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Global evidence on the Russia–Ukraine conflict and energy stock returns☆

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ABSTRACT

Using the event-study and difference-in-differences approaches, this paper examines the impact of the Russia–Ukraine conflict on the stock returns of alternative energy and oil & gas producers from 48 countries. We focus on multiple critical events from the beginning of the invasion through eight months into the conflict. Our empirical results indicate that renewable energy and oil & gas producers performed better than the general stock market. Oil & gas producers generated greater returns when compared with alternative energy firms, especially at the beginning of the conflict. The gap in stock returns between the two groups of energy producers shrank significantly as the conflict progressed. Particularly in Europe, later stages of the conflict witnessed greater alternative energy stock returns than oil & gas ones. A further examination of the index returns for the segment of well-established energy firms reveals that renewable indices performed better then oil & gas indices in every critical phase of the conflict. Finally, we show that the stock returns of renewable energy equipment manufacturers also exceeded those of oil & gas equipment producers during the crisis. Overall, our results indicate investors' optimism about the prospect of green energy following the Russian invasion of Ukraine.

1. Introduction

The Russian invasion of Ukraine that started on February 24, 2022, has created shock waves affecting the global economy, which was still fragile following the outbreak of the COVID-19 pandemic. Threats of nuclear escalation forced migration of Ukrainian refugees, and economic sanctions imposed by the Western alliance have caused economic uncertainty.[1] Global energy prices have skyrocketed due to Russia's role as a major producer and exporter of energy. The conflict unavoidably affected economic growth and inflation since energy represents one of the biggest drivers of economic growth and affect prices (Gross, 2012; Stern, 2000) .

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[1] Among the economic sanctions are the SWIFT ban on some Russian banks and the freezing of the assets of the Russian Central Bank. A detailed list and timeline of sanctions can be found at https://www.piie.com/blogs/realtime-economics/russias-war-ukraine-sanctions-timeline.

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This paper adopts an event-study approach to examine how the Russia–Ukraine conflict affected stock returns for two groups of energy producers: (i) alternative energy and (ii) oil & gas. As a major contributor to greenhouse gas emissions, oil & gas producers are responsible for 57.1% of global energy consumption. The share for alternative energy is only 11.4%. A rapid switch to this source of energy is needed to reduce environmental pollution (Ritchie et al., 2020). Our investigation into the impact of the war has strong implications for the green economy transition. There are conflicting views regarding whether the Ukraine war will disrupt or accelerate the transition to green energy around the world.[2] We contribute to this debate by making a comparison between the stock returns of alternative energy and oil & gas producers as well as between the returns of equipment manufacturers and services providers for the two groups of energy producers. The latter analysis provides a credible indicator of investors' perception of the future. Furthermore, we examine the dynamics of stock market changes in response to the major events that occurred during the first eight months of the conflict.

Fig. 1 shows the changes in stock market indices since the invasion that took place on February 24, 2022. Renewable energy and oil & gas producer indices performed much better than the overall index represented by Morgan Stanley Capital International (MSCI) World. Since share prices convey noisy but unbiased information about a firm's future prospects (Faure-Grimaud, 2002), the findings of this paper are likely to shed light on future investments in the energy sector. This will help with understanding the financial and environmental impacts of the war between Russia and Ukraine, enabling investors, portfolio managers, and policy makers to design effective strategies. In addition, the paper extends the previous literature on the relationship between wars and stock markets, which mainly focuses on the Second World War and military conflicts in the Middle East (Fernandez, 2008; Frey &; Hudson & Urquhart, 2015; Kucher, 2000; Schneider & Troeger, 2006).

The Russian-Ukrainian conflict has prompted an increasing number of studies regarding its impact on both stock markets and energy companies. Ngo et al. (2022) show that the country's public sentiment can be explained by the trading intensity of each country with Russia. Nerlinger and Utz (2022) find that stocks of fossil fuel producing energy companies outperformed the overall market. In addition, they demonstrate that renewable energy firms experienced short-lived upward movement and subsequently underperformed when compared to fossil fuel producers. Nerlinger and Utz (2022) further point out the existence of regional heterogeneities – renewable energy producers in Europe performed worse than their counterparts in North America. Approaching the same issue from a slightly different angle, Liao (2023) reveals that European firms that rely heavily on renewable energy tend to experience lower stock return declines than firms that rely less on it. In another recent study, Yousaf et al. (2022) confirm the finding that regional stock markets responded differently to the conflict between Russia and Ukraine. European and Asian markets are more adversely affected by the war than other regions. Federle et al. (2022) elaborate on the findings of Ngo et al. (2022) and Yousaf et al. (2022) to show that two thirds of the "proximity penalty"[3] is explained by trade linkages and the remainder could be attributed to military disaster risk which increases with geographic proximity. In their study, Tosun and Eshraghi (2022) focus on unexplored differences between companies that chose to leave and those that stayed in Russia after the conflict erupted. A portfolio consisting of "stayers" shows lower returns than a portfolio of "leavers" and the market benchmark, indicating that investors penalize "stayers" who remain in Russia.

Using the single index model (CAPM), historical mean model (HMM), and the Fama and French (1993) three-factor model (FF3), we estimate the reaction of stock prices by measuring daily abnormal returns. We employ six different event windows ranging from −5 to +20 days around the event day. Using a sample of actively traded stocks of 627 alternative energy and oil & gas producing firms from 48 countries, we compute their cumulative average returns and cumulative average abnormal returns to unveil any significant reactions in the stock indices. We augment our event study framework with a difference-in-differences (DID) analysis to test whether our findings hold under a different methodology.

We contribute three important insights to the literature on wars and conflicts (particularly the Russian-Ukraine conflict) and financial markets. Unlike Ahmed et al. (2023), Yousaf et al. (2022), and Tosun and Eshraghi (2022), which cover broad industry sectors, our event-study analysis focuses on energy specific sectors, and it begins with a focus on stock market responses surrounding the invasion (February 24, 2022). This is in line with Nerlinger and Utz (2022), Liao (2023), and Umar et al. (2022). Our analysis is further extended to cover the major events that occurred during the first eight months of the crisis. Specifically, we focus on the impact of the sanctions as well as other notable events during the war, all the way up to September 20, 2022, the announcement date of partial mobilization in Russia. To the best of our knowledge, this study is the first to examine the dynamic changes in the impact of the conflict on renewable energy and oil & gas stock returns over time. Having a longer time coverage, our empirical investigation reveals additional subtleties in energy stocks' reactions. Our results confirm the finding of Nerlinger and Utz (2022) that fossil fuel producing energy firms outperformed the overall stock market. Renewable energy firms experienced a short-lived upward movement, which was followed by a subsequent under-performance when compared to fossil fuel producers. In spite of this, the difference between stock returns of renewables and oil and gas producers continued to decrease towards the end of September, signaling a positive indicator for green energy.

Furthermore, unlike previous studies (Liao, 2023; Umar et al., 2022) that examined the reaction of fossil fuel producers and consumers, this paper investigates renewable versus oil & gas related equipment producers' performance. The equity returns of equipment manufacturers may provide insight into investor expectations for longer-term horizons for the industries under scrutiny, particularly the energy sector (Jooet al. 2007). Our estimations indicate that renewable energy related equipment manufacturers and service providers outperformed their oil & gas related counterparts. This indicates investors' expectations for the future of green

[2] For media coverage on this topic, see (Hook & Hume, 2022) in *Financial Times* (March 8, 2022).

[3] Proximity penalty could be defined as the sum of factors stemming from trade linkages and geographical closeness of the countries to the conflict zone, which results in the lower equity returns around the start of the conflict.

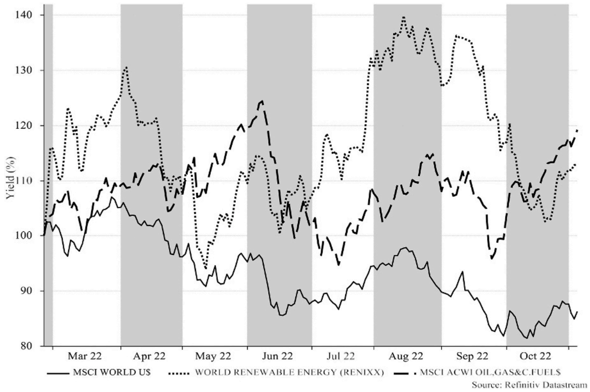

Fig. 1. MSCI World, World Renewable Energy and MSCI ACWI Oil, Gas & Fuel stock indices in the period from February 24 to November 1, 2022. Due to the large variation in the absolute values of the three indices, they are all re-scaled to a commencement value of 100% on February 24, 2022.

transition, suggesting that the conflict might boost alternative energy production.

Lastly, similar to Nerlinger and Utz (2022), Liao (2023), Umar et al. (2022), and Federle et al. (2022), we examine regional heterogeneities in the impact of the conflict on energy companies. Contrary to Liao (2023) who focuses on renewable energy companies, and in line with Nerlinger and Utz (2022), our results indicate that North American renewable and oil & gas producers outperformed European ones. However, the stock return indicators for European firms are statistically more significant than those for North America. Due to our extended period of coverage, we are able to demonstrate that European alternative energy firms performed better than oil & gas producers later in the conflict. These findings indicate disparities in the expectations regarding renewables and the green transition in different regions.

The remainder of the paper is organized as follows. Section 2 reviews the literature. Section 3 discusses the data, followed by the methodology explained in Section 4. Section 5 presents the empirical results and Section 6 concludes.

2. Literature review

Prior literature on the impact of wars, military conflicts, and economic sanctions on financial markets is relatively limited. There is a lack of consistency in the conclusions reached by studies attempting to evaluate the effects of the World War II (WWII). For example, using event-study and regression analysis, Hudson and Urquhart (2015) find limited evidence of a link between WWII related events and British stock returns. Choudhry (2010), on the other hand, uses the structural shift test to show that the majority of WWII events resulted in structural breaks both in price movement and stock return volatility. Frey and Kucher (2000) investigate the effect of WWII on the sovereign bond prices of five European countries. They show that in addition to the outbreak of WWII, loss and gain of national sovereignty influenced the European capital markets. Some war events that are generally considered crucial are clearly reflected in government bond prices, while other events are not (most prominently, Germany's capitulation in 1945). The inconsistent findings could not be only due to application of different empirical approaches to different markets. It may be due to the "surprise" element of the news, the severity of the shock, the changing level of market efficiency over time caused by changes in institutions, market regulations, and information technologies. Furthermore, the disagreements in results could also be attributed to the "corporate learning" history of firms. For instance, Tosun et al. (2021, 2023) find that firms learn from their experience and the stock market values this learning. Organizational resilience formed from exposure to crises such as COVID-19, Global Financial Crisis, and previous military conflicts may impact the performance of firms. Additionally, policy responses to crises may impact stock returns over time as they unfold (Kakhkharov & Bianchi, 2022). In this paper, we consider "information leakage" by including pre-event days in our event windows and identify the events by using the spread between Russian and US sovereign bonds.

The US declaration of the war on terror and the subsequent invasion of Iraq mostly affected developed financial markets, according to Fernandez (2008). Rigobon and Sack (2005) use a heteroskedasticity-based estimation technique and show that increases in Iraq war risk caused declines in Treasury yields and equity prices, a widening of lower-grade corporate spreads, a fall in the dollar, and a rise in oil prices. Schneider and Troeger (2006) examine how the conflict between Iraq and the United Nations, as well as the conflict between Israel and the Palestinians, and the civil wars in Ex-Yugoslavia, impacted French, British, and American stock indices. They show that the conflicts caused a negative reaction in all three markets, with the notable exception of the Operation Desert Storm. This result shows that not all international wars affect the stock markets in the same way. These differences reflect the heterogeneous responses of the markets and industries to a militarized conflict.

As noted in Schneider and Troeger (2006), investors perceive wartime events as exogenous shocks that can become relevant for the financial markets depending on the severity of the war related events. During times of war, equity markets may be impacted by higher or lower share prices, or by increased risk. If investors do not use relevant information, they face losses. The development of firms, sectors, or all equity markets can be affected by war-related events. When war escalates and intimidation (such as sanctions) increases, investors may perceive this as disrupting economic activities, which could reflect in stock prices.

Initial empirical investigations into the Russian invasion of Ukraine, by Boungou and Yatié (2022), reveal a negative effect on global stock market indices, although this impact is heterogeneous. Ahmed et al. (2023) observe that the European stock markets tended to react negatively to this conflict. The magnitude of the stock price reactions shows considerable variation across industries, countries, and the size of the company. The analysis focusing on the start of the military campaign shows a significant negative impact of the conflict on the stock markets of Hungary, Russia, Poland, and Slovakia even before the invasion. Interestingly, for some other countries located remotely from the conflict zone (such as Australia, India, Japan, South Africa, and Spain) the stock markets responded only after the invasion had occurred (Yousaf et al., 2022). A globalized world presents few safeguards against the conflict's fallout. As a result of this conflict, globalized economies were more susceptible to it, whereas NATO markets generated higher returns. Boubaker et al. (2022) show that better performance of NATO countries could be attributed to greater expected military expenditures.

Empirical inquiries into the performance of global energy firms indicate that these firms outperformed the stock market. In fact, North American firms fared better than European and Asian ones, which may suggest that energy firms competing with those in Russia performed better than other energy firms (Nerlinger & Utz, 2022). Alternative explanation of the underperformance of European firms is "proximity penalty" (Federle et al., 2022). However, policy reaction from the EU was prompt. As a result of the conflict disrupting the global energy market, the European Commission launched REPowerEU in May 2022 to save energy, produce clean energy, and diversify energy supplies. In March 2023, the EU agreed on stronger legislation to increase its renewables capacity, raising the EU's binding target for 2030 to 42.5%, with the ambition to reach 45%. This would almost double the existing share of renewable energy in the EU (European Commission, 2023). A positive impact of these policy actions may also be seen on the share price of European alternative energy producers.

To sum up, most studies find that financial markets were adversely affected by military conflicts, although there are notable exceptions. Based on the previous literature and considering that Russia is the largest exporter of energy in the world, we hypothesize that the military conflict in Ukraine may have significant but potentially heterogeneous effects on the stocks of alternative energy and oil & gas producers. Based on the literature review, we form the following testable hypotheses.

H1. *Considering the power of the shock associated with the Russian-Ukraine conflict, importance of Russian energy supplies, and increased efficiency of stock markets, we expect both fossil fuel and alternative energy producers to perform better than the market.*

This is because investors would anticipate that both types of energy firms would benefit from higher prices for energy.

H2. *Firms in various regions are affected differently by the war due to the "proximity penalty".*

However, we expect that this relationship is not static, and the course of the conflict may have an impact on its dynamics. In addition, the differences in policies regarding alternative vs fossil energy in different regions may influence the dynamics of this heterogeneity.

3. Data

Our goal is to investigate the behavior of shares of alternative energy and oil & gas producers by conducting an event-study analysis at crucial time points of the Russia–Ukraine crisis. Emerging literature applying a similar event-study approach uses the start date of February 24, 2022 (the day of invasion) to examine the immediate impact (Boubakeret al. 2022; Nerlinger & Utz, 2022; Yousaf et al., 2022). However, there were several significant events during the invasion, which created strong shockwaves throughout the global markets. These include sanctions against Russia, counter sanctions of Russia, and military escalations including partial mobilization in Russia. We follow the approach of Mamonov et al. (2022) to approximate the severity of sanctions and escalations by the sovereign international bond spread between 10-year US and 10-year Russian sovereign bonds. Based on the conclusion of Mendoza & Yue (2012), this indicator summarizes investors' expectations for the future path of the economy. In our event-study framework, we focus on the five largest increases in the spread since the beginning of the invasion. These five hikes, depicted in Fig. 2, occurred on February 24, March 4, March 21, June 29, and September 20 of 2022, respectively.

In our empirical analysis, we use the global sample of share returns that includes all companies covering all markets in Refinitiv Datastream[4] in two sectors – (i) Alternative Energy and (ii) Oil & Gas Producers. We use the data on daily stock returns for all publicly traded firms between November 1, 2020 and November 1, 2022. We select ordinary shares of firms traded in major exchanges as classified by Refinitiv. Since many large companies may have shares issued in various markets, selecting all shares issued by these firms may result in double-counting. To alleviate this concern, we select quotes only from primary markets where the firms are domiciled. Information efficiency of stocks which are not liquid and traded irregularly is low. Therefore, we follow Demirgüç-Kunt et al. (2021) and drop 737 stocks that were traded in less than 30% of the business days in each country throughout the sampling period. This leaves a sample of 640 alternative energy and oil & gas producers. We further drop Russian stocks (all of them are major oil and gas companies) as Russia is a major party involved in this conflict and due to the suspension of the Russian stock exchange. At the outset of the conflict, trading in the largest stock exchange in Russia MICEX (the Moscow Stock Exchange) was suspended from February 24 to March 21, 2022. Our final sample includes 627 firms in Alternative Energy and Oil & Gas Producers sectors from 48 countries. The distributions by industry groups and continents appear in Table 1. As expected, oil & gas producers account for a substantial portion of the sample. Moreover, the majority of firms appear to be located in North America, Australasia, and Europe. Therefore, we concentrate on the impact of the conflict on energy firms in these regions.

[4] For more information and access options: https://www.refinitiv.com.

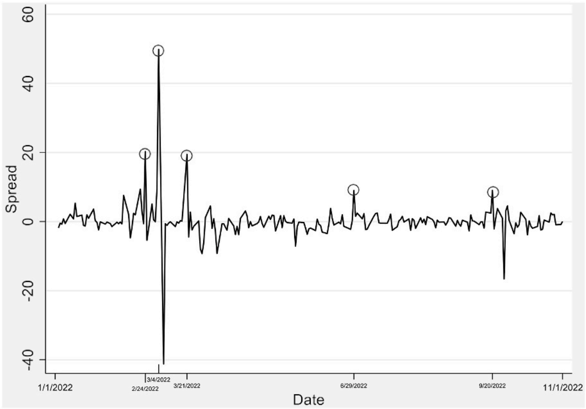

Fig. 2. Spread in percentages between 10-Year US and Russian Treasure bonds in the period from January 1, 2022 to November 1, 2022.

Table 1
Industry group & continent breakdown of the sample.

	N	%
Industry Group:		
Alternative Energy	254	40.51
Oil & Gas Producers	373	59.49
Continent:		
Africa	2	0.32
Australasia	197	31.42
Europe	154	24.56
North America	258	41.15
South America	16	2.55
Total	627	100.00

We also compare the results obtained using our sample with those based on the performance of indices tracking alternative energy and oil & gas sectors. The data for these indices are obtained from Refinitiv Datastream. The list of these indices appears in Appendix Table A1.

4. Empirical methodology

Our analysis employs the event-study methodology, which has two main strengths; simplicity and parsimony (Aït-Sahalia et al., 2012).[5] Since the predominant assumption is that markets are largely efficient and rational, the effects of an event will be reflected immediately in security prices. As such, a measure of the event's impact can be constructed using security prices observed over a relatively short period of time (MacKinlay, 1997).

We estimate the reaction of stock prices for alternative energy and oil & gas producers by measuring daily abnormal returns (ARs), which are computed as the difference between the actual ex-post return of the security over the event window and its normal or expected return over the same window without conditioning on the event taking place. In our sample of alternative energy and oil & gas producers, we first measure the reaction to the conflict related events.

In our baseline analysis, we estimate ARs using three different models including (i) single index model (CAPM), (ii) historical mean model (HMM), and (iii) Fama and French (1993) three-factor model (FF3).[6] The benchmark index for the single index model is MSCI World. Three-factor model daily factors are obtained from the website of Professor Kenneth R. French.[7] The parameters of the market models are obtained using daily returns of the alternative energy and oil & gas firms over a 250-day estimation period, ending 20 days before the event.

The most common model used in the literature is CAPM. The main advantage of CAPM is that it is a simple model that can be easily tested to derive a range of possible outcomes. The downside is that it can be difficult to determine beta accurately. In many cases HMM's results are similar to CAPM and its pros and cons are also similar to CAPM's. The three-factor model, introduced by Fama and

[5] The approach is implemented in Stata using the *estudy* program developed by Pacicco et al. (2021).
[6] HMM model assumes that the historical mean return over the estimation window represents expected normal performance unconditioned to the event, which Brown and Warner (1985) argue yield results comparable with the single index model.
[7] We are grateful to Professor Kenneth French for making the factor data available through the following website https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

French (1993), improves the variance explained and facilitates AR detection.

ARs for indices are cumulated over a period of time (i.e., cumulative abnormal returns or CARs) around the announcement date ($t = 0$) for firms in our sample. Following Nerlinger and Utz (2022), our event window ranges from −5 to +20 days around the event day. Specifically, our event windows are [–1; 1], [–5; 5], [–1; 3], [–1; 5], [–1; 10], and [–1; 20]. Since event periods are relatively short and the invasion and following sanctions represented a strong shock for the sectors covered, it is likely that the war and the war-related events were the only substantial factors impacting the shares. Therefore, the event-study approach is appropriate for studying the reaction of alternative energy and gas & oil producer stocks to the Russia–Ukraine conflict.

For each event window, lasting from t_1 to t_2, CARs are calculated as follows:

$$CAR_i(t_1,t_2)=\sum_{t=t_1}^{t_2}AR_{i,t} \tag{1}$$

In the case of our main sample of 627 firms, we are interested in cross-section aggregation and average abnormal returns (AARs) that are calculated using Equation (2):

$$AAR_t=\frac{1}{N}\sum_{i=1}^{N}AR_{i,t} \tag{2}$$

where $AR_{i,t}$ is the AR estimated on the ith security at time t and N is the population of shares.

Finally, when we focus on the average effect over multiple days, it is necessary to calculate the cumulative average abnormal return (CAAR), which is the sum of the AARs for a certain period, as shown in Equation (3).

$$CAAR_i(t_1,t_2)=\sum_{t=t_1}^{t_2}AAR_{i,t} \tag{3}$$

After computing CARs and CAARs, we test whether a reaction in stock indices is significantly different from zero using the Kolari and Pynnönen (2010) test that accounts for heteroskedasticity.

While the event-study methodology is an appropriate framework to analyze the impact of the conflict through the prism of stock market reaction, it is not sufficient to make strong claims about validity of our results. This is because the event-study framework, although parsimonious and powerful in reflecting the investors sentiment, does not incorporate firm and country fixed effects as well as macro-economic parameters impacting the stock prices via market factors. To make sure our results are not driven by such factors and to validate our findings from the baseline event-study estimations, we employ difference-in-differences (DID) estimations to compare between two groups of energy companies under scrutiny in this paper. In doing so, we adopt the approach applied for studying negative shocks (Tosun et al., 2021, 2023; Tosun, 2021) using panel OLS fixed effects models to incorporate these factors. We run DID regressions by estimating a set of panel regressions of the form:

$$y_{i,t}=\alpha+\gamma' D_{i,\tau}\times \mathrm{Alt}_i+\beta' z_{i,t}+\mu_i+\varepsilon_{i,t} \tag{4}$$

where τ identifies the event window, $y_{i,t}$ represents the variable of interest, the stock return for firm i at time t; Alt_i is a dummy variable that takes a value of one for alternative energy firms and zero for oil & gas companies; $D_{i,\tau}$ is a vector of event windows corresponding to the ones utilized in our event-study approach and zero otherwise; $z_{i,t}$ is a set of control variables including risk factor portfolios and year-by-month fixed effects; and μ_i is the firm-fixed effects. The hypothesis that alternative energy producers perform worse than oil & gas companies is tested based on the regressions coefficients γ over event windows, which represent the reaction of $y_{i,t}$ to shocks associated with the spike in the sovereign bond spread for alternative energy producers vs oil & gas firms over the event window.

5. Empirical results

5.1. The impact of the invasion

We first examine the immediate impact of the full-scale invasion of the Russian army into Ukraine on February 24, 2022. On that particular day, not only did the war begin, but the sovereign bond spread spiked by 21.44%. Table 2 Panel A indicates that all energy firms in our sample performed better than the benchmark. In particular, the results obtained using Fama-French three-factor model are statistically significant except for the event window of [–1; 1].

It appears that this result is predominantly driven by high returns for oil & gas producers, which is in conformity with findings of Nerlinger and Utz (2022). However, the results for alternative energy firms are statistically significant for a greater number of event windows. This could be due to more uniform performance of alternative energy firms. These results are graphically illustrated in Appendix Figures A1, A2, and A3. To test the robustness of the results, we re-run the regressions after filtering the sample for “stayers and leavers” – the corporations that decided either to remain in Russia after the war started and those which discontinued their operations. Tosun and Eshraghi (2022) note that despite public pressure to exit Russia and sanctions announced by the West at the very beginning of the military conflict, some companies decided to continue their activities in Russia. Tosun and Eshraghi (2022) found that a portfolio of “remainers" underperforms a portfolio of “leavers" and the market benchmark in the period between February 3, 2022 and March 8, 2022, which corresponds to the period under investigation in Table 2. This probably means that investors impose a

Table 2
CAARs for alternative energy and oil & gas producers (event date: 24 February).

Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
PANEL A: All Energy Firms								
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	1.06	1.08	1.10	627	3.97	3.94[b]	4.00	627
Alternative Energy	0.54	0.44	0.44	254	1.74	1.71	1.71	254
Oil & Gas	1.08	1.09	1.12	373	4.03	4.00[b]	4.05	373
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	1.99[c]	2.06[c]	2.04	627	2.87[c]	2.85[a]	2.91	627
Alternative Energy	0.93[b]	0.79[b]	0.82[b]	254	1.27[c]	1.13[a]	1.15[c]	254
Oil & Gas	2.02	2.08[b]	2.07	373	2.91	2.88[b]	2.95	373
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	6.11	6.09[c]	6.11	627	9.63	9.66[b]	9.63	627
Alternative Energy	3.34[b]	3.27[a]	3.26[b]	254	5.28[c]	5.21[b]	5.17[c]	254
Oil & Gas	6.05	5.94[c]	5.99	373	9.28	9.28	9.22	373
PANEL B: Excluding Stayer and Leaver Firms								
Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	1.06	1.09	1.11	605	3.95[a]	3.94[b]	4.01	605
Alternative Energy	0.55	0.44	0.44	250	1.74	1.71	1.72	250
Oil & Gas	1.08	1.09	1.12	355	4.04	4.00***	4.06	355
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	1.99[b]	2.06[a]	2.04[b]	605	2.88[b]	2.85[a]	2.91[b]	605
Alternative Energy	0.93[b]	0.79[b]	0.83[b]	250	1.28[c]	1.13[a]	1.16[c]	250
Oil & Gas	2.02	2.09[a]	2.07	355	2.92[c]	2.89[a]	2.95	355
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	6.12	6.09[a]	6.12	605	9.67[b]	9.66[b]	9.64	605
Alternative Energy	3.35[b]	3.28[a]	3.26[b]	250	5.28[c]	5.21[b]	5.17[c]	250
Oil & Gas	6.06	5.95[c]	6.00	355	9.29	9.24	9.24	355
PANEL C: Firms Exposed to GFC								
Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	1.04	1.06	1.09	313	3.42	3.43[b]	3.47	313
Alternative Energy	0.43[c]	0.39[c]	0.39[c]	81	1.39	1.38[c]	1.36	81
Oil & Gas	1.05	1.07	1.10	232	3.33	3.40[b]	3.40	232
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	1.62[c]	1.60[a]	1.66[c]	313	2.38[c]	2.34[a]	2.41[c]	313
Alternative Energy	0.84[b]	0.76[a]	0.80[b]	81	1.20[b]	1.11[b]	1.15[b]	81
Oil & Gas	1.52	1.56[b]	1.56	232	2.28	2.30[b]	2.32	232
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	5.65	5.62[c]	5.64	313	8.83	8.87[c]	8.83	313
Alternative Energy	2.99[b]	2.95[a]	2.97[b]	81	4.24[c]	4.20[b]	4.21[c]	81
Oil & Gas	5.29	5.26	5.23	232	8.50	8.54	8.45	232
PANEL D: Firms with IPOs Issued after the GFC								
Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	0.78	0.80	0.83	314	3.49	3.47[b]	3.51	314
Alternative Energy	0.51	0.40	0.40	173	1.44	1.45	1.41	173
Oil & Gas	0.80	0.81	0.84	141	3.54	3.49[b]	3.54	141
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	1.73[c]	1.80[a]	1.78[c]	314	2.63[c]	2.60[a]	2.66[c]	314
Alternative Energy	0.73[c]	0.62[b]	0.61[c]	173	0.96	0.86[b]	0.84	173
Oil & Gas	1.76	1.81[a]	1.81	141	2.67	2.63[b]	2.71	141
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	4.67[b]	4.72[a]	4.73[b]	314	7.00[c]	7.05[a]	7.04[c]	314
Alternative Energy	2.57[b]	2.54[a]	2.46[b]	173	4.18[c]	4.12[b]	4.04[c]	173
Oil & Gas	4.52	4.56[bb]	4.56	141	6.40	6.41[b]	6.41	141

Notes: This table shows the cumulative average abnormal returns (CAARs) for all firms, alternative energy and oil & gas producer industry sectors and event windows around event date – *February 24, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.

[a] $p < 0.01$.
[b] $p < 0.05$.

[c] $p < 0.10$.

penalty on the companies staying in Russia. Re-estimating our model with a smaller sample, without stayers and leavers, allowed us to dig deeper into this issue. The results in Table 2 Panel B indicate that while there is a minor change in the value of coefficients, the statistical significance of results increased. We interpret this outcome as evidence that the findings of our baseline results in Table 2 Panel A are valid.

Tosun et al. (2023) suggests that firms having experienced big negative shocks such as disasters learn from those events and be better prepared for a similar shock in the future. This is based on organizational learning concept explored in detail by Marquis and Tilcsik (2013) and Smith and Elliott (2007). There may be a correlation between investors' attitudes towards firms that have survived such shocks in the past and those that have not. Therefore, our results could be biased due to presence of firms in our sample which were exposed to similar shocks in the past. The most recent big shock in the past was COVID-19. However, the pandemic was a very recent event and the number of firms in the industries under scrutiny in this study did not change significantly after COVID-19. Another big shock to energy producers was the Global Financial Crisis (GFC), with prices of energy increasing to record levels just before GFC and plummeting during the GFC. In the aftermath of the conflict in Ukraine, the firms that survived these shocks could have provided investors with a safe haven. Hence, we divided our sample into two parts: one part consisting of firms who accomplished their IPOs before the GFC was over (before January 1, 2009) and those that issued their IPOs after the GFC. Interestingly, this resulted in the creation of two almost equal subsamples: 313 firms that had experienced the GFC and 314 firms that did not. Nevertheless, the proportion of alternative energy and fossil fuel producing firms in the two sub-samples was quite different – 81 versus 232 respectively in pre-GFC sample and 173 versus 141 respectively in post-GFC sample. This is because alternative energy is a relatively new industry that has developed significantly relatively recently.

We re-run our model for the two sub-samples and the results are presented in Panels C and D of Table 2. The results indicate that the differences between our baseline estimations and those for the two sub-samples are essentially similar. The only noticeable difference is the value of the coefficients for the subsample of firms without previous exposure to the crisis, lending partial support to conclusions of Tosun et al. (2023). Nevertheless, the similarities between the results of baseline model and estimations in sub-samples indicate that "corporate learning" was not the factor impacting performance of energy firms during the Russia-Ukraine conflict.[8]

To test the impact of the event on the major renewables and oil & gas indices, we turn our attention to Table 3. It shows that renewable indices performed much better on the day of the event relative to oil & gas indices. Moreover, while the results are statistically significant for renewables indices in virtually all event windows, oil & gas indices are significant only for three-factor Fama-French model. Since components of the index are usually chosen considering "earnings and market perception" and "high dividend and low volatility", mostly reputable and well-established firms are selected into the indices.[9] It appears that investors expect well-established firms specialized in renewable energy to perform better in the future compared to reputable oil and gas firms.

This is in line with our expectation given the fact that renewable energy is a relatively new industry, and oil & gas is a well-established sector. Therefore, considering better prospects for renewables, investors would prefer to invest in reputable firms specialized in renewables rather than smaller/less established alternative energy producers. The results are depicted graphically in Appendix Figures A4 and A5. Next, we analyze the impact of the onset of the war on different regions using a single index model.[10] We focus on Europe (EU), North America (NA), and Australasia. In addition, we investigate the effects of the war on India and China separately from Asia as these two large emerging economies benefited from buying Russian oil and gas at discounted prices. Table 4 shows that the impact was statistically insignificant for firms in most regions. The notable exception is European alternative energy firms. We also note that the difference in performance of European alternative energy firms is not as big as for the total sample, as reported in Table 2.

Table 5 repeats the same exercise using a sample of regional renewables and oil & gas indices. We observe that North American renewable indices performed slightly better than European ones. More strikingly, we find that renewable indices outperformed oil & gas indices. Moreover, the CARs for North American and European renewables are statistically significant for the majority of the event windows, whereas only North American oil & gas index CAR is statistically significant over two event windows ([–1;5] and [–1; 10]).

5.2. The impact of the sanctions

As previously mentioned, sanctions were imposed against Russia as a result of the military conflict, which Russia retaliated in kind. The second week of the war witnessed probably the highest density of sanctions including the freeze of the Russian Central Bank assets, SWIFT ban on Russian banks, expansion by EU of its third major package of sanctions, and many others. As a result, the spread between 10-year US Treasury bond and 10-year Russian bond increased by astronomical 49.81% on 4 March 2022. Although it declined by 41.16% in the next day, a two-day net increase of 8.65% was one of the biggest during the conflict period. Here, we estimate returns for

[8] Since the estimations without leavers and stayers as well as firms with stocks publicly traded prior and post-GFC in other dates of interest yielded results that are broadly similar to our baseline estimations, for the sake of brevity they are not presented in the rest of the paper. These results are available from the authors upon request.

[9] For details of constituent selection process at MSCI and Refinitiv, see the following websites: https://www.msci.com/our-solutions/indexes/gics and https://www.refinitiv.com/en/financial-data/indices.

[10] For regional regressions only CAPM results are reported. Results using FF3 and HHM models are qualitatively the same for most of the regional analysis in the paper. They are available upon request.

Table 3
CARs for alternative energy and oil & gas indices (event date: February 24, 2022).

Indices	CAPM	FF3	HMM	CAPM	FF3	HMM
	CAAR [-1;1]			**CAAR [-5;5]**		
RENIXX	0.11[a]	0.09[a]	0.11[a]	0.09	0.11[c]	0.09
MSCI Oil & Gas	0.02	0.02	0.02	0.02	0.08[a]	0.02
Ref. Global Ren.	0.11[a]	0.08[a]	0.11[a]	0.08	0.12[b]	0.07
Ref. Oil & Gas	0.01	0.01	0.00	−0.15	0.04	−0.00
	CAAR [-1;3]			**CAAR [-1;5]**		
RENIXX	0.20[a]	0.15[a]	0.20[a]	0.16[a]	0.13[a]	0.15[b]
MSCI Oil & Gas	0.03	0.08[a]	0.03	0.05	0.07[a]	0.05
Ref. Global Ren.	0.21[a]	0.16[a]	0.21[a]	0.15[a]	0.13[a]	0.15[a]
Ref. Oil & Gas	0.01	0.05[b]	0.01	0.02	0.04[c]	0.02
	CAAR [-1;10]			**CAAR [-1;20]**		
RENIXX	0.24[a]	0.23[a]	0.23[a]	0.26[a]	0.21[a]	0.27[b]
MSCI Oil & Gas	0.07	0.11[a]	0.73	0.09	0.10[b]	0.09
Ref. Global Ren.	0.24[a]	0.25[a]	0.24[a]	0.28[a]	0.29[a]	0.28[a]
Ref. Oil & Gas	0.01	0.05	0.01	0.03	0.04	0.03

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by MSCI and Refinitiv, and event windows around event date – *February 24, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 4
Regional differences in all firm sample cumulative average abnormal returns.

Industry groups	Europe	NA	Australasia	India/China	Europe	NA	Australasia	India/China
	CAAR [-1;1]				**CAAR [–5;5]**			
Alternative energy	0.26 (N = 83)	0.49 (N = 68)	0.30 (N = 100)	0.17 (N = 57)	0.91 (N = 83)	1.50 (N = 68)	0.10 (N = 100)	0.48 (N = 57)
Oil & Gas	0.823 (n = 71)	0.884 (N = 190)	0.456 (N = 97)	0.169 (N = 21)	0.207 (N = 71)	3.774 (N = 190)	1.638 (N = 97)	0.654 (N = 21)
	CAAR [-1;3]				**CAAR [-1;5]**			
Alternative energy	0.61[c] (N = 83)	0.86[c] (N = 68)	0.48 (N = 100)	0.30 (N = 57)	0.77[c] (N = 83)	1.20 (N = 68)	0.68 (N = 100)	0.38 (N = 57)
Oil & Gas	1.17 (N = 71)	1.84 (N = 190)	0.68 (N = 97)	0.19 (N = 21)	1.40 (N = 71)	2.75 (N = 190)	1.18[c] (N = 97)	0.38 (N = 21)
	CAAR [-1;10]				**CAAR [-1;20]**			
Alternative energy	2.52[b] (N = 83)	2.59[c] (N = 68)	1.30 (N = 100)	0.88 (N = 57)	3.73[a] (N = 83)	4.37[c] (N = 68)	1.80 (N = 100)	1.31 (N = 57)
Oil & Gas	2.92 (N = 71)	5.81 (N = 190)	1.92 (N = 97)	1.06 (N = 21)	4.99 (N = 71)	9.01 (N = 190)	3.15 (N = 97)	1.64 (N = 21)

Notes: This table shows the cumulative average abnormal returns (CAARs) in different regions for alternative energy and oil & gas producer industry sectors and event windows around event date – *February 24, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

event windows considering March 4 of 2022 as Day 0.

The CAARs for alternative energy and oil & gas producers, displayed in Table 6, are not statistically significant in the majority of the windows for both sectors. It is notable that the results for alternative energy firms are statistically significant over the window of [–5; 5] for all three models. This may indicate that the impact of the shock on alternative energy firms was more consistent than that on oil and gas producers.

Table 7 demonstrates the impact of the event on and around March 4 of 2022 on renewables and oil & gas producer sector indices. Similar to the pattern shown in Table 3, renewables indices performed better. Moreover, the results for both renewables indices are statistically significant in four out of the six event windows when using Fama and French three-factor model, whereas for oil & gas producers results are significant only in three out of the six event windows, and only for one of the indices.

Table 5
Regional differences in index CARs (event date: February 24, 2022).

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAR[–1; 20]
Refinitiv EU Renewable	0.12[a]	0.09	0.22[b]	0.14[b]	0.22[b]	0.19
Refinitiv NA Renewable	0.13[b]	0.10	0.27[a]	0.21[b]	0.33[a]	0.42[a]
Refinitiv Asia Pacific Renewable	0.03	−0.00	0.03	0.00	0.07	0.05
Refinitiv Renewable Indices CAR for All Regions	0.18[b]	0.24	0.30[c]	0.26	0.45[a]	0.58[c]
Refinitiv EU Oil & Gas	−0.01	−0.08	−0.05	−0.04	−0.06	−0.00
Refinitiv NA Oil & Gas	0.03	0.06	0.07	0.08[c]	0.13[b]	0.13
Refinitiv Asia Pacific Oil & Gas	−0.02	0.02	−0.00	0.03	−0.00	0.05
Refinitiv Oil & Gas Indices CAR for All Regions	0.01	0.06	0.03	0.08	0.17	0.25

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by Refinitiv, and event windows around event date – *February 24, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.

[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 6
CAARs for alternative energy and oil & gas producers (event date: March 4, 2022).

Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	1.81	1.78[c]	1.76	627	5.65	5.61[b]	5.60	627
Alternative Energy	0.63	0.68[c]	0.64	254	3.13[b]	3.18[b]	3.13[c]	254
Oil & Gas	1.82	1.79	1.78	373	5.58	5.45	5.47	373
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	2.95	2.95	2.91	627	3.80	3.77	3.73	627
Alternative Energy	1.79	1.87	1.81	254	2.31	2.42[a]	2.32	254
Oil & Gas	2.85	2.76	2.76	373	3.71	3.59	3.58	373
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	5.76	5.83	5.71	627	8.74	8.87	8.70	627
Alternative Energy	3.36	3.47	3.39	254	4.91	5.01	4.93	254
Oil & Gas	5.58	5.54	5.46	373	8.38	8.42	8.28	373

Notes: This table shows the cumulative average abnormal returns (CAARs) for all firms, alternative energy and oil & gas producer industry sectors and event windows around event date – *March 4, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.

[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 8 compares regional performance of all firms in the sample. Once again, we note that the results are statistically significant for alternative energy firms in Europe, but not for those in North America. This time we also find that the results are statistically significant for alternative energy firms in India and China. Another interesting trend is that European alternative energy firms fared slightly better than their North American counterparts.

Table 9 presents the estimation results for regional renewables and oil & gas indices. Individual index results are not statistically significant except for CAR for North America over the shortest event window of [–1; 1]. However, renewable index CARs for all regions are positive and statistically significant, whereas the results for oil & gas producers index CARs are mostly negative. We interpret this as further evidence that investors preferred large alternative energy producers over large companies specializing in oil & gas production.

5.3. The impact of other notable events

A further sizeable increase in bond spread by 19.44% took place on March 21, 2022. In the week preceding to this increase, the EU imposed its fourth major package of sanctions. It restricted imports of iron and steel from Russia and exports of luxury goods to Russia and prohibited new investments and added export controls targeting the Russian energy industry. It also expanded export controls previously applied to the Russian defense and security sectors, prohibited transactions with certain Russian state-owned enterprises and the provision of credit-rating services, and sanctioned additional Russian oligarchs.

A few days after this increase in spread, Group of 7 (G7) and EU leaders met at NATO headquarters in Brussels and committed to fully implement sanctions already announced, work with other governments to impose similar sanctions, and prevent evasion,

Table 7
CARs for alternative energy and oil & gas indices (event date: March 4, 2022).

Industry Group	CAPM	FF3	HMM	CAPM	FF3	HMM
	CAAR [-1;1]			**CAAR [-5;5]**		
RENIXX	0.02	0.09[a]	0.02	0.20[a]	0.21[a]	0.20[b]
MSCI Oil & Gas	0.01	0.05[a]	0.01	0.07	0.08[a]	0.07
Ref. Global Ren.	−0.01	0.09[a]	−0.02	0.17	0.18[a]	0.16[b]
Ref. Oil & Gas	−0.03	−0.02	−0.04	−0.03	−0.02	−0.04
	CAAR [-1;3]			**CAAR [-1;5]**		
RENIXX	0.08	0.12[a]	0.08	0.07	0.12[b]	0.06
MSCI Oil & Gas	0.00	0.02	0.00	0.01	0.02	0.01
Ref. Global Ren.	0.08	0.13[a]	0.07	0.06	0.13[a]	0.05
Ref. Oil & Gas	−0.04	−0.02	−0.04	−0.03	−0.02	−0.04
	CAAR [-1;10]			**CAAR [-1;20]**		
RENIXX	0.07	0.05	0.07	0.12	0.08	0.12
MSCI Oil & Gas	−0.02	−0.03	−0.02	0.02	0.01	0.01
Ref. Global Ren.	0.08	0.06	0.08	0.11	0.06	0.11
Ref. Oil & Gas	−0.06	−0.07[b]	−0.05	−0.01	−0.02	−0.01

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by MSCI and Refinitiv, and event windows around event date – *March 4, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
*$p < 0.10$.
[a] $p < 0.01$.
[b] $p < 0.05$.

Table 8
Regional differences in all firm sample CAARs (event date: March 4, 2022).

Industry groups	Europe	NA	Australasia	India/China	Europe	NA	Australasia	India/China
	CAAR [-1;1]				**CAAR [–5;5]**			
Alternative energy	0.60 (N = 83)	0.63 (N = 68)	0.16 (N = 100)	0.05** (N = 57)	2.54*** (N = 83)	2.30 (N = 68)	1.22 (N = 100)	0.79 (N = 57)
Oil & Gas	0.69 (n = 71)	1.84 (N = 190)	0.50 (N = 97)	0.26 (N = 21)	2.70 (N = 71)	5.33 (N = 190)	1.69 (N = 97)	0.99 (N = 21)
	CAAR [-1;3]				**CAAR [-1;5]**			
Alternative energy	1.65 (N = 83)	1.33 (N = 68)	0.28 (N = 100)	0.12** (N = 57)	2.01* (N = 83)	1.57 (N = 68)	0.54 (N = 100)	0.38 (N = 57)
Oil & Gas	1.57 (N = 71)	2.77 (N = 190)	0.92 (N = 97)	0.71 (N = 21)	1.80 (N = 71)	3.65 (N = 190)	1.09 (N = 97)	0.79 (N = 21)
	CAAR [-1;10]				**CAAR [-1;20]**			
Alternative energy	2.79** (N = 83)	2.48 (N = 68)	0.99 (N = 100)	0.80* (N = 57)	3.82** (N = 83)	3.81 (N = 68)	1.53 (N = 100)	1.20** (N = 57)
Oil & Gas	2.71 (N = 71)	5.49 (N = 190)	1.45 (N = 97)	1.11 (N = 21)	4.42 (N = 71)	8.32 (N = 190)	2.70 (N = 97)	1.72 (N = 21)

Notes: This table shows the cumulative average abnormal returns (CAARs) in different regions for alternative energy and oil & gas producer industry sectors and event windows around event date – *March 4, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility. ***$p < 0.01$; **$p < 0.05$; *$p < 0.10$.

circumvention and backfilling that would undercut the effectiveness of already imposed sanctions.[11] Leaders announced a joint initiative to respond to evasive measures, including gold transactions by the Central Bank of Russia. It is possible that the information about some of the planned G7 measures leaked to the public and impacted the spread.

We estimated the impact of this shock, with the results presented in Appendix Tables A2, A3, A4, and A5. We find that this event had statistically stronger and positive impact on oil & gas firms and indices. However, the performance for the full sample and indices was statistically very weak.

Another sizeable increase in bond spreads occurred on June 29 of 2022 when the spread widened by 8.97%. On June 27, 2022, at the G7 summit in Germany, leaders stated they were exploring new ways to isolate Russia from the global economy and crack down on evasion and backfilling activities. It was announced that the subsequent sanctions included measures to reduce Russia's revenues from

[11] "Backfilling" in the context of sanctions against Russia means finding other sources or markets for sanctioned supplies or resources.

Table 9
Regional differences in index CARs (event date: March 4, 2022).

Indices	CAR [-1; 1]	CAR [-5; 5]	CAR [-1; 3]	CAR [-1; 5]	CAR [-1; 10]	CAR [-1; 20]
RF Europe Renewable	−0.01	0.15[c]	0.07	0.05	0.05	0.06
RF NA Renewable	−0.01	0.208[c]	0.10	0.07	0.10	0.16
RF Asia Pacific Renewable	−0.02	0.09	0.01	0.05	0.05	0.03
Renewable Indices CAAR for all regions	0.03	0.33[a]	0.14[c]	0.19[a]	0.25[a]	0.35[b]
RF Europe Oil & Gas	−0.04	−0.12[c]	0.02	0.04	−0.01	0.03
RF NA Oil & Gas	−0.07[b]	−0.04	−0.04	−0.08[c]	−0.06	−0.06
RF Asia Pacific Oil & Gas	−0.02	−0.02	−0.02	−0.02	−0.00	0.04
Oil & Gas Indices CAAR for all regions	0.04	0.17	0.07	0.08	0.10	0.20

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by Refinitiv, and event windows around event date – *March 4, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

selling gold, further reduce dependency on Russian energy, coordinate tariff measures on Russia's exports, and target individuals responsible for war crimes as well as those contributing to food insecurity by stealing and exporting Ukrainian grain.

The estimation results for this event are reported in Appendix Tables A6, A7, A8, and A9. Around the event date, oil & gas producers outperformed alternative energy firms and the estimates are positive and statistically significant in some event windows. Tables A7 and A9 indicate that renewable energy indices generated higher returns relative to oil & gas indices, while most of the indices are negative. Renewable indices of all regions in Table A9 are, however, positive for all event windows.

Finally, the last big increase in spread occurred on September 20, 2022, which is related to the announcement of partial mobilization in Russia. This was a clear signal of the escalation of the conflict and spread responded by a 9.4% increase. Table 10 demonstrates that at this stage of the conflict, and over the shorter event window of [–1; 3], alternative energy firms performed better than oil & gas producers and the result is statistically significant. Over event windows of [–1; 5] and [–5; 5], oil & gas producers were outperforming alternative energy producers. Over longer event windows, however, only the performance of alternative energy firms is statistically significant.

Author statement

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We understand that the Corresponding Author (Ilke Onur) is the sole contact for the editorial process. He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Jakhongir Kakhkharov, Ilke Onur, Erkan Yalcin, and Rong Zhu.

The CARs for indices, reported in Table 11, indicate that neither renewables nor oil & gas producers outperformed the benchmark. However, this result is negative and statistically significant for oil & gas producers.

We also observe interesting trends in the regional impact of the escalation, as indicated in Table 12. Alternative energy firms appear to be clearly outperforming oil & gas producers in Europe in all event windows, which is not the case in other regions. This is probably an indication of emerging pattern of disparate impact of the conflict on renewables and oil & gas producers across different regions.

All regional indices, reported in Table 13, underperformed around the date of partial mobilization in Russia, confirming the trend detected in Table 11. The escalation in the conflict appears to hit large energy companies first and foremost.

5.4. Evidence from difference-in-differences analysis

We now estimate the magnitude and direction of stock returns over the event windows using DID estimations to capture market reactions. Specifically, we estimate Equation (4) by conditioning on a set of risk factors and year-by-month fixed effects ($z_{i,t}$). Table 14 reports the results of the regression coefficients, which represent the reaction of stock returns to shocks on the dates when sovereign bond spread surged, for alternative energy producers compared to oil & gas companies over various event windows.

The DID panel regression estimates in Table 14 confirm that alternative energy firms performed significantly worse than oil & gas producers at the outset of the conflict. Particularly, in the event windows around March 21 (a little over 3 weeks into the conflict), alternative energy producer return differentials are negative and statistically significant in four out of six event windows. However, shocks at later stages of the conflict, on June 29 and September 20, did not have statistically significant impact on the performance

Table 10
CAARs for alternative energy and oil and gas producers (event date: September 20, 2022).

Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	0.75	0.77	0.77	627	3.89[a]	3.84	3.88[a]	627
Alternative Energy	0.37	0.41	0.64	254	2.78[a]	2.93	2.58[a]	254
Oil & Gas	0.76	0.79	0.65	373	3.00[a]	2.87	3.09[b]	373
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	1.35[a]	1.44	1.38[a]	627	2.00[a]	2.10	2.04[a]	627
Alternative Energy	0.99[b]	1.09	1.15[b]	254	1.36[b]	1.49	1.42[b]	254
Oil & Gas	0.97[b]	0.96	1.04[a]	373	1.64[a]	1.64	1.99[b]	373
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	4.69	4.74	4.79	627	8.57	9.18	8.47	627
Alternative Energy	2.66[c]	2.85[b]	2.95	254	5.52	5.72[c]	5.56	254
Oil & Gas	4.14	4.13	4.06	373	7.60	7.91	7.28	373

Notes: This table shows the cumulative average abnormal returns (CAARs) for all firms, alternative energy and oil & gas producer industry sectors and event windows around event date – *September 20, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 11
CARs for alternative energy and oil & gas indices (event date: September 20, 2022).

Indices	CAPM	FF3	HMM	CAPM	FF3	HMM
	CAAR [-1;1]			**CAAR [-5;5]**		
RENIXX	−0.00	0.01	−0.02	−0.09	−0.01	−0.12
MSCI Oil & Gas	−0.02	0.00	−0.02	−0.16[a]	−0.20	−0.16[a]
Refinitiv Global Renewable	−0.03	−0.02	−0.05	−0.14	−0.00	−0.17[c]
Refinitiv Oil & Gas	−0.02	0.00	−0.02	−0.15[b]	−0.00	−0.15[b]
	CAAR [-1;3]			**CAAR [-1;5]**		
RENIXX	−0.07	−0.04	−0.09	−0.07	−0.03	−0.09
MSCI Oil & Gas	−0.10[b]	−0.03	−0.10[b]	−0.11[b]	−0.01	−0.11
Refinitiv Global Renewable	−0.09	−0.04	−0.12[c]	−0.10	−0.03	−0.12
Refinitiv Oil & Gas	−0.09[b]	−0.02	−0.09[b]	−0.11[b]	0.00	−0.11[b]
	CAAR [-1;10]			**CAAR [-1;20]**		
RENIXX	−0.10	−0.10	0.10	−0.21	−0.20[b]	−0.23
MSCI Oil & Gas	−0.00	0.03	−0.00	−0.01	0.02	−0.01
Refinitiv Global Renewable	−0.08	−0.08	−0.09	−0.19	−0.16[c]	−0.20
Refinitiv Oil & Gas	0.01	0.03	−0.01	0.01	0.04	−0.01

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by MSCI and Refinitiv, and event windows around event date – *September 20, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

differential between these two types of energy producers. We interpret this as a positive shift in market perception of alternative energy firms as the conflict progressed.

5.5. Robustness analysis

Preceding analysis indicated that at the start of the conflict investors clearly preferred oil & gas producers over alternative energy firms. However, as the conflict continued, their preferences have changed; the gap between CAARs and CARs for alternative energy and oil & gas producers closed and returns on alternative energy stocks started performing better. This trend may signal that investors' perception of these business models may have shifted in favor of alternative energy. To check the validity of this hypothesis, we calculate and then test the statistical significance of CARs for indices of equipment manufacturers and service providers for both renewables and oil & gas producers around the event windows associated with February 24, 2022 and September 20, 2022. The

Table 12
Regional differences in all firm sample CAARs (event date: September 20, 2022).

Industry groups	Europe	NA	Australasia	India/China	Europe	NA	Australasia	India/China
	CAAR [-1;1]				**CAAR [–5;5]**			
Alternative energy	0.30 (N = 83)	0.25 (N = 68)	0.13 (N = 100)	0.14 (N = 57)	1.43[b] (N = 83)	2.28 (N = 68)	0.52[a] (N = 100)	0.52[b] (N = 57)
Oil & Gas	0.08 (n = 71)	0.70 (N = 190)	0.37 (N = 97)	0.37 (N = 21)	0.66[b] (N = 71)	2.96[b] (N = 190)	0.93[b] (N = 97)	0.72 (N = 21)
	CAAR [-1;3]				**CAAR [-1;5]**			
Alternative energy	0.70[b] (N = 83)	0.67[b] (N = 68)	0.26 (N = 100)	0.27 (N = 57)	0.84[b] (N = 83)	1.07[c] (N = 68)	0.36 (N = 100)	0.38 (N = 57)
Oil & Gas	0.23[b] (N = 71)	0.90[b] (N = 190)	0.44 (N = 97)	0.430 (N = 21)	0.41[c] (N = 71)	1.57[b] (N = 190)	0.55[b] (N = 97)	0.47 (N = 21)
	CAAR [-1;10]				**CAAR [-1;20]**			
Alternative energy	1.70 (N = 83)	2.39 (N = 68)	0.79 (N = 100)	0.56 (N = 57)	3.12 (N = 83)	5.20 (N = 68)	1.73 (N = 100)	1.38 (N = 57)
Oil & Gas	1.27 (N = 71)	4.12 (N = 190)	1.07[c] (N = 97)	0.66 (N = 21)	2.16 (N = 71)	7.65 (N = 190)	2.08[c] (N = 97)	1.23 (N = 21)

Notes: This table shows the cumulative average abnormal returns (CAARs) in different regions for alternative energy and oil & gas producer industry sectors and event windows around event date – *September 20, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.

[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 13
Regional differences in index CARs (event date: September 20, 2022).

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAAR[–1; 20]
Refinitiv EU Renewable	−0.03	−0.21[b]	−0.09	−0.10	−0.04	−0.06
Refinitiv NA Renewable	−0.03	−0.12	−0.09	−0.11	−0.10	−0.27
Refinitiv Asia Pacific Renewable	−0.04	−0.11[c]	−0.05	−0.05	−0.07	−0.09
Refinitiv Renewable Indices CAR for All Regions	0.00[b]	−0.04[a]	−0.02[a]	−0.02[b]	0.06[b]	0.11[b]
Refinitiv EU Oil & Gas	−0.03	−0.18[b]	−0.11[b]	−0.13[b]	0.01	0.01
Refinitiv NA Oil & Gas	−0.01	−0.14[b]	−0.09[c]	−0.09[c]	0.02	−0.02
Refinitiv Asia Pacific Oil & Gas	−0.01	−0.11[a]	−0.04	−0.08[b]	−0.05	−0.06
Refinitiv Oil & Gas Indices CAR for All Regions	−0.01	−0.07[a]	−0.05[a]	−0.06[a]	0.07	0.11

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by Refinitiv, and event windows around event date – *September 20, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs and CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.

[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

rational for this robustness analysis is that if investors put greater confidence in one of these sectors' long-term future, this will result in greater investment in firms that produce equipment for these sectors. The results are displayed in Table 15, 16, 17 and 18. Although some of the losses for oil & gas equipment manufacturers may be due to loss of business in Russia given the sanctions, in general it emanates that investors clearly prefer to invest in manufacturers of equipment and services for renewables over companies that produce equipment and services for oil & gas producers.[12]

To sum up, our event-study framework focusing on CAARs and CARs indicates that while oil & gas firms generated higher returns, investors preferred to bet on large renewable companies, especially in Europe and Asia. Higher returns associated with renewables equipment manufacturers may indicate that the conflict helped accelerate the transition to "green economy".

6. Conclusion

In this paper we use the event-study approach to investigate the impact of the Russia–Ukraine conflict on alternative energy and oil

[12] We also performed estimations for other notable dates (March 4, March 21, and June 29 of 2022). These results are not reported, but they are available upon request.

Table 14
Spikes in interest rate spread and alternative energy vs oil & gas firm returns.

	[-1, 1]	[-5, 5]	[-1, 3]	[-1, 5]	[-1, 10]	[-1, 20]
February 24	0.181 (0.444)	−0.598[c] (0.312)	0.080 (0.370)	0.162 (0.398)	−0.324 (0.306)	−0.231 (0.309)
March 4	−0.444 (0.481)	0.099 (0.297)	−0.363 (0.385)	0.166 (0.321)	0.640[a] (0.241)	0.443 (0.320)
March 21	−0.408 (0.481)	−0.080 (0.172)	−0.702[a] (0.269)	−0.626[a] (0.223)	−0.415[b] (0.174)	−0.490[a] (0.171)
June 29	0.048 (0.342)	0.640[a] (0.170)	0.186 (0.251)	0.219 (0.205)	0.216 (0.139)	0.111 (0.097)
September 20	−0.092 (0.316)	−0.057 (0.192)	0.322 (0.281)	0.249 (0.270)	−0.005 (0.169)	−0.095 (0.119)
Firm FE	YES	YES	YES	YES	YES	YES
Control variables	YES	YES	YES	YES	YES	YES
Observations	58,514	58,514	58,514	58,514	58,514	58,514
Overall R^2	0.017	0.017	0.017	0.018	0.018	0.017

Notes: This table reports the results from the fixed effects panel estimations of Equation (4). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The control variables include risk factors and year-by-month fixed effects.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 15
CARs for renewable equipment manufacturers and services indices (event date: February 24, 2022).

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAR[–1; 20]
Refinitiv BIC Renewable Energy Services & Equipment	−0.01	−0.01	−0.00	−0.00	−0.00	−0.00
Refinitiv G7 Renewable Energy Services & Equipment	0.12[b]	0.08	0.24[a]	0.18[b]	0.30[a]	0.38[a]
Refinitiv EU Renewable Energy Services & Equipment	0.12[b]	0.01	0.22[a]	0.14[b]	0.22[b]	0.18
Refinitiv Global Renewable Energy Services & Equipment	0.11[a]	0.07	0.20[a]	0.14[b]	0.24[a]	0.27[a]
Refinitiv NA Renewable Energy Services & Equipment	0.13[b]	0.08	0.26[a]	0.19[b]	0.32[a]	0.42[a]
Refinitiv Global Renewable Energy Services & Equipment (Excluding USA)	0.01[b]	0.01	0.16[a]	0.10[c]	0.17[b]	0.14
Refinitiv EU Renewable Energy Services & Equipment (Excluding UK and Ireland)	0.12[a]	0.09	0.23[a]	0.14[b]	0.22[b]	0.18
Americas-Datastream Renewable Services & Equipment	0.12[b]	0.07	0.24[a]	0.18[b]	0.29[b]	0.38[b]
Asia-Datastream Renewable Services & Equipment	0.01	−0.01	0.03	−0.01	0.04	−0.07
World-Datastream Renewable Services & Equipment	0.09[b]	0.05	0.17[a]	0.11[c]	0.19[a]	0.18*

Notes: This table shows the cumulative abnormal returns (CARs) for renewable energy equipment manufacturer & services industry indices developed by Refinitiv, and event windows around event date – *February 24, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

& gas producers by collecting comprehensive global data about the stock returns of firms in these two sectors. While general stock market declined at the start of the conflict, we show that these two sectors experienced positive abnormal returns around the crucial event dates during the crisis. Furthermore, we find that oil & gas firms generated abnormal returns at the beginning of the conflict that were significantly higher than those generated by alternative energy firms. These findings are in line with those of Nerlinger and Utz (2022), in which the authors focus solely on the impact of the onset of the conflict. We additionally consider multiple critical events during the first eight months of the crisis. We also consider firms' decisions to remain in Russia or leave after the conflict began, as well as corporate learning experience (being exposed to previous crisis episodes), which may have influenced returns. Moreover, we examine the performance of alternative energy producers versus oil & gas producers by utilizing DID analysis in a panel setting. We find that the conflict led investors to become more optimistic about renewable energy. We also show that the impact of the conflict on the two sub-sectors was disparate, which is clearly observed in Europe and the performances measured by renewable energy indices. At almost all crucial points of the conflict, alternative energy indices outperformed oil & gas ones. At later stages of the crisis, the abnormal stock returns of alternative energy firms equaled the returns of oil & gas producers even in the full sample. These results render some optimism regarding the future of the "green transition".

Although the Russia–Ukraine conflict has caused considerable hardship and has become a tragedy for the two nations, it may have

Table 16
CARs oil and gas equipment and related services indices (event date: February 24, 2022).

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAR[–1; 20]
Refinitiv Global Oil & Gas Related Services & Equipment	0.03	0.03	0.03	0.06[c]	0.10[b]	0.11[c]
Refinitiv EU Oil & Gas Related Services & Equipment	0.01	−0.02	0.01	0.00	0.06	0.10[c]
Refinitiv G7 Oil & Gas Related Services & Equipment	0.03	0.04	0.03	0.07[c]	0.11[b]	0.11[c]
Refinitiv Global Oil & Gas Related Services & Equipment (Excluding USA)	0.02	0.03	0.03	0.05[b]	0.05[c]	0.07
Refinitiv EU Oil & Gas Related Services & Equipment (Excluding UK and Ireland)	0.01	−0.01	0.01	0.03	0.06	0.11[c]
Refinitiv US Oil & Gas Related Services & Equipment	0.03	0.04	0.03	0.08	0.14[c]	0.13
Refinitiv Asia Pacific Oil & Gas Related Services & Equipment	0.00	0.03	0.03	0.04	0.01	0.03
Refinitiv North America Oil & Gas Related Services & Equipment	0.03	0.04	0.04	0.07[c]	0.12[b]	0.12[c]
Refinitiv Asia Pacific Oil Related Services & Equipment	0.01	0.01	0.04	0.03	0.02	0.05
Refinitiv UK Oil & Gas Related Services & Equipment	0.00	0.09	0.03	0.01	0.01	0.02

Notes: This table shows the cumulative abnormal returns (CARs) for oil & gas related equipment manufacturer & services industry indices developed by Refinitiv, and event windows around event date – *February 24, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 17
CARs for renewable equipment manufacturers and services indices (event date: September 20, 2022).

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAR[–1; 20]
Refinitiv BIC Renewable Energy Services & Equipment	−0.05	−0.16[b]	−0.06	−0.08	−0.10	−0.09
Refinitiv G7 Renewable Energy Services & Equipment	−0.03	−0.12	−0.09	−0.10	−0.10	−0.26
Refinitiv EU Renewable Energy Services & Equipment	−0.03	−0.21	−0.09	−0.10	−0.04	−0.08
Refinitiv Global Renewable Energy Services & Equipment	−0.03	−0.14	−0.09	−0.10	−0.08	−0.20
Refinitiv North America Renewable Energy Services & Equipment	−0.03	−0.11	−0.09	−0.11	−0.10	−0.28
Refinitiv Global Renewable Energy Services & Equipment (Excluding USA)	−0.04	−0.16[b]	−0.07	−0.07	−0.05	−0.09
Refinitiv EU Renewable Energy Services & Equipment (Excluding UK and Ireland)	−0.03	−0.21[c]	−0.09	−0.10	−0.04	−0.08
Americas-Datastream Renewable Energy Equipment	−0.03	−0.11	−0.09	−0.11	−0.12	−0.27
Asia-Datastream Renewable Energy Equipment	−0.33	−0.12	−0.05	−0.04	−0.09	−0.12
World-Datastream Renewable Energy Equipment	−0.03	−0.14	−0.09	−0.09	−0.08	−0.17

Notes: This table shows the cumulative abnormal returns (CARs) for renewable energy equipment manufacturer & services industry indices developed by Refinitiv, and event windows around event date – *September 20, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

Table 18
CARs for oil and gas equipment and related services indices (event date: September 20, 2022).

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAR[–1; 20]
Refinitiv Global Oil & Gas Related Services & Equipment	−0.01	−0.16***	−0.09**	−0.11**	−0.04	−0.04
Refinitiv EU Oil & Gas Related Services & Equipment	−0.02	−0.02***	−0.10**	−0.12***	−0.03	−0.03
Refinitiv G7 Oil & Gas Related Services & Equipment	−0.02	−0.16***	−0.09**	−0.12***	−0.03	−0.03
Refinitiv Global Oil & Gas Related Services & Equipment (Excluding USA)	−0.02	−0.01***	−0.08***	−0.10***	−0.05	−0.00
Refinitiv EU Oil & Gas Related Services & Equipment (Excluding UK and Ireland)	−0.01	−0.15***	−0.09**	−0.10**	−0.04	−0.04
Refinitiv US Oil & Gas Related Services & Equipment	−0.03	−0.17**	−0.10**	−0.13**	−0.02	−0.01
Refinitiv Asia Pacific Oil & Gas Related Services & Equipment	0.00	−0.09*	−0.03	−0.08**	−0.09*	−0.11
Refinitiv North America Oil & Gas Related Services & Equipment	−0.02	−0.17***	−0.10**	−0.12***	−0.03	−0.02
Refinitiv Asia Pacific Oil Related Services & Equipment	−0.03	−0.12**	−0.06*	−0.11***	−0.11**	−0.15**
Refinitiv UK Oil & Gas Related Services & Equipment[a]	N/A	N/A	N/A	N/A	N/A	N/A

Notes: This table shows the cumulative abnormal returns (CARs) for renewable energy equipment manufacturer & services industry indices developed by Refinitiv, and event windows around event date – *September 20, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility. ***.

[a] Data for this index for 20 September was not available at the time of writing this paper.

provided a unique opportunity to re-evaluate the importance of various energy resources. Our analysis indicates that investors are weighing their options, with alternative energy investments appearing to be comparatively more appealing following the crisis.

Data availability

The authors do not have permission to share data.

Appendix

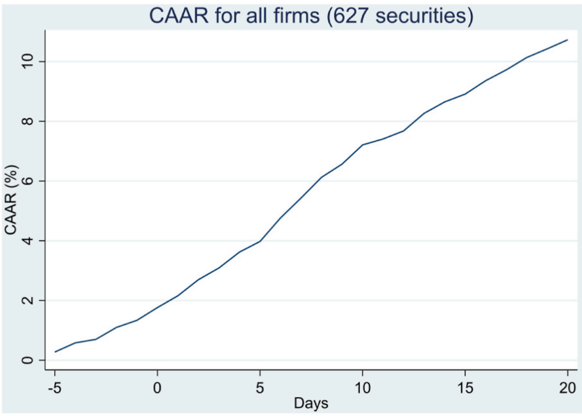

Fig. A1. CAARs for full sample of alternative energy and oil & gas producers for the period of −5 to 20 days around the Russian invasion of Ukraine on February 24, 2022.

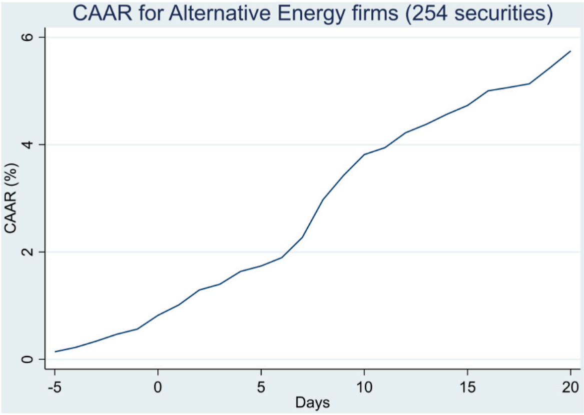

Fig. A2. CAARs for alternative energy firms for the period of −5 to 20 days the Russian invasion of Ukraine on February 24, 2022.

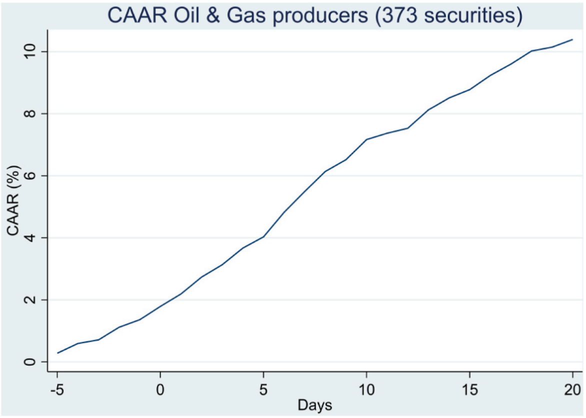

Fig. A3. CAARs for oil & gas producers for the period of −5 to 20 days around the Russian invasion of Ukraine on February 24, 2022.

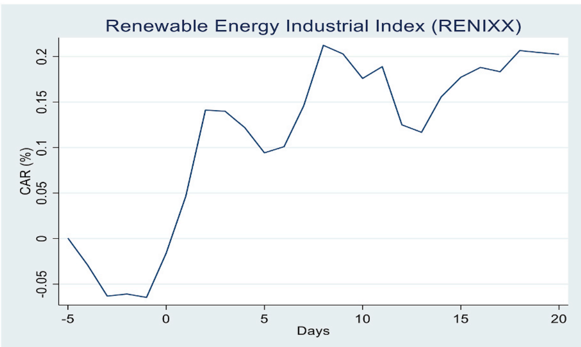

Fig. A4. CARs for RENIXX index for the period of −5 to 20 days around the Russian invasion of Ukraine on February 24, 2022.

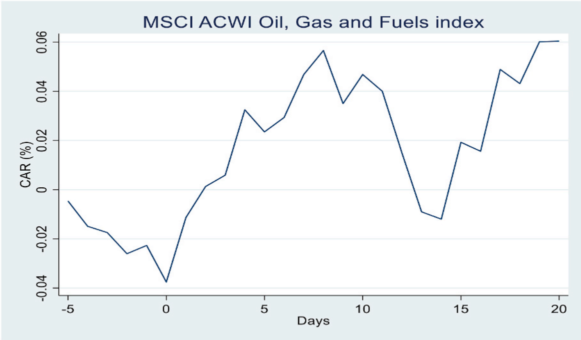

Fig. A5. CARs for MSCI ACWI Oil, Gas and Fuels index for the period of −5 to 20 days around the Russian invasion of Ukraine on February 24, 2022.

Table A1
Indices used in the event-study estimations

Indices	Descriptions
MSCI World	The MSCI World Index captures large and mid-cap representation across 23 Developed Markets (DM) countries. With 1511 constituents, the index covers approximately 85% of the free float-adjusted market capitalization in each country.
World Renewable Energy	The global stock index RENIXX (Renewable Energy Industrial Index, ISIN: DE000RENX014) for renewable energy tracks the 30 largest companies of the renewable energy industry worldwide by market capitalization
MSCI ACWI Oil, Gas & Fuel	MSCI All Country World Index Oil, Gas and Consumable Fuels
Refinitiv Global Renewable	Refinitiv Global Renewable Energy Index international index with 60 constituents
Refinitiv Oil & Gas	Refinitiv Global International Oil and Gas Index containing 18 constituents
Refinitiv Europe Renewable	Refinitiv Europe Renewable Energy index containing of 16 constituents
Refinitiv North America Renewable	Refinitiv North America Renewable Energy containing 21 constituents
Refinitiv Asia Pacific Renewable	Refinitiv Asia Pacific Renewable Energy containing 38 constituents
Refinitiv Europe Oil & Gas	Refinitiv Europe Oil and Gas containing 39 constituents
Refinitiv North America Oil & Gas	Refinitiv North America Oil and Gas containing 109 constituents
Refinitiv Asia Pacific Oil & Gas	Refinitiv Emerging Markets Asia Pacific Oil and Gas
Refinitiv BIC Renewable Energy Services and Equipment	Refinitiv index consisting of 5 constituents from Brazil, India, and China
Refinitiv G7 Renewable Energy Services and Equipment	Refinitiv index of Renewable Energy Services and Equipment consisting of 20 constituents from G7 countries
Refinitiv Europe Renewable Energy Services and Equipment	Refinitiv Europe Renewable Energy Services and Equipment index with 11 constituents
Refinitiv Global Renewable Energy Services and Equipment	Refinitiv index with 49 constituents
Refinitiv North America Renewable Energy Services and Equipment	Refinitiv index with 16 constituents
Refinitiv Global excluding United States Renewable Energy Services and Equipment	Refinitiv index with 34 constituents
Refinitiv European Union excluding United Kingdom and Ireland Renewable Energy Services and Equipment	Refinitiv index with 11 constituents
Americas-Datastream Renewable Energy Equipment	Refinitiv index with 4 constituents
Asia-Datastream Renewable Energy Equipment	Refinitiv index with 4 constituents
World-Datastream Renewable Energy Equipment	Refinitiv index with 4 constituents
Refinitiv Global Oil and Gas Related Equipment and Services	Refinitiv index with 131 constituents
Refinitiv Europe Oil and Gas Related Equipment and Services	Refinitiv index with 37 constituents
Refinitiv G7 Oil and Gas Related Equipment and Services	Refinitiv index with 80 constituents
Refinitiv Global excluding United States Oil and Gas Related Equipment and Services	Refinitiv index with 77 constituents
Refinitiv European Union excluding United Kingdom and Ireland Oil and Gas Related Equipment and Services	Refinitiv index with 35 constituents
Refinitiv United States Oil and Gas Related Equipment and Services	Refinitiv index with 54 constituents
Refinitiv Asia Pacific Oil and Gas Related Equipment and Services	Refinitiv index with 18 constituents
Refinitiv North America Oil and Gas Related Equipment and Services	Refinitiv index with 70 constituents
Refinitiv Asia Pacific Oil Related Services and Equipment	Refinitiv index with 10 constituents
Refinitiv United Kingdom Oil and Gas Related Equipment and Services	Refinitiv index with 3 constituents

Table A2
CAARs for Alternative Energy and Oil & Gas Producers (Event Date: March 21, 2022)

(*continued on next page*)

Table A2 (*continued*)

Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	1.22	1.22	1.21	627	4.09	4.21	4.14	627
Alternative Energy	0.40	0.63	0.40	254	2.17	2.16	2.17	254
Oil & Gas	1.24	1.24	1.23	373	3.80	3.80	3.85	373
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	1.81	1.81**	1.78	627	2.57	2.60*	2.60	627
Alternative Energy	1.01	0.98	0.99	254	1.38	1.38	1.37	254
Oil & Gas	1.61	1.62**	1.60	373	2.37	2.42**	2.42	373
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	3.59	3.68*	3.61	627	6.37	6.53*	6.39	627
Alternative Energy	1.95	1.94	1.95	254	3.56	3.66	3.57	254
Oil & Gas	3.42	3.52	3.45	373	6.03	6.16**	6.05	373

Notes: This table shows the cumulative average abnormal returns (CAARs) for all firms, alternative energy and oil & gas producer industry sectors and event windows around event date – *March 21, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.

***$p < 0.01$.

**p < 0.05.

*$p < 0.10$.

Table A3

CARs for alternative energy and oil & gas indices (event date: March 21, 2022)

Indices	CAPM	FF3	HMM	CAPM	FF3	HMM
	CAAR [-1;1]			**CAAR [-5;5]**		
RENIXX	0.03	0.02	0.03	0.01	−0.00	−0.02
MSCI Oil & Gas	0.02	0.02	0.02	0.02	−0.00	0.01
Refinitiv Global Renewable	0.02	−0.00	0.02	0.02	−0.06	0.03
Refinitiv Oil & Gas	0.03	0.02	0.03	0.03	−0.00	0.02
	CAAR [-1;3]			**CAAR [-1;5]**		
RENIXX	0.03	0.01	0.03	0.02	0.02	0.03
MSCI Oil & Gas	0.04	0.05**	0.04	0.04	0.04*	0.03
Refinitiv Global Renewable	0.02	0.00	0.03	0.00	−0.00	0.00
Refinitiv Oil & Gas	0.04	0.05**	0.04	0.04	0.04**	0.04
	CAAR [-1;10]			**CAAR [-1;20]**		
RENIXX	0.10	0.04	0.10	0.04	0.05	0.04
MSCI Oil & Gas	0.04	0.07**	0.04	0.06	0.09**	0.06
Refinitiv Global Renewable	0.07	−0.00	0.07	−0.00	0.00	−0.00
Refinitiv Oil & Gas	0.05	0.07**	0.05	0.07	0.10**	0.07

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by MSCI and Refinitiv, and event windows around event date – *March 21, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.

***$p < 0.01$.

**p < 0.05.

*p < 0.10.

Table A4

Regional differences in all firm sample CAARs (event date: March 21, 2022)

Industry groups	Europe	NA	Australasia	India/China	Europe	NA	Australasia	India/China
	CAAR [-1;1]				**CAAR [–5;5]**			
Alternative energy	0.27 (N = 83)	0.41 (N = 68)	0.19 (N = 100)	0.16 (N = 57)	1.47 (N = 83)	1.88 (N = 68)	0.59 (N = 100)	0.51* (N = 57)
Oil & Gas	0.92 (n = 71)	1.23 (N = 190)	0.57* (N = 97)	0.31 (N = 21)	2.10 (N = 71)	3.77 (N = 190)	1.32 (N = 97)	0.73 (N = 21)
	CAAR [-1;3]				**CAAR [-1;5]**			
Alternative energy	0.44 (N = 83)	1.40 (N = 68)	0.26 (N = 100)	0.22 (N = 57)	0.83 (N = 83)	1.25 (N = 68)	0.37 (N = 100)	0.32 (N = 57)
Oil & Gas	1.26** (N = 71)	1.59 (N = 190)	0.88* (N = 97)	0.34 (N = 21)	1.49* (N = 71)	2.37 (N = 190)	1.05* (N = 97)	0.52 (N = 21)

(*continued on next page*)

Table A4 (*continued*)

Industry groups	Europe	NA	Australasia	India/China	Europe	NA	Australasia	India/China
	CAAR [-1;10]				**CAAR [-1;20]**			
Alternative energy	1.32 (N = 83)	1.75 (N = 68)	0.67 (N = 100)	0.52 (N = 57)	2.24 (N = 83)	3.26 (N = 68)	1.12 (N = 100)	1.00 (N = 57)
Oil & Gas	2.17* (N = 71)	3.44 (N = 190)	1.41 (N = 97)	0.77 (N = 21)	3.17* (N = 71)	5.54 (N = 190)	2.69 (N = 97)	1.13 (N = 21)

Notes: This table shows the cumulative average abnormal returns (CAARs) in different regions for alternative energy and oil & gas producer industry sectors and event windows around event date – *March 21, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.10$.

Table A5
Regional differences in index CARs (event date: March 21, 2022)

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAAR[–1; 20]
Refinitiv EU Renewable	−0.01	−0.06	−0.05	−0.07	−0.01	−0.02
Refinitiv NA Renewable	0.04	0.09	0.08	0.06	0.13	−0.00
Refinitiv Asia Pacific Renewable	−0.01	−0.04	−0.00	−0.03	0.00	−0.02
Refinitiv Renewable Indices CAR for All Regions	0.03	0.09	0.05	0.03	0.16	0.20
Refinitiv EU Oil & Gas	0.03	0.00	0.04	0.04	0.04	0.08
Refinitiv NA Oil & Gas	0.02	0.06	0.04	0.03	0.04	0.05
Refinitiv Asia Pacific Oil & Gas	0.03	0.06*	0.04*	0.05*	0.06	0.03
Refinitiv Oil & Gas Indices CAR for All Regions	0.04*	0.11	0.06***	0.08*	0.10	0.14***

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by Refinitiv, and event windows around event date – *March 21, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs and CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.10$.

Table A6
CAARs for Alternative Energy and Oil & Gas Producers (Event Date: June 29, 2022)

Industry Group	CAPM	FF3	HMM	N	CAPM	FF3	HMM	N
	CAAR [-1;1]				**CAAR [-5;5]**			
All Firms	1.71	1.68	1.69	627	5.36*	5.19*	5.42*	627
Alternative Energy	0.74	0.82	0.75	254	2.41	2.44	2.42	254
Oil & Gas	1.37	1.31	1.35	373	4.92**	4.74**	4.99**	373
	CAAR [-1;3]				**CAAR [-1;5]**			
All Firms	2.04	2.00	2.19	627	3.23*	3.06	3.25*	627
Alternative Energy	1.09	1.15	1.09	254	1.62	1.69	1.62	254
Oil & Gas	1.63	1.56	1.60	373	2.83**	2.63	2.85**	373
	CAAR [-1;10]				**CAAR [-1;20]**			
All Firms	4.82	5.25	4.86	627	8.25	8.63	8.27	627
Alternative Energy	2.75	3.38	2.74	254	5.29	5.82	5.25	254
Oil & Gas	4.38	4.23	4.41	373	7.17	7.09	7.22	373

Notes: This table shows the cumulative average abnormal returns (CAARs) for all firms, alternative energy and oil & gas producer industry sectors and event windows around event date – June *29, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.10$.

Table A7
CARs for alternative energy and oil & gas indices (event date: June 29, 2022)

Indices	CAPM FF3	HMM	CAPM	FF3	HMM
RENIXX	CAR[–1;1]		CAR[–5;5]		

(*continued on next page*)

Table A7 (*continued*)

Indices	CAPM FF3		HMM	CAPM	FF3	HMM
	−0.04	−0.02	−0.04	0.02	−0.05	0.03
MSCI Oil & Gas	−0.03	−0.00	−0.03	−0.12**	−0.04	−0.12**
Refinitiv Global Renewable	−0.06	−0.03	−0.06	−0.04	−0.11*	−0.03
Refinitiv Oil & Gas	−0.03	−0.00	−0.25	−0.01**	−0.05	−0.13**
RENIXX	**CAR [−1;3]**			**CAR [−1;5]**		
	−0.02	0.00	−0.18	−0.00	−0.01	0.00
MSCI Oil & Gas	−0.01	0.00	−0.01	−0.09**	−0.02	−0.09**
Refinitiv Global Renewable	−0.05	−0.02	−0.05	−0.06	−0.07	−0.06
Refinitiv Oil & Gas	−0.02	−0.00	−0.02	−0.09**	−0.02	−0.09**
RENIXX	**CAR [−1;10]**			**CAR [−1;20]**		
	0.05	0.03	0.05	0.07	−0.02	0.08
MSCI Oil & Gas	−0.09*	−0.03	−0.09	−0.03	−0.02	−0.03
Refinitiv Global Renewable	−0.03	−0.05	−0.04	0.04	−0.06	−0.06
Refinitiv Oil & Gas	−0.09*	−0.03	−0.09*	−0.03	−0.02	−0.03

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by MSCI and Refinitiv, and event windows around event date – *June 29, 2022*. We estimate daily abnormal returns using the single index model (CAPM), the Fama and French Three-Factor model (FF3), and the historical mean model (HMM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.10$.

Table A8
Regional differences in all firm sample CAARs (event date: June 29, 2022)

Industry Groups	EU	NA	Australasia	India/China	EU	NA	Australasia	India/China
	CAAR [-5;1]				**CAAR [–5;5]**			
Alternative Energy	0.25 (N = 83)	0.78 (N = 68)	0.40 (N = 100)	0.19 (N = 57)	0.99 (N = 83)	2.40 (N = 68)	1.06 (N = 100)	0.86 (N = 57)
Oil & Gas	0.42 (N = 71)	1.38 (N = 190)	0.30 (N = 97)	0.34 (N = 21)	0.98** (N = 71)	4.70** (N = 190)	1.57 (N = 97)	0.86 (N = 21)
	CAAR [-1;3]				**CAAR [-1;5]**			
Alternative Energy	0.58 (N = 83)	1.01 (N = 68)	0.56 (N = 100)	0.36 (N = 57)	0.69 (N = 83)	1.57 (N = 68)	0.72 (N = 100)	0.53 (N = 57)
Oil & Gas	0.49 (N = 71)	1.61 (N = 190)	0.53 (N = 97)	0.49 (N = 21)	0.75* (N = 71)	2.83** (N = 190)	0.75 (N = 97)	0.52 (N = 21)
	CAAR [-1;10]				**CAAR [-1;20]**			
Alternative Energy	1.18 (N = 83)	2.63 (N = 68)	1.12 (N = 100)	0.92 (N = 57)	3.32 (N = 83)	4.58 (N = 68)	2.10 (N = 100)	1.42 (N = 57)
Oil & Gas	1.48 (N = 71)	4.34 (N = 190)	0.96 (N = 97)	0.68 (N = 21)	2.44 (N = 71)	7.17 (N = 190)	1.62 (N = 97)	1.22 (N = 21)

Notes: This table shows the cumulative average abnormal returns (CAARs) in different regions for alternative energy and oil & gas producer industry sectors and event windows around event date – *June 29, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.10$.

Table A9
Regional differences in index CAARs (event date: June 29, 2022)

Indices	CAR[–1; 1]	CAR[–5; 5]	CAR[–1; 3]	CAR[–1; 5]	CAR[–1; 10]	CAR[–1; 20]
Refinitiv America EU Renewable	−0.09*	−0.10	−0.07	−0.08	−0.03	−0.02
Refinitiv America NA Renewable	−0.06	−0.02	−0.05	−0.07	−0.03	0.08
Refinitiv Asia Pacific Renewable	0.00	0.02	−0.01	−0.02	−0.04	−0.00
Refinitiv Renewable Indices CAR for all Regions	0.01	0.11	0.02*	0.02**	0.11**	0.32
Refinitiv EU Oil & Gas	−0.05	−0.14**	−0.03	−0.10*	−0.11	−0.03
Refinitiv NA Oil & Gas	−0.01	−0.12*	0.00	−0.10**	−0.10	−0.05
Refinitiv Asia Pacific Oil & Gas	0.00	−0.07*	−0.03	−0.05*	−0.07	−0.03
Refinitiv Oil & Gas Indices CAR for all Regions	−0.00	−0.01***	0.03	−0.00***	0.00***	0.12***

Notes: This table shows the cumulative abnormal returns (CARs) for alternative energy and oil & gas producer industry indices developed by Refinitiv, and event windows around event date – *June 29, 2022*. We estimate daily abnormal returns using the single index model (CAPM). The event windows range from the shortest window of [–1; 1] days to the longest [–1; 20] days. The statistical significance of CAARs and CARs is calculated by employing the Kolari and Pynnönen (2010) adjustment to the Boehmer et al. (1991) procedure to account for possible cross-sectional correlation of abnormal

returns and to capture potential event-induced increases in returns volatility.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.10$.

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