BANCA D'ITALIA

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THE INVASION OF UKRAINE AND THE ENERGY CRISIS: COMPARATIVE ADVANTAGES IN EQUITY VALUATIONS

by Fabrizio Ferriani* and Andrea Gazzani*

Abstract

We study the impact of the widening energy price differentials caused by the war in Ukraine on the returns of European and US firms. Using several measures of firms' exposure to energy consumption, we show that return differentials between EU and US firms widened significantly after the outbreak of the war in Ukraine. Our results indicate a persistent comparative disadvantage between the two regions, driven by heterogeneous energy costs, which has continued even after the partial subsiding of the energy shock by the end of 2022. These findings suggest that the impact of the war on energy prices may have lasting economic implications for Europe, potentially exacerbating its competitiveness disadvantages compared with other geographic regions that have access to more affordable energy inputs.

JEL Classification: G12, G14, G32, G33.
Keywords: war in Ukraine, energy impacts, energy comparative advantage, financial performance.
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Contents

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1 Introduction [1]

"BASF *has said it will have to downsize permanently in Europe, with high energy costs making the region increasingly uncompetitive*" (Financial Times, 26 October 2022)

The Russian invasion of Ukraine was undoubtedly the most significant geopolitical event of 2022, causing repercussions across various domains with the first and most dramatic consequence certainly being the immense loss of human lives and the massive devastation of Ukraine. The war also had large macroeconomic impacts resulting in heightened recession risks and deteriorating economic outlook, trade disruptions and supply bottlenecks amid increasing economic fragmentation. However, the most abrupt consequence was the outburst of a major energy crisis, which had global reverberations, but was particularly acute in Europe due to its heavy dependence on energy imports from Russia.

Studying the real implications of such an energy crisis is a particularly daunting task because of the short-sample characterized by large instabilities in the macro and financial data associated to the affected commodities, primarily natural gas. Our study overcomes this limitations by exploiting equity prices in a panel setting to investigate how firms' heterogeneous exposure to the energy shock across diverse geographic regions has lead investors to revise stocks valuations. Specifically, we aim to explore how firms equity prices can provide insights into comparative advantages associated with energy costs. To this purpose, we conduct a comparative analysis between European firms, which experienced significant pressure in the energy market due to the war in Ukraine, and firms in the United States (US). In the latter, the impact of energy prices was definitely more subdued, primarily due to the access to relatively cheaper energy inputs following the

[1] We thank Piergiorgio Alessandri, Riccardo Cristadoro, Ivan Faiella, Marco Taboga, Giovanni Veronese, and participants at Bank of Italy seminars for suggestions. The views expressed in the paper are those of the authors and do not involve the responsibility of the Bank of Italy.

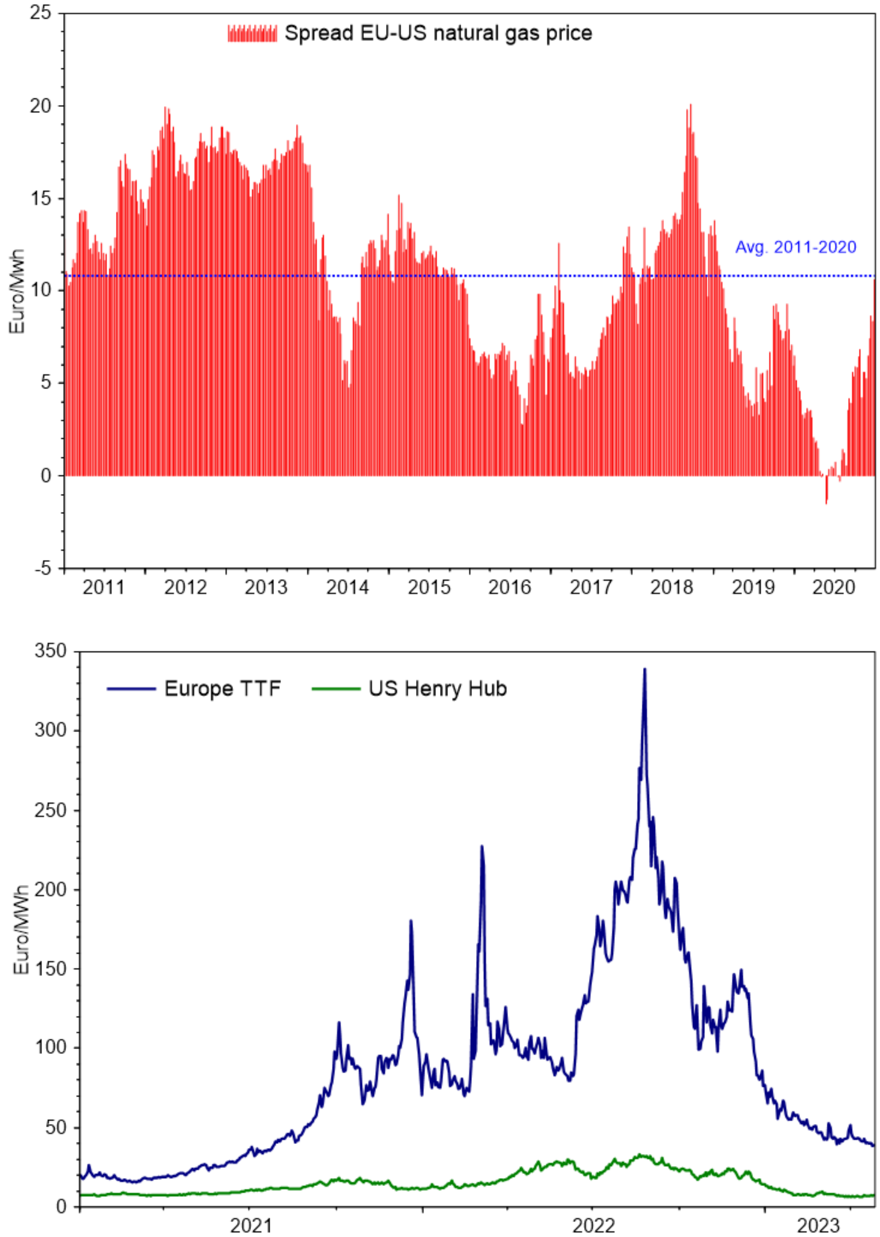


FIGURE 1: *The upper plot displays the spread between EU and US natural gas prices during the period 01/01/2011-31/12/2020, the lower plot displays EU and US natural gas prices during the period 01/01/2021-30/04/2023. Data are obtained from Refinitiv and refer to the TTF natural gas price (benchmark for Europe) and to the Henry Hub natural gas price (benchmark for the US, converted in Euro/MWh).*

advent of shale revolution that has lead the US to switch its status from energy importer to exporter (Arezki et al., 2017).

Owing to the limited fossil energy production, energy prices in the European Union (EU) have historically been higher than in other parts of the world.[2] This has important implications for the overall competitiveness of European firms, as recently highlighted in a communication by the European Commission (European Commission, 2023). The upper plot of Figure 1 illustrates Europe's comparative disadvantage in accessing energy sources. Between 2011 and 2020, EU natural gas prices consistently exceeded those in the US, averaging around 11 Euro/MWh; the differential between the two regions dramatically widened after the start of the conflict, reaching an average of about 207 Euro/MWh at the peak of tensions in the European energy market in August 2022 (as shown in the lower plot of Figure 1).

This paper extends the approach developed in a companion paper (Ferriani and Gazzani, 2023) to investigate whether the widening *energy price* differential across geographical areas is reflected in the *equity return* differentials among EU and US firms. We focus on the impact of natural gas prices, which have caused tension in the European energy market due to Europe's heavy reliance on this energy source and the Russian weaponisation of natural gas exports in retaliation of Western sanctions. While Ferriani and Gazzani (2023) use a cross-sectional framework, here we employ a panel multi-area setup to analyze the effects of the various events that impacted the energy market throughout 2022. Our study proposes multiple definitions of firms' exposure to energy prices, and consistently finds that return differentials between EU and US firms significantly widened after the outbreak of the war in Ukraine. Interestingly, we observe that price differentials remained negative and statistically significant even after the energy price shock partially subsided at the end of the 2022/2023 winter. These findings suggest that investors believe the comparative disadvantage between the two regions to persist over time, driven by differences

[2] In the following we will use the acronym EU to generally identify Europe, and not exclusively countries that are part of the European Union.

in access to more affordable energy sources.

To mitigate the impacts of the energy shock, several policy initiatives have been announced in Europe, such as the REPowerEU plan. This plan aims to enhance the EU's energy independence through a three-pillar strategy based on reducing energy demand, diversifying fossil fuel energy supply, and accelerating the transition to renewable energy resources. These initiatives, along with a major reshuffling in global energy flows and favourable weather conditions throughout 2022, contributed to ease pressure on the EU energy market. However, uncertainties on natural gas price developments in the 2023/24 winter seasons remain, related to possibly adverse weather conditions, lower availability of LNG for the European market due to increasing Asian competition, or a complete interruption of Russian gas deliveries, which could reignite market tensions (International Energy Agency, 2023). Our results are consistent with this, as we show that EU-US equity return differentials did not materially narrow even when energy tensions partially diminished. While the increasing reliance of the EU on US LNG gas imports significantly contributes to ensuring EU's access to natural gas supplies during the 2022/2023 winter season, it is likely to exacerbate the comparative advantage of the US over Europe going forward, and may prompt a potential dislocation of production in search of more affordable energy prices, particularly for energy-intensive industries (Bialek et al., 2023).

The rest of the paper is structured as follows. Section 2 briefly reviews the main literature of interest, Section 3 introduces the dataset, Section 4 illustrates the empirical strategy and presents the main findings; finally, Section 5 offers our conclusions and discusses some policy implications.

2 Literature

Our study contributes to and bridges two main strands of literature. The first strand pertains to studies that examine the financial market's response to the war in Ukraine and the financial sanctions imposed against Russia, primarily utilizing event-study methodologies. For instance, Boungou and Yatié (2022) and Federle et al. (2022) document a negative impact of the war on international stock markets, with more pronounced effects observed in countries bordering Ukraine and Russia, Boubaker et al. (2022) also show a negative response in equity returns, with variations across countries driven by the level of economic globalization, Izzeldin et al. (2023) expand the analysis to commodity markets and found that the war significantly influenced commodity price volatility, particularly in the case of commodities for which Russia and Ukraine hold major exporting shares. Ferriani and Gazzani (2023) analyze the impact of higher energy prices on the financial performance of European firms and find that more energy intensive firms significantly increase their probability of default. Deng et al. (2022) compare the performance of European and US firms in response to the war in Ukraine, highlighting that firms with greater transition risks outperformed, particularly in the US, potentially suggesting a divergence in the pace of transition towards net-zero across the two regions; similarly, Bauer et al. (2022) report much stronger returns for brown over green stocks in G7 equity markets during the first half of 2022.

The second strand of literature that we are contributing to examines the association between energy costs and firms' performance. Studies in this field utilize both sectoral-level data and detailed microdata and consistently reveal a negative impact of higher energy expenditures on various indicators of corporate performance and firms' competitiveness. For instance, (Ratti et al., 2011) demonstrate that increased energy prices negatively affect firm-level investment, Sato and Dechezleprêtre (2015) find that differences in industrial energy prices influence international trade, particularly in energy-intensive sectors, (Abeberese, 2017) identifies a negative correlation between electricity costs and firms' productivity growth, Rentschler and Kornejew (2017) observe that elevated energy prices adversely affect firms' long-term competitiveness proxied by profit margins, Faiella and Mistretta (2020) propose an energy-augmented measure of unit labor costs and demonstrate that higher energy costs lead to reduced firms' exports. These findings are particularly relevant when analysing the competitiveness of the European industry, especially when compared to firms in the United States, where the advent of the shale revolution have amplified energy-related comparative advantages (European Commission, 2014, Astrov et al., 2015, Arezki et al., 2017).

Our empirical approach, illustrated in the following sections, use equity prices as an indicator of investors' expectations of firms' future profitability and examines how the corporate exposure to the energy shock is reflected in asset prices. We document that, since the start of the war, investors have adjusted their valuations to incorporate a new risk factor related to the significance of energy costs in firms' production functions.

3 Data

Our sample consists of large European and US non-financial firms listed in the Eurostoxx and the S&P500, respectively. We propose four different measures to assess firms' exposure to the energy shock, as reported in Table 1.

For exposure measures 1-3, the exposure is given by the 2021 amount of energy consumption (thousands of MW hours) converted in monetary terms by using the 2021 average prices of natural gas and normalized by firms' market capitalisation, revenues and op-

Exposure 1 - Market capitalization	Exposure 2 - Revenues
$\frac{Energy\ consumption * Avg.\ gas\ price}{Market\ capitalization}$	$\frac{Energy\ consumption * Avg.\ gas\ price}{Revenues}$
Exposure 3 - Costs	**Exposure 4 - Emissions**
$\frac{Energy\ consumption * Avg.\ gas\ price}{Operating\ costs}$	$\frac{Scope\ 1\ emissions}{Market\ capitalization}$

Table 1: **Exposure measures.** The table displays the exposure measures to the energy shock adopted in the empirical analysis. Energy consumption is the firm-level energy consumption (thousands of MWh) in 2021, average gas price is the 2021 average price of natural gas prices in Europe (TTF) and the US (Henry Hub) expressed in Euro/MWh. Scope 1 emissions are the 2021 CO2-equivalent emissions produced from sources that are directly owned or controlled by each firm (e.g. caused by the combustion of fossil fuels or released throughout the industrial process).

erating costs, respectively. We focus on natural gas prices as they embody the energy source hit more severely by the invasion of Ukraine; moreover, natural gas prices are the marginal fuel for the production of electricity in EU and, as such, they determine electricity prices directly. Natural gas prices refer to the prices recorded for the two representative benchmarks of the geographical areas of interest, i.e. the TTF for the European market and the Henry Hub for the US market. Exposure 1 and 2 (hereafter E1 and E2) quantify energy exposure relative to two proxies of corporate size, whereas Exposure 3 (E3) assesses the exposure to the energy shock by measuring the proportion of energy costs in relation to the overall operating costs. Exposure measure 4 (E4) represents the amount of Scope 1 emissions normalized by market capitalization and is not only correlated with the firm's energy use, but also informative of the firm's potential exposure to climate transition risk (Ilhan et al. 2021 and Bolton and Kacperczyk 2021).[3] We employ accounting data, market capitalization, energy consumption, and carbon emissions that

[3]Results are qualitatively similar when we also include Scope 2 emissions.

are all based on the year 2021 for each of the four exposure measures. This approach allows us to capture the exposure to the energy shock as primarily predetermined to the consequences of the Russian invasion on the energy market. In our empirical analysis, we designate E1 as our benchmark exposure measure but also provide insights from the other exposure proxies. Based on the availability of data on energy consumption, we have information on the E1-E3 measures for a maximum of 436 non-financial companies in the European sample and 348 in the US sample. Concerning the E4 measure, the number of firms further reduces to 362 for the Eurostoxx and 274 for the S&P500, given the limited data availability for carbon emissions.[4] Table 2 presents the top 7 industries that are highly exposed to the energy shock according to our four alternative exposure measures, broken down by geographical areas of interest. As expected, firms that use energy more intensively are concentrated in industries such as energy, utilities, airlines, construction, and oil and gas, both in Europe and in the US. However, it is noteworthy that the median incidence of energy exposure is generally larger in the European market, providing a preliminary indication of the competitive advantage of US firms in accessing energy inputs.

To investigate the relationship between the widening of energy price differential across different regions and asset prices, we use firms' equity returns as our dependent variable. Specifically, we calculate daily cumulated returns starting from October 5th, 2021 - a symbolic date on which the TTF price for wholesale natural gas in the European market surpassed 100 Euro/MWh for the first time - and end the analysis on April 30th, 2023, by which concerns about the European capacity to survive the 2022/2023 winter season had mostly subsided. Our period encompasses significant events and stages of the energy crisis, such as the surge in energy prices towards the end of 2021 due to pent-up demand

[4] Data on energy consumption are obtained from Bloomberg and are expressed in thousands of megawatt hours (MWh) whereas Scope 1 emissions are retrieved from Carbon 4 finance. Accounting data, market capitalisation and energy prices are obtained from Refinitiv and expressed in Euros.

a) Eurostoxx

Exposure 1 - Market Cap.		Exposure 2 - Revenues		Exposure 3 - Costs		Exposure 4 - Emissions	
Oil & Gas	6.7	Electricity Produc.	5.8	Containers & Pack.	11.9	Paper & Forest	133
Containers & Pack.	8.6	Containers & Pack.	11.3	Energy Equip.	14.5	Electric Utilities	136
Paper & Forest	8.9	Electric Utilities	12.2	Airlines	14.7	Metals & Mining	257
Multi-Utilities	10.5	Energy Equip.	12.9	Electric Utilities	21.7	Oil & Gas	441
Airlines	16.8	Airlines	23.7	Construction Mater.	30.7	Multi-Utilities	942
Construction Mater.	25.3	Construction Mater.	25.6	Paper & Forest	33.1	Electricity Produc.	2732
Electricity Produc.	47.6	Paper & Forest	29.2	Electricity Produc.	35.4	Construction Mater.	3183

b) S&P500

Exposure 1 - Market Cap.		Exposure 2 - Revenues		Exposure 3 - Costs		Exposure 4 - Emissions	
Metals & Mining	0.5	Oil & Gas	1.6	Oil & Gas	1.7	Air Freight	218
Oil & Gas	1.3	Road & Rail	1.8	Road & Rail	3.0	Oil & Gas	269
Electric Utilities	2.5	Airlines	4.6	Airlines	4.8	Commercial Serv.	270
Containers & Pack.	2.6	Containers & Pack.	5.1	Containers & Pack.	6.0	Containers & Pack.	404
Multi-Utilities	2.7	Multi-Utilities	8.1	Multi-Utilities	7.7	Multi-Utilities	669
Airlines	4.3	Electric Utilities	8.3	Electricity Produc.	9.7	Electric Utilities	1067
Electricity Produc.	5.9	Electricity Produc.	10.1	Electric Utilities	9.8	Electricity Produc.	2539

Table 2: **Exposure to the energy shock**. Top 7 most exposed industrial sectors in terms of median exposure to the energy shock. Exposure measures are defined in Table 1. Statistics for exposure measures E1-E3 are expressed in percentage. The upper panel refers to firms included in the Eurostoxx index, the lower panel to firms in the S&P 500. We classify firms with respect to the GICS classification scheme, the table reports the industry level (penultimate level of classification); the exact label of each industry is available upon request.

following the Covid-19 pandemic and tensions mounting at the Ukraine border, the onset of the invasion, the imposition of several rounds of sanctions on Russia by Western countries, the Russian request of settling gas supplies in rubles, the indefinite shutdown of the Nord Stream 1 pipeline, and the implementation of an EU natural gas price cap in December 2022. As a robustness exercise we also present estimates based on a shorter time interval starting on the 24th of January 2022 in line with the study of Deng et al. (2022). [5] Descriptive statistics on the dependent variables and the four exposure measures are displayed in Table 3. Details on the sectoral composition of the two benchmark indices is reported in Table A.1 of Appendix A.

a) Eurostoxx

	Mean	Dev. st.	p25	p50	p75
Cumulated returns	0.93	0.23	0.79	0.95	1.06
Exposure 1 - Market Cap.	3.90	14.46	0.19	0.54	2.13
Exposure 2 - Revenues	3.16	9.86	0.06	0.21	1.02
Exposure 3 - Costs	7.52	51.16	0.19	0.53	2.14
Exposure 4 - Emissions	146.06	538.10	0.74	3.67	20.49

b) S&P500

	Mean	Dev. st.	p25	p50	p75
Cumulated returns	0.98	0.24	0.84	0.99	1.10
Exposure 1 - Market Cap.	1.14	3.34	0.04	0.1	0.43
Exposure 2 - Revenues	0.50	1.46	0.01	0.03	0.17
Exposure 3 - Costs	1.32	4.02	0.05	0.13	0.53
Exposure 4 - Emissions	104.51	353.69	0.49	2.32	11.64

Table 3: **Descriptive statistics.** Returns are cumulated daily returns over the period 05/10/2021-30/04/2023; p25, p50, p75 refer to the distribution percentiles Exposure measures are defined in Table 1. Statistics for exposure measures E1-E3 are expressed in percentage. The upper panel refers to firms included in the Eurostoxx index, the lower panel to firms in the S&P 500.

[5] Differently from us, Deng et al. (2022) focus on the impact of the war on transition paths between EU and US. Our exercises are not fully comparable because of differences in the time frame and sample composition. However, the channel identified in our paper does not necessarily exclude the one discussed in Deng et al. (2022) and our estimates are robust to controls of transition risks as discussed in Section 4.

4 Econometric model and empirical results

4.1 Basic evidence

As a preliminary evidence, we estimate the time-average relationship between energy exposure and equity returns by means of the following regression model:

$$y_{i,t} = \alpha_s + \alpha_d + \alpha_c + \beta s_i + \delta \alpha_c s_i + \gamma X_i + \varepsilon_{i,t} \tag{1}$$

where $y_{i,t} = log(p_{i,t}) - log(p_{i,t_0})$ is the cumulative return of firm i in day t, t_0 is the sample start (October 5th, 2021),[6] α_s are industry-level fixed-effects (GICS classification), α_d are daily fixed effects that capture the common daily co-movement in equity returns, α_c is a dummy variable equal to 1 for firms included in the Eurostoxx 600 and zero if belonging to the S&P500, s_i is our key explanatory variable i.e. one of the four exposure measures presented in Table 1, X_i is a set of firm specific controls including leverage, firm size (proxied by revenues), return on assets (ROA), and the interest coverage ratio (ICR), and $\varepsilon_{i,t}$ is a standard error term. To enhance the comparability of the response across different measures we standardize each exposure variable; the inference is based on robust standard errors.

Table 4 reports the estimated values of α_c, β and δ for the four exposure measures previously described. The estimated α_c indicates that European firms have performed worse than their US counterparts in our sample, by almost 5 percentage points (p.p.). The estimated δ points towards a significant heterogeneous firm-level implications of energy exposure across areas: in the US (EU), firms' equity performances have improved (worsen)

[6] For a similar approach using cumulative returns see Albuquerque et al. (2020), Ramelli and Wagner (2020), and Pagano et al. (2020) among many others.

with their energy exposure. Focusing on our benchmark measure E1, a one standard deviation increase in the energy exposure is associate with 0.7 p.p. higher equity returns in the US and a differential with European firms of 1.6 p.p., which yields an estimate for Europe itself equal to -0.9 p.p.; the impact is highly statistically significant and it is similar in magnitude when considering the alternative measures of energy exposure. In the next section, we investigate the dynamics of the energy exposure - return relationship over time.

4.2 Time-varying evidence

4.2.1 Econometric specification

In the second empirical exercise we aim at analyzing the time-variation of the heterogeneous impact of the energy crisis on stock returns in Europe and in the US. We first rely on the following panel regression model, estimated separately for each of the two geographical areas at the daily frequency:

$$y_{i,t} = \alpha_s + \alpha_d + \alpha_w \cdot \beta s_i + \gamma X_i + \varepsilon_{i,t} \qquad i \in \{EU, US\} \tag{2}$$

where the definition of each variable follows the one in Equation 1, but we now include a variable α_w that is a week fixed effect capturing the evolution of β over time. Thus, the interaction term $\alpha_w \beta$ informs us on how stock prices have responded over time to the energy exposure of firms in each region i (EU and US).

Then, we make use of the following specification that employs both European and US

VARIABLES	(1) Cumulative returns	(2) Cumulative returns	(3) Cumulative returns	(4) Cumulative returns
α_c	-0.048***	-0.049***	-0.050***	-0.048***
	(0.001)	(0.001)	(0.001)	(0.001)
US - Market Cap.	0.007***			
	(0.001)			
EU - Market Cap.	-0.016***			
	(0.001)			
US - Revenues		0.006***		
		(0.001)		
EU - Revenues		-0.012***		
		(0.001)		
US - Costs			0.012***	
			(0.001)	
EU - Costs			-0.018***	
			(0.001)	
US - Emissions				0.014***
				(0.001)
EU - Emissions				-0.024***
				(0.001)
Constant	0.819***	0.849***	0.851***	0.715***
	(0.012)	(0.012)	(0.012)	(0.013)
Observations	297,675	297,675	297,675	239,670
R-squared	0.30	0.30	0.30	0.31
Daily FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES

Table 4: **Equity returns and energy exposure**. Dependent variable is the cumulated daily equity return over the period 05/10/2021-30/04/2023. Energy exposure measures are defined in Table 1. Robust standard errors in parentheses. *, **, and *** denote significance at, respectively, the 10%, 5% and 1% level. Controls include ROA, ICR, leverage ratio, capital, and size (log of revenues). The coefficients associate to the EU are marginal effects compared to the US baseline effect.

data to explicitly estimate the differential effect across the two geographical areas:

$$y_{i,t} = \alpha_s + \alpha_d + \alpha_c + \alpha_c \cdot \alpha_w \cdot \beta s_i + \alpha_w \cdot \beta s_i + \gamma X_i + \varepsilon_{i,t} \tag{3}$$

where compared to Eq. (2) we have added the area fixed effect α_c that enters the regression by itself, but that it is also interacted with $\alpha_w \cdot \beta s_i$. The evolution of $\alpha_c \alpha_w \beta$ represents how the exposure to the energy shock has affected, on average and over time, stock returns in Europe *relative* to the US.

4.2.2 Results

Our baseline specification employs energy costs normalized by market capitalization (E1) as key regressor of interest. Figure 2 (upper panels) displays the coefficients $\alpha_w \beta$ respectively for Europe and the US estimated from regression Eq. (2). The estimates suggest that the energy exposure has exerted a detrimental effect on European firms' equity evaluation in our sample as the coefficient is overall negative, sizable and highly statistically significant. Although a partial correction emerges in April-May, when natural gas prices partially stabilized, and in Autumn 2022, likely thanks to the improvement of the European gas market balance (favored by strong LNG imports despite the collapse of Russian flows), the effect that we uncover appear to be very persistent. In the US, the coefficient displays a similar pattern before the invasion of Ukraine and then turns into positive as firms seem to have benefited from the war via their exposure to relatively more affordable energy inputs. Figure 2 (lower panel) reports instead the explicit estimate of the differential geographical effects described by $\alpha_c \alpha_w \beta$ in Eq. (3). We observe that the estimated delta is sizable and statistically significant, fluctuating around a 3 p.p. since the summer of 2022. Our results suggest that the lower energy costs faced by US firms, combined with the risk of energy rationing for European firms, have provided a crucial competitive advantage for US counterparts in international markets, which have materialised in corporate asset prices channeled via the extent of energy use in firms' production functions. Interestingly, even after the inclusion of the European price cap and the partial subsiding

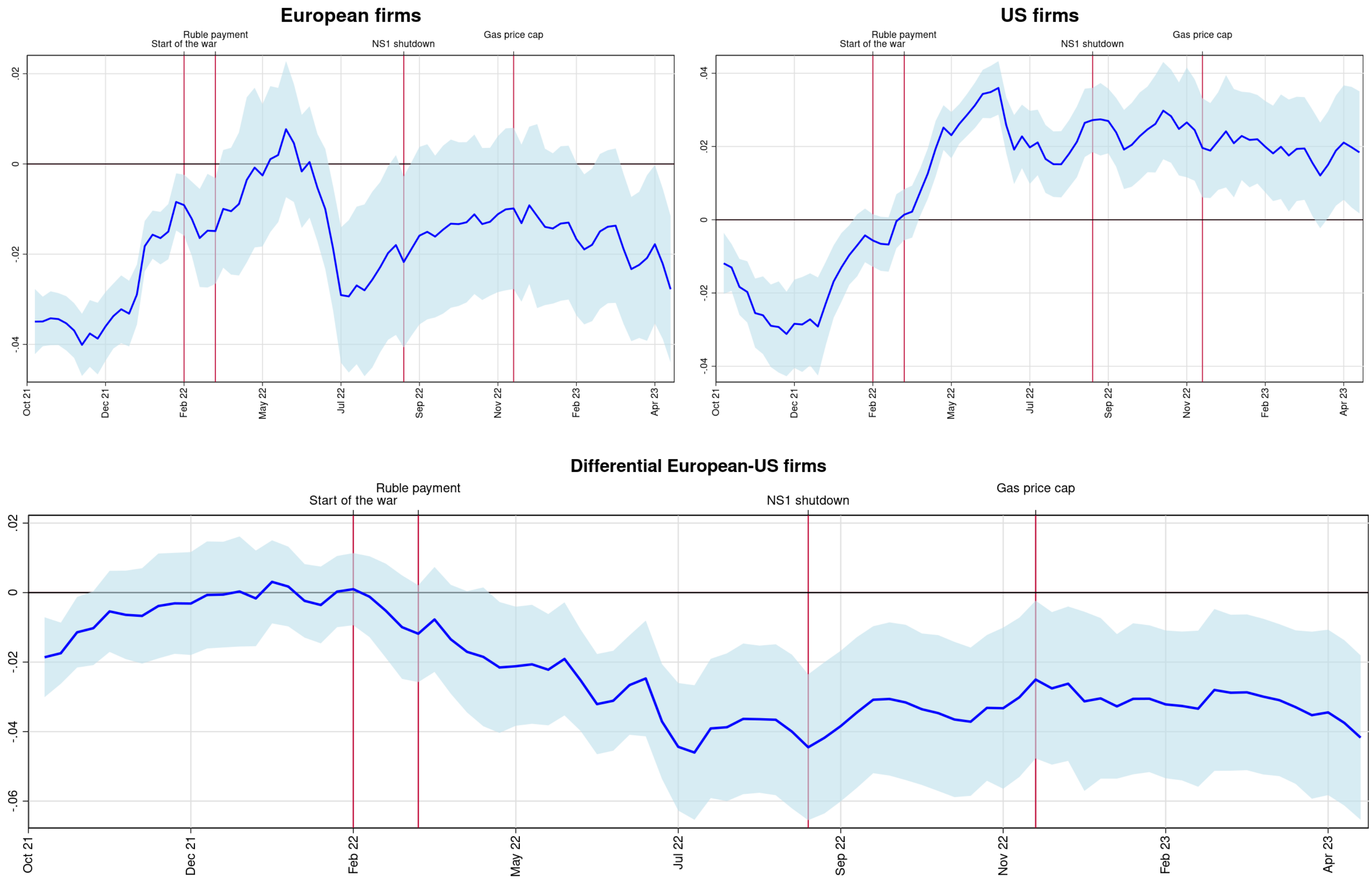


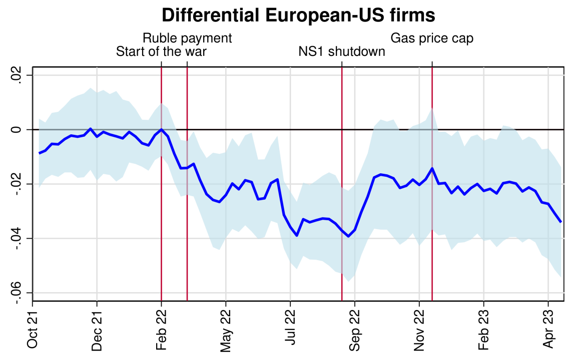
FIGURE 2: ***Equity returns and energy exposure - time varying evidence***. *The graph dynamically displays the impact of energy exposure (E1) on cumulated daily equity return over the period 05/10/2021-30/04/2023. The left plot in the upper panel shows the evolution of the coefficient $\alpha_w\beta$ for EU firms based on the empirical specification in Equation 2, the right plot shows the corresponding estimates for US firms. The lower panel plots the differential impact of energy exposures between EU and US firms captured by $\alpha_c\alpha_w\beta$, as defined in Equation 3.*

of the energy price shock at the end of the 2022/2023 winter, the return differentials did not return to zero, suggesting that investors believe the EU comparative disadvantage to persist over time. In Figure 3 we display the results using the alternative measures of firms' energy exposure presented in Table 1.[7] The time varying-impact is broadly in line with the one obtained using measure E1 and, in some cases, exhibits even larger magnitudes, for ES3 and ES4, consistently with the estimates reported in Table 4.

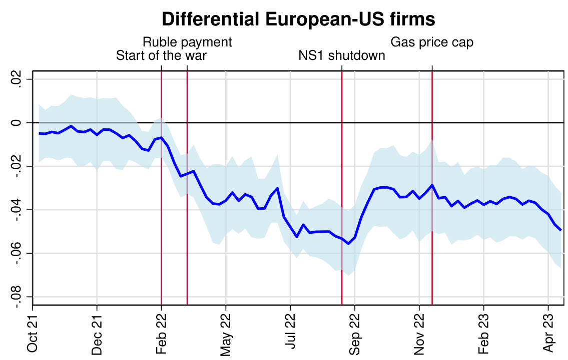
Robustness and additional results. The insights from our analysis are robust across perturbations of the baseline specification that are reported in Appendix B. First, we exclude energy firms in both areas as the record profits registered by these companies in 2022 may alter the estimates; the results are reported in Figure B.1 and are qualitatively similar to the full sample estimates. Second, we replicate the analysis starting our sample in January 24th, 2022 as in Deng et al. (2022) who study the impact of regulatory risk to net-zero transition during the first four months of 2022. Also in this case the estimates are comparable to the baseline (see Figure B.2). Moreover, we show that our results hold even controlling for the channel proposed in Deng et al. (2022) concerning the divergence in the green transition path across EU and US. More precisely, we include in our regressions the firm-level measures of regulatory (transition) exposure and opportunity exposure related to net-zero transition developed by Sautner et al. (2023). Results are respectively displayed in Figures B.3 and B.4: the dynamics of the differential is generally unaffected by the inclusion of these controls (only the statistical significance of the coefficients associate to E2 is somewhat impaired since the summer of 2022).

[7] We limit the evidence to the plots of return differentials, but the full set of results is available upon request

a) Exposure 2 - Revenues



b) Exposure 3 - Costs



c) Exposure 4 - Emissions

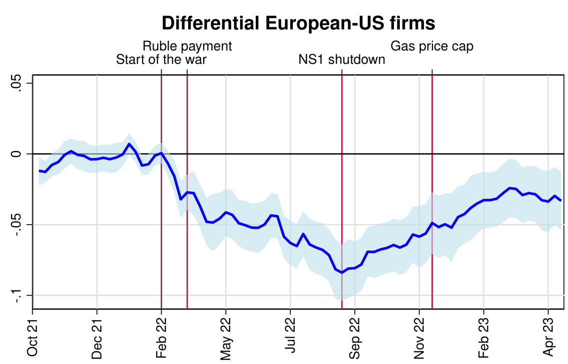


FIGURE 3: ***Equity returns and energy exposure - time varying evidence*** *(ES2-ES4). The figure displays the differential impact of energy exposures between EU and US firms captured by $\alpha_c \alpha_w \beta$, as defined in Equation 3 for the exposure measures ES2 (upper plot), E3 (middle plot), and E4 (lower plot).*

5 Conclusions

The conflict in Ukraine has sparked a profound global energy crisis. Europe, heavily dependent on Russian energy imports, has been particularly vulnerable to disruptions in the energy market. However, as winter 2022/2023 drew to a close, it becomes evident that the adverse effects of the energy crisis have been at least partially alleviated through a combination of factors, including the redirection and substitution of energy flows, favorable weather conditions, policy measures aimed at enhancing energy security and promoting energy conservation, see (McWilliams et al., 2023) and (Kotek et al., 2023) for some contributions reviewing the unfolding of the energy crisis in EU and the initiatives adopted by the European authorities.

Despite experiencing a substantial decline of approximately 90% from their peak in August 2022, natural gas prices in Europe at the end of April 2023 were still considerably high in historical terms, being approximately double the average price recorded in the five-year period preceding the onset of the conflict. In this study we focus on how the preexisting differential in energy prices between EU and the US has been amplified by the outburst of the crisis and on how this differential is reflected in equity market prices across the two regions. Since the onset of the war, we have observed persistent and statistically significant negative return differentials between the EU and the US, even after the partial alleviation of the energy price shock by the end of winter 2022/2023. This discrepancy underscores investors' anticipation of an ongoing and enduring disadvantage for European firms, primarily driven by variations in access to more cost-effective energy resources. In the absence of substantial progress in energy efficiency and the transition to a low-carbon economy, the enduring disparities in energy input costs have the potential to undermine European competitiveness (ECB, 2023) and may prompt the relocation of production in search of more affordable energy prices, particularly in energy-intensive industries (Bialek et al., 2023). Additionally, the absence of a EU coordinated energy policy combined with the lack of harmonized support schemes for large energy consumers can exacerbate these challenges (Faiella and Mistretta, 2020,González and Alonso, 2021), potentially leading to an uneven distribution of energy-related competitive concerns within the EU bloc.

Looking ahead, the natural gas market in Europe is anticipated to maintain a state of high uncertainty, leaving it vulnerable to a resurgence of price volatility. This uncertainty stems from several factors, including weather-related conditions such as a dry summer that could impact power generation and a potentially colder winter than in 2022/2023, the possibility of a complete halt in Russian pipeline gas deliveries to the European Union, the tightening of LNG markets as China's demand recovers following the relaxation of Covid-related restrictions (International Energy Agency, 2023). All these factors have the potential to exert additional pressure on the European gas markets, calling policymakers to implement continued and coordinated policy actions aimed at addressing subsidies, promoting energy efficiency, ensuring solidarity and energy security through cross-border energy flows, and pursuing investments in renewable energy sources to achieve sustainable long-term energy independence (Sgaravatti et al., 2023).

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A Dataset

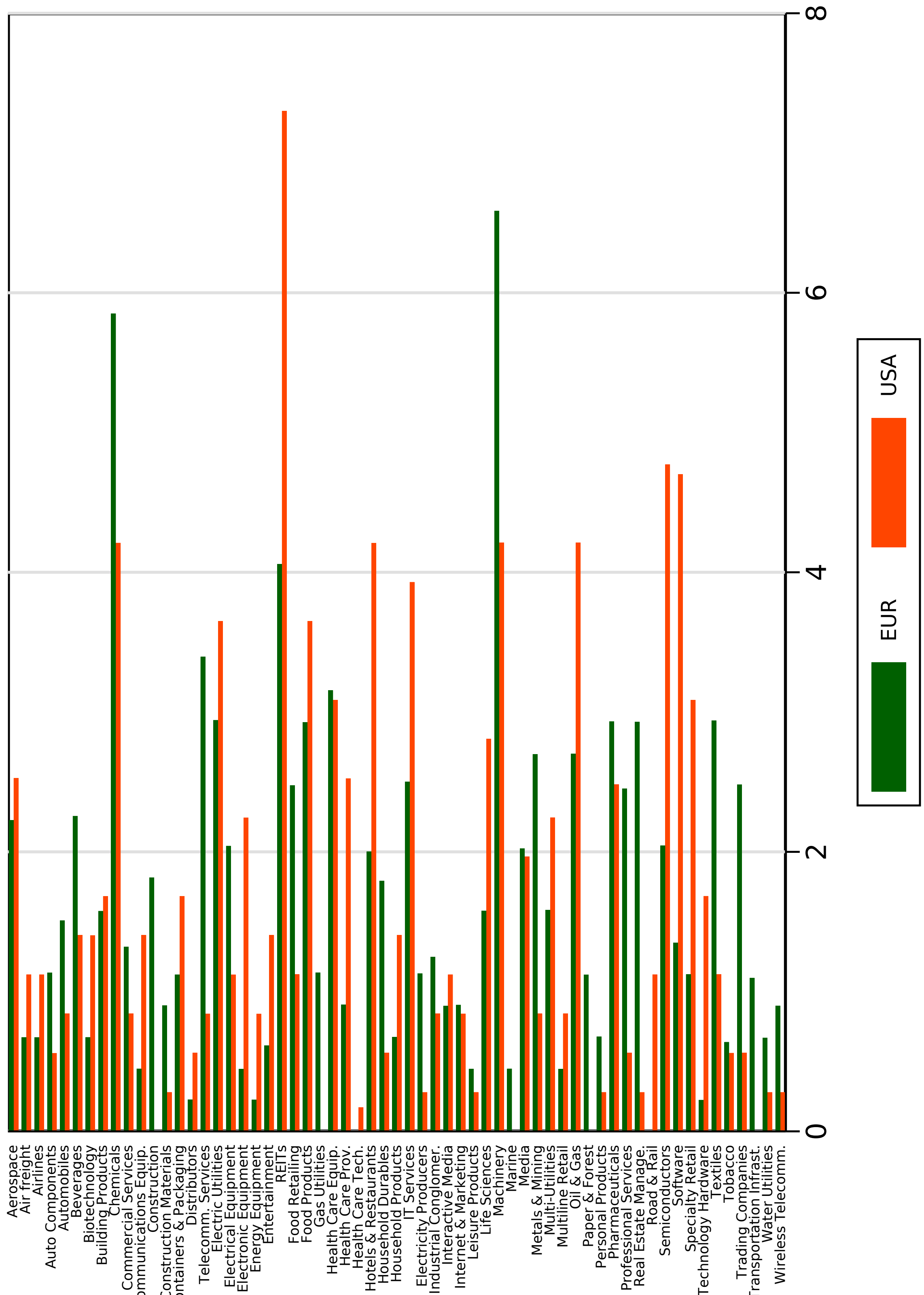


Figure A.1: *Industrial sectors.* *The graph displays the distribution of firms across industries (GICS classification - industry level). Data are expressed in percentage. The exact label of each industry is available upon request.*

B Robustness exercises

This Appendix displays robustness results for the differential geographical effects (triple interaction term $\alpha_c \cdot \alpha_w \cdot \beta s_i$ in Eq. 3) across different energy exposure measures. The full set of results is available upon request.

Exclusion of energy firms from the sample

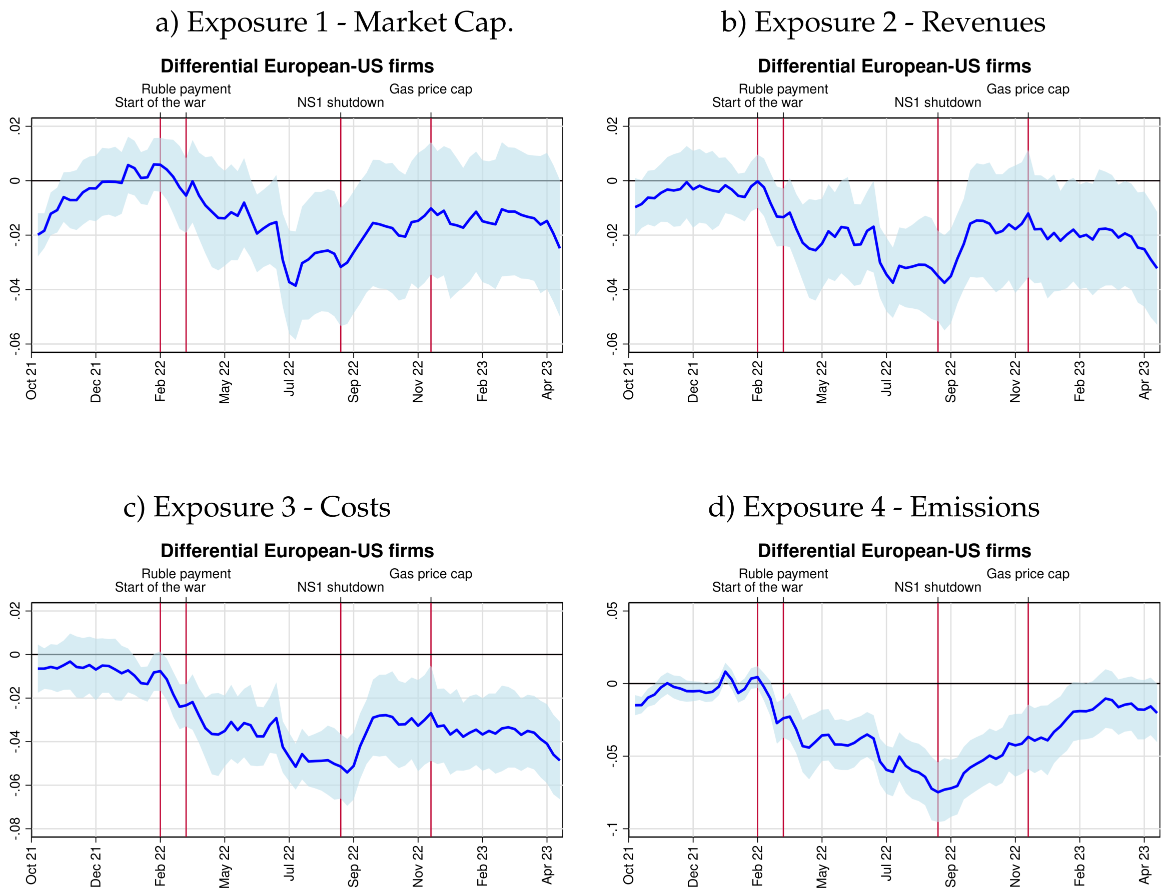
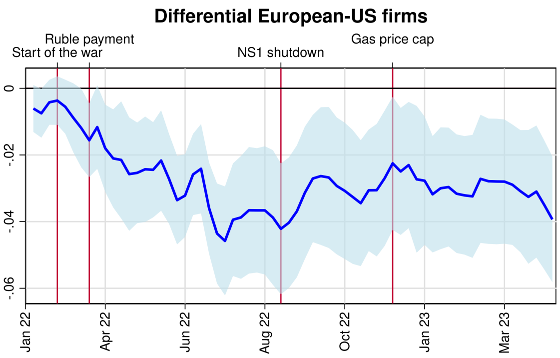


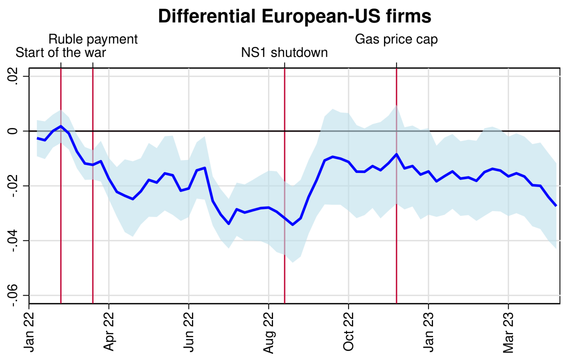
FIGURE B.1: ***Equity returns and energy exposure - time varying evidence excluding energy firms.*** *The figure displays the differential impact of energy exposures between EU and US firms captured by $\alpha_c \alpha_w \beta$, as defined in Equation 3; firms included in the GICS sector "Energy" are excluded.*

Time period starting on January 24th, 2022 (Deng et al., 2022)

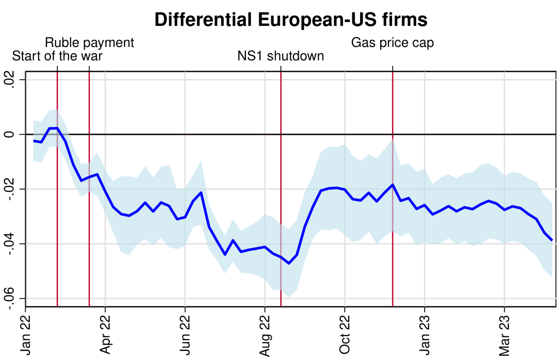
a) Exposure 1 - Market Cap.



b) Exposure 2 - Revenues



c) Exposure 3 - Costs



d) Exposure 4 - Emissions

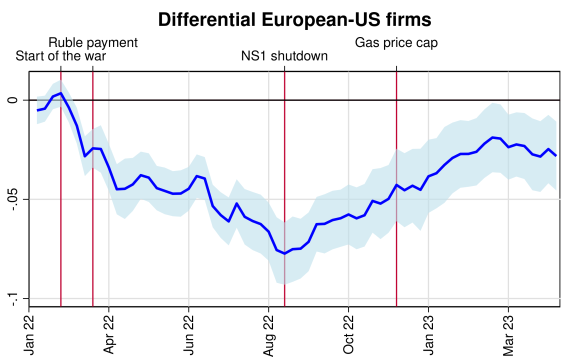
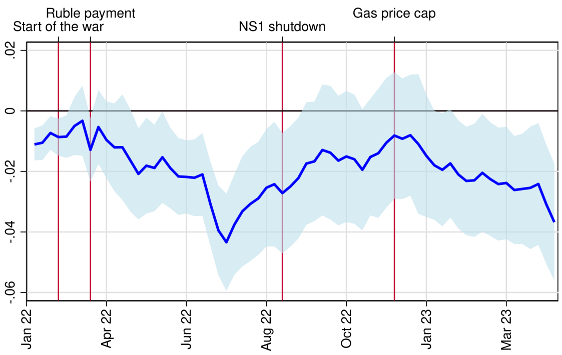


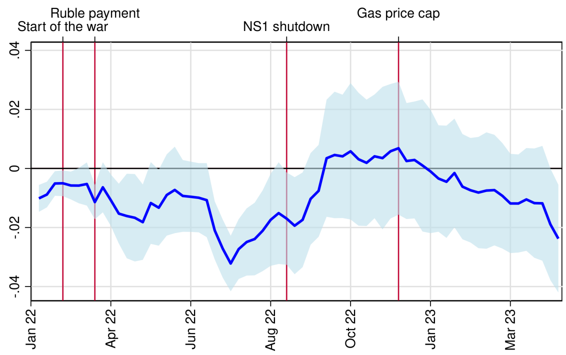
FIGURE B.2: ***Equity returns and energy exposure - time varying evidence starting from January 24th, 2022***. *The figure displays the differential impact of energy exposures between EU and US firms captured by $\alpha_c \alpha_w \beta$, as defined in Equation 3. The starting date to compute cumulated returns is January 24th, 2022 as in Deng et al. (2022).*

Time period starting on January 24th, 2022 (Deng et al., 2022) - controlling for exposure to regulatory risk related to net-zero transition

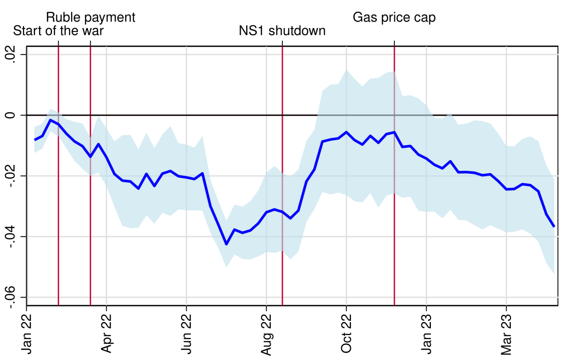
a) Exposure 1 - Market Cap.



b) Exposure 2 - Revenues



c) Exposure 3 - Costs



d) Exposure 4 - Emissions

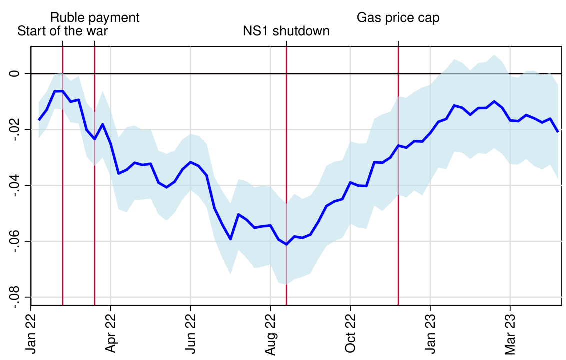


FIGURE B.3: ***Equity returns and energy exposure - time varying evidence controlling for regulatory exposure***. *The figure displays the differential impact of energy exposures between EU and US firms captured by* $\alpha_c \alpha_w \beta$*, as defined in Equation 3. The starting date to compute cumulated returns is January 24th, 2022 as in Deng et al. (2022); controls also include a firm-level measure of exposure to regulatory risk related to net-zero transition developed by Sautner et al. (2023).*

Time period starting on January 24th, 2022 (Deng et al., 2022) - controlling for climate opportunity exposure

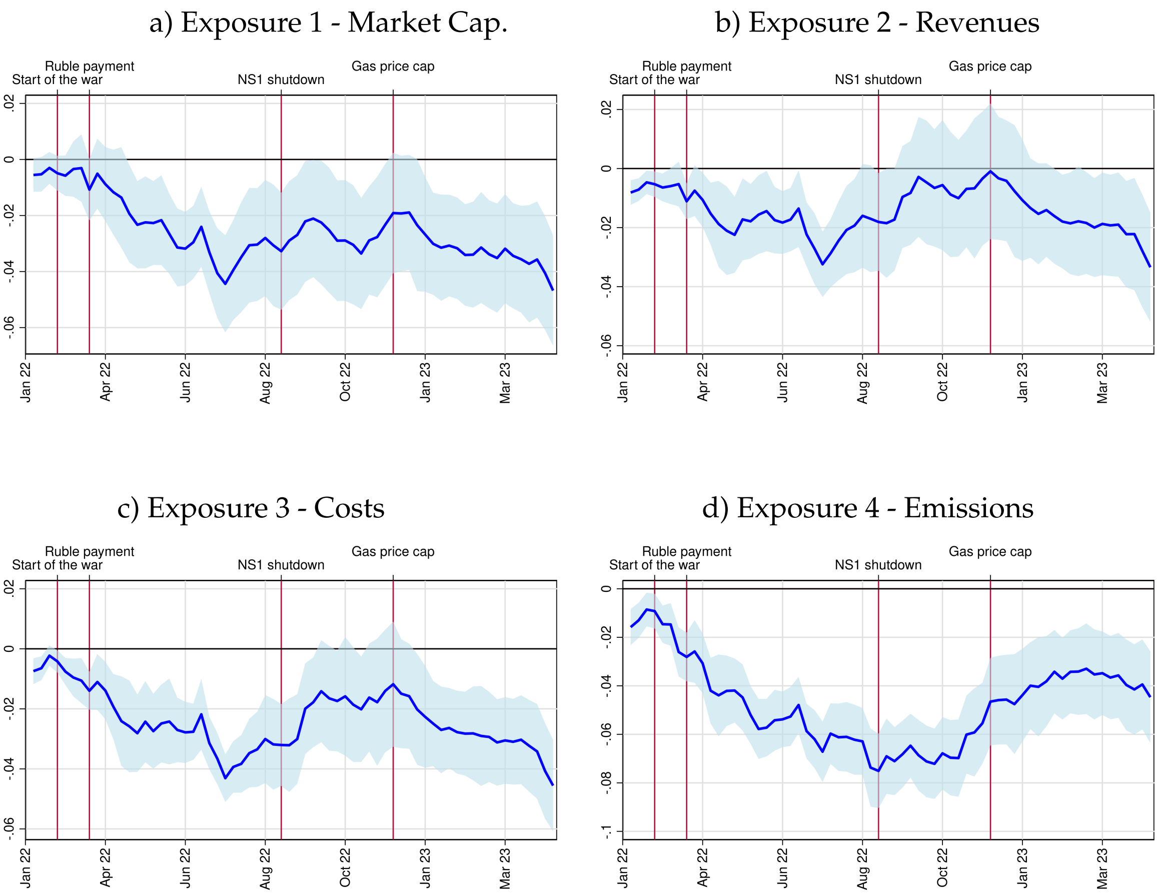


FIGURE B.4: ***Equity returns and energy exposure - time varying evidence controlling for climate opportunity exposure****. The figure displays the differential impact of energy exposures between EU and US firms captured by $\alpha_c \alpha_w \beta$, as defined in Equation 3. The starting date to compute cumulated returns is January 24th, 2022 as in Deng et al. (2022); controls also include a firm-level measure of climate opportunity exposure related to net-zero transition developed by Sautner et al. (2023).*