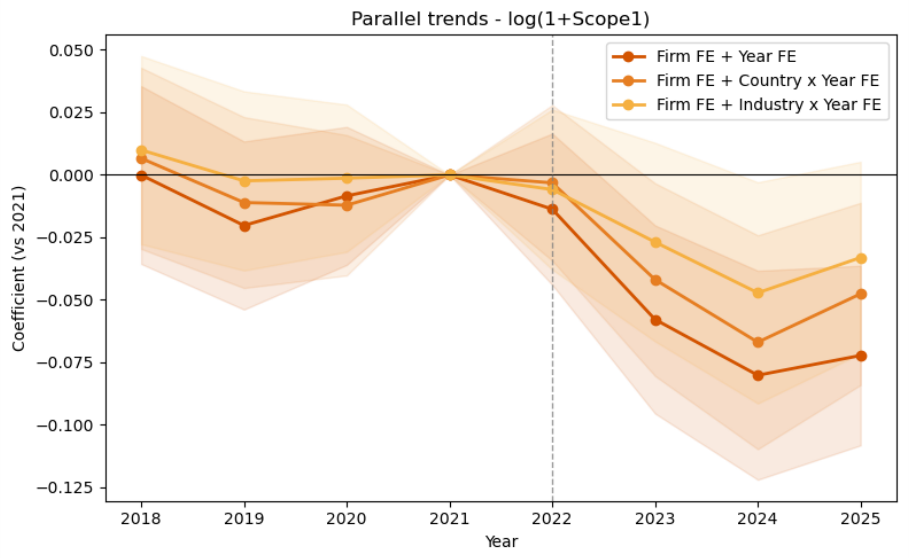
3

Event Study & Inference

An **event-study specification tests pre-trends** and traces the dynamic post-war response, using 2021 as the reference year. The same three fixed-effects specifications are applied to the event-study model. Standard errors are clustered at the firm level.

Parallel Trends Diagnostic

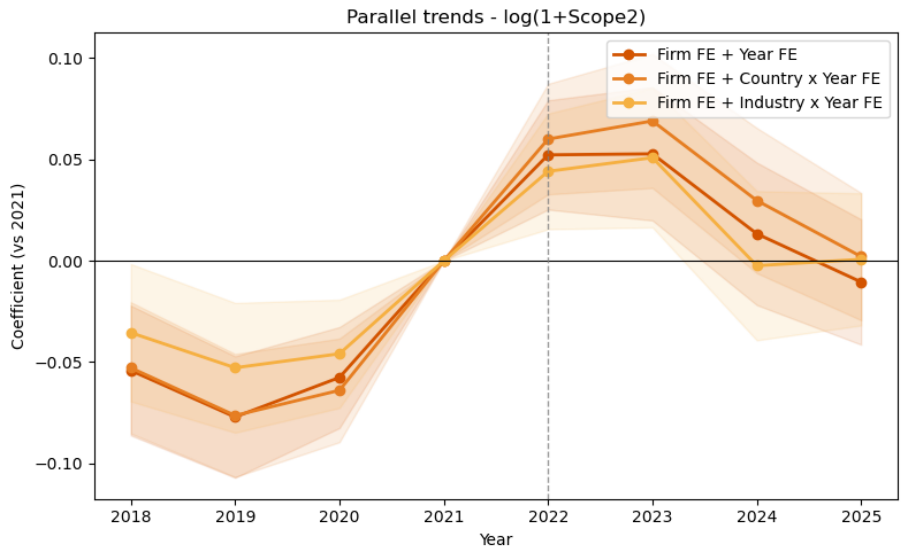
GHG Scope1: No pre-trends. The joint Wald test on pre-treatment event study coefficients does not rejects parallel trends for Scope 1 in any of the three specifications.



Wald p =

0.148 - 0.672

GHG Scope2: Pre-war divergence violates the identifying assumption. Post-2022 movement can not be treated as causal effect.



Wald p <

0.001

Main results: binary treatment DiD

Scope 1 declines across all three specifications, while Scope 2 cannot be interpreted causally

Scope 1 results

- **Negative coefficient** in all three specifications
- Magnitude ranges from **-3% to -4.9%.**
- Significant with
  - Firm FE + Year FE (p=0.003)
  - Firm FE + Country × Year FE (p=0.031)
  - Firm FE + Industry × Year FE (p = 0.077)

Scope 2 results

- **Positive and significant** in all three specifications
- Magnitude ranges from **+5.7% to +8.9%.**

→ **But parallel trends are violated**

Scope 2 emissions trends cannot be used for causal explanations as they do not respect the DiD assumption

Role of fixed effects

- Country × Year FE and Industry × Year FE attenuates Scope 1 coefficient, as expected
- But the effect **remains statistically significant**
- Results are thus **less likely being driven by common country or sector shocks**

Takeaway

- Exposed firms show a **decline** in Scope 1 emissions
- **Scope 2 results are contaminated** by pre-trends

Event study: lagged Scope 1 Response

2020

Pre-trends: before the war, **coefficients are small** and statistically indistinguishable from zero.

2021

Parallel trends: using 2021 as the reference year, **the pre-treatment pattern supports the parallel-trends** assumption for Scope 1.

2022

Scope 1 effect is **still not significant in 2022**: −0.014 (p = 0.37). There is no immediate emission adjustment after the invasion.

2023 onwards

Scope 1 becomes significant in 2023, 2024 and 2025, **suggesting a lagged effect,** which represents an additional form or robustness. A **smooth pattern signals** that the headline negative effects are not driven by an idiosyncratic shock.

Robustness checks

The credibility of the main Scope 1 findings is assessed against three set of robustness exercises.

Stability across fixed-effects

The Scope 1 result is presented under **three nested fixed-effects** specifications of increasing demands.

1. -0.049: **baseline (Firm + Year FE)**
2. -0.036: **country-by-year FE**
3. -0.030: **industry-by-year FE**

Revenues Control

The model is augmented with a **time-varying control for firm revenues**, to verify whether the estimated reduction in emissions is capturing just a **mechanical scale effect or a differential emissions**. Coefficients remain negative and significant across all three fixed-effects structures.

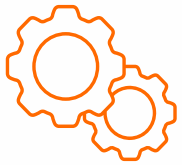
1. -0.055: **baseline (Firm + Year FE)**
2. -0.042: **country-by-year FE**
3. -0.039: **industry.by-year FE**

Placebo test

Specifically, **the treatment is artificially assumed to start in 2020 and 2021**. The results show that the placebo coefficients are small in magnitude and statistically insignificant across all fixed-effects specifications. This indicates that **exposed firms did not experience systematic changes** in Scope 1 emissions relative to unexposed firms **before the actual shock**. **Therefore, the placebo evidence supports the validity of the main Scope 1 results.**

Discussion: interpreting the pattern of results (1)

Emission reductions likely reflect operational disengagement, while Scope 2 changes reflect energy market disruptions rather than clean causal effects



Scope 1 reduction by operational withdrawal

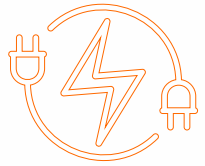
- Exposed firms reduce direct emissions by **scaling down existing operations**
- Closure of facilities, termination of contracts and **supply chain disruptions** reduce fuel use
- **Effects remain after controlling** for country and industry trends

Emission decline reflects the loss of carbon-intensive activities, not a shift toward a greener production

Implementation constraints & lag

- **No significant effect in 2022** despite immediate announcements
- **Strong** and increasing negative effect **in 2023-2025**
- **Adjustments delayed by**
  - Contract termination delays
  - Asset decommissioning
  - Administrative closure of subsidiaries

Lag captures the gap between strategic decisions and operational executions



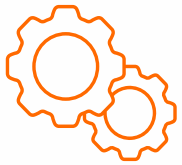
Scope 2: no clean causal interpretation

- Pre-treatment trends show **exposed firms already reducing** emissions
- **Post-war increase reflects**
  - Mean reversion toward trend
  - Energy crisis effects : shift toward more carbon-intensive electricity

Scope 2 results are consistent with an indirect emissions rise due to a dirtier energy mix, not increased activity but they cannot be interpreted causally

Discussion: interpreting the pattern of results (2)

Scope 1 reductions may reflect efficiency improvements or investments to reduce emissions, while Scope 2 increases may reflect substitution toward purchased electricity



Scope 1 reductions may reflect efficiency gains

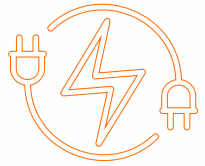
- Firms with exposure to RU/UA reduce direct emissions **even after controlling for revenues**
- The reduction is not fully explained by lower firm size or lower business activity, so
- Firms may **improve production processes**, reduce energy waste and optimize fuel use

Emission decline may reflect lower energy intensity in remaining operations

Operational reorganization may strengthen the effect

- The war shock increased firms' incentives to **reduce energy costs** and **limit operational exposure**
- Firms **may accelerate** maintenance, retrofits and **investment**
- Firms may have relocated production to jurisdictions with **stricter environmental standards**

Operational reorganization may allow firms to maintain activity with lower direct emissions



Scope 2 increases may reflet energy substitution

- Firms may **reduce on-site fuel combustion** while relying more on purchased electricity
- **The substitution** lowers Scope 1 emissions but increases Scope 2 emissions
- The increase does **not necessarily imply higher total production** or higher energy use

Scope 2 changes are suggestive of energy reallocation, but they remain non-causal

Limitations & caveats

1

Exposure measure

Revenue captures only one dimension of firm exposure. Commercial relationships with Russia and Ukraine extend well beyond the direct sale of goods and services. Some exposed firms may thus be misclassified as controls. Other dimensions are difficult to observe consistently and are not systematically captured.

2

Confounding post-2022 shock

The post-2022 period also includes the energy crisis, inflation, pandemic unwinding and monetary tightening. Some of these developments may have affected exposed and unexposed firms differently in ways **not fully captured** by country-by-year or industry-by-year fixed effects.

3

Sample composition

The sample is composed **exclusively of publicly listed firms** covered by the Trucost Environment dataset. **Smaller and private firms**, for whom reputational and regulatory pressures were weaker and operational disruption potentially more severe, are systematically absent, limiting the generalizability of the findings.

Conclusion

1 Main findings

Higher pre-war exposure to Russia and Ukraine leads to a **causal reduction in Scope 1 emissions**, emerging with a **1-2 years lag**. For Scope 2, results are **not causally interpretable** due to the rejection of parallel trends, despite positive estimated effects.

2 Mechanism

The decline reflects a combination of **operational withdrawal** and efficiency improvements.
Firms reduced emissions both by **scaling down carbon-intensive activities** in affected markets and by **improving energy efficiency** in remaining operations, according to our views.

3 Implications & Next steps

Geopolitical shocks may act as **involuntary decarbonization** mechanisms, but their **persistence is uncertain**. Future research should assess whether these effects are structural using alternative exposure measures, **extended fixed effects and sensitivity analyses**.

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