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Revealing the impact of floods on stock returns of energy companies in Europe

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Abstract

This research will investigate the impact of floods in Europe on the daily stock returns of European traditional and renewable energy companies. The data I will utilize are the stock returns of 203 European energy companies in 2019 and 2023, as well as 11 events selected by combining factors such as the frequency of floods and the damage caused, which occurred in Europe. The study is expected to reflect investors' shifting expectations of flood risk and provide valuable information to investors and regulators in long-term investment development. According to the event study, traditional energy companies generally experience significant changes in their cumulative abnormal returns (CAAR) following flood events, with both positive and negative outcomes depending on the specific event and its location. In contrast, renewable energy companies did not generally show significant changes in CAAR across the studied events. There is generally no significant difference in CAAR between companies located at the event site and those that are not, especially in shorter event windows ([T,T+3] and [T,T+5]). However, at longer event windows ([T,T+10] and [T,T+20]), the negative and significant coefficients suggest that being located at the event site is disadvantageous.

Key wards: Event study, Stock return, Energy industry, Flood, Climate change

1 Introduction

Floods, as one of the most common and destructive extreme hydrological events in Europe, pose substantial risks to a variety of industries, including the energy sector. This study aims to investigate the impact of such floods on the abnormal returns of energy companies in the stock market. By investigating this relationship, I seek to understand how natural disasters influence financial performance and investor behavior within the energy sector, providing valuable insights for stakeholders and policymakers.

As known to all, extreme hydrological events result from variable elements that endanger nature, buildings, infrastructure, and human health, while many studies have shown that natural disasters and extreme weather can impact stock markets. For instance, in 2011, Japan experienced a catastrophic earthquake followed by a massive tsunami, which triggered the Fukushima nuclear plant incident. This disaster led to a series of hydrogen explosions and reactor meltdowns, releasing substantial amounts of radioactive materials into the environment. The incident not only caused immediate widespread devastation and loss of life but also had long-lasting environmental and economic impacts, raising global concerns about the safety and sustainability of nuclear energy. The Fukushima disaster has created a profound awareness of the potential risks of natural disasters to our living and economic environments. Lei et al. (2015) find significant abnormal returns for Japanese nuclear utility firms existed with regional heterogeneity during and after the event. In research concerning hurricanes in the US, Jüppner et al. (2020) discover that tornado activity ultimately had opposite effects on stock returns in the Midwest and South area. Their findings emphasize the complexities and regional differences in how extreme weather events affect financial markets.

The increasingly severe floods, one of the extreme hydrological events, can also result in some well-known widespread damages. First of all, Infrastructure damage and the associated economic costs are particularly notable. For instance, during 2021 European floods, the extensive damage to infrastructure, with roads, bridges and buildings were enormous, requiring substantial public and private investments for reconstruction. Moreover, floods may disrupt supply chains, exacerbating economic vulnerabilities exacerbated by climate risk. In this case, Mason and Giurco (2013) indicate that extreme weather events in Australia underscore the costs associated with mining and mineral processing operations unprepared for climate risks. In particular, the 2010-2011 Queensland floods resulted in the closure or restricted production of approximately forty out of fifty coal mines in Queensland, leading to losses exceeding 2 billion dollars in production. Haraguchi and Lall (2015) highlight similar consequences in Thailand, where prolonged floods severely affected primary industrial sectors such as automotive and electronics industries, causing extensive economic repercussions across the country. Despite these findings, there is still an significant gap in the literature about the impact of extreme weather on European equity markets. Few studies have systematically examined how such events, including floods, storms, and heatwaves, affect the stock performance of European companies, leaving a critical area of financial and environmental research underexplored. However, between 1980 and 2021, extreme hydrological events caused economic losses of approximately 560 billion euro in EU Member States, with floods being one of the most expensive natural disasters. Meanwhile, flood events also cause serious damage to ecosystems, including water pollution and reduced vegetation cover and climate change, which in turn may further increase the probability and frequency of flood events, leading to a vicious cycle.

The focus on energy companies is driven by climate concerns, alongside an interest in the performance and long-term prospects of renewable energy and traditional fossil fuel companies in the face of natural disasters. Specifically, the research aims to determine whether there are differences in investor reactions and expectations for these energy companies during catastrophic events in Europe from 2016 to 2023, contributing to the literature on exogenous shocks and their effects on capital markets.

Utilizing event studies and regression analysis, I will focus on the impact of floods on the stock market returns of European listed energy companies. The objective is to determine whether, in the short period following each flood event, firms within the energy sector exhibit positive cumulative average abnormal returns. Through this analysis, the research will offer valuable insights into investor behavior and market dynamics in the context of natural disasters and provide empirical evidence to inform strategies for managing climate change risks. Previous studies have demonstrated the application of these methods in similar contexts. For example, Bourdeau-Brien and Kryzanowski (2017) investigate the impact of natural disasters on stock returns and volatility of local firms by using the Fama-French stock return model and event study. Ferstl et al. (2012) analyze the impact of the Fukushima nuclear disaster on the stock prices of nuclear utility and alternative energy firms in multiple countries. In addition, Lei et al. (2015) compare the differences in abnormal returns of global coal and renewable energy firms on European and U.S. stock exchanges, respectively, through an event study.

2 Literature Review

Several studies conduct worldwide have shown that climatic changes, human activities are the main cause of the increase in the incidence, severity, and duration of flood disasters. Kundzewicz et al. (2014) investigate the impacts of climate change on flooding in Europe and found that climate change exacerbates the frequency and intensity of floods in Europe. IPCC (2014) concludes that an increase in global temperatures could lead to an increase in the amount of water vapor in the atmosphere, which increases the probability of extreme heavy rainfall events, thus exacerbating the frequency and intensity of flooding. Hirabayashi et al. (2013) assess the impacts of climate change on the risk of flooding globally by using a global flood model, and their findings suggest that warming may increase the risk of flooding in the future, especially in regions such as Europe. Semmler et al. (2004) predict that global warming will exacerbate the increase in the magnitude and frequency of precipitation events, especially flash floods, over much of Europe in the coming decades. Flood hazards are also likely to increase during wetter and warmer winters when rainfall becomes more frequent. Simulations using global climate models in a study by Zhang et al. (2019) find significant impacts of climate change on global flooding and predicted more frequent and severe flood events in the future. A study by Milly et al. (2002) proposes the hypothesis of "wetter in humid areas and drier in arid areas" and concluded that climate change will exacerbate the frequency and intensity of flood and drought events. Additionally, Keenan et al. (2016) state that vegetation can reduce carbon emissions, which is essential for maintaining climate stability and regulating the carbon balance in the atmosphere, while Alfieri et al. (2017) also argue that flood hazards pose a serious threat to terrestrial vegetation ecosystems, which, in turn, is detrimental to their ability to improve air quality, soil and water conservation, and climate regulation.

This trend of increased extreme hydrological weather has significant implications for infrastructure, finance, and investors, making it critical to understand the impact of extreme weather events on economic and financial markets. Many scholars have long focused on studying the influence of unexpected events on economic and financial markets. Natural disasters and geopolitical unrest can disturb the financial markets and change investor sentiments. Bourdeau-Brien and Kryzanowski (2017) find that certain natural disasters can have a significant impact on the stocks of firms in disaster-affected regions of the United States over the long term, particularly in the two to three months following the peak of disaster news coverage. Moreover, the volatility of local stock returns can be more than twice the original level. Mu (2007) believes that weather has a significant effect on both the mean and volatility of natural gas futures returns. Liu et al. (2021) conduct event study analysis and demonstrated that following catastrophic hurricanes, the daily average abnormal returns of different energy categories typically statistically differ from zero. Fink et al. (2010) confirm that hurricane force 4 in Mexico increased the price of refined petroleum relative to crude oil by about 13.5 percent.

However, some studies have yielded different results. Cagle (1996), in her study of Hurricane Hugo, finds that stocks with low-risk exposure remained unaffected. Worthington (2008) concludes that natural events and disasters in Australia have no impact on Australian stock market returns. The integrated stock markets in the United States and Japan exhibit no wealth effect from Wang and Kutan’s study (2013) , indicating their ability to effectively diversify the impact of natural disasters on stock returns. Lioui et al. (2019) also note that high-momentum stocks experience a negative impact on their returns an order of magnitude greater than other stocks. Similarly, Hsiang (2010) provides tropical cyclones negatively impact individual sectors, especially agriculture and tourism. Ewing et al. (2006) indicate that insurer stock prices were negatively affected during the synoptic life cycle of the storm as well. Lately, Xiaoyu and Lewis (2023) observe a sample of U.S. firms between 1996 and 2022 and find that those located in counties and cities that are frequently hit by natural disasters face a higher risk of stock market crashes. The findings suggest that while surplus management may lead to short-term profitability, these firms are more vulnerable to windfall gains and revenue disruptions from climate risk.

Additionally, research by Bostrom et al. (2013) found that individuals who have directly experienced extreme weather events such as hurricanes and floods tend to be more supportive of policies aimed at mitigating climate change. Studies by Osberghaus and Demski (2019) also indicate that people show greater acceptance of renewable energy sources and a stronger desire to reduce carbon emissions after experiencing flooding.

In the literature search, only a few studies focused on the impact of natural disasters on European stock markets, so it is urgent to fill the gap in the effect of European floods on the stock returns of conventional and renewable energy companies. It's important to know that Europe is leading ESG investments, with a growing number of investors putting environmental factors into their decision-making processes. They would consider companies' environmental performance and strategies for mitigating climate change. Therefore, studying how flooding in Europe affects the stock returns of both traditional and renewable energy companies can offer valuable insights. Investors can better understand how flooding impacts these companies' operations and market performance, aiding them in making more informed investment decisions.

Furthermore, as European countries place a high priority on environmental and climate issues, my research will have a significant impact on such policies. European governments and regulators are actively promoting the use of cleaner and sustainable energy sources by companies and encouraging investment in the renewable energy sector. For example, the Renewable Energies Act (EEG), a legal framework implemented in Germany since April 2000, supports the development of renewable energies through mechanisms such as preferential purchasing of renewable energies, fixed subsidized prices, and long-term contracts. Understanding how flooding affects the stock performance of companies in these industries can help policymakers make better decisions about reducing the risk of natural disasters and encouraging sustainable energy growth.

An in-depth analysis of the mechanisms by which floods affect the stock markets has far-reaching implications for companies. Firstly, it can help firms identify and assess risks more accurately to take appropriate preventive measures to reduce the potential for business disruption, such as flood resilience programs, and emergency response plans. Also, optimizing supply and production chains to improve flood resilience so as not to reduce their reputation. Finally, it significantly influences firms' investment and financing decisions, as investors and financing institutions may consider a firm's sensitivity and resilience to natural disasters. Therefore, analyses of the impact mechanisms of natural disasters can help firms deal with risks more effectively and improve their recovery capability, thereby ensuring stable and sustainable business development.

3 Theoretical Framework

Against the background, the theoretical framework of this study is as follows:

Firstly, based on capital markets efficiency, current capital markets are rational, generally efficient, and capable of fully reflecting all available information (Fama, 1970), including the impact of extreme weather on companies and industries. Meanwhile, according to behavioral finance, investors' decisions are influenced by emotions. Many studies have shown that factors, such as weather, temperature, humidity, sunlight, and climate change affect investor sentiment, which can influence their financial decisions and financial markets (Persinger (1975), Howarth (1984), Hirshleifer and Shumway (2003), Bansal et al. (2010), Santi (2023)). Therefore, if investors can associate flood events with broader weather and climate change impacts and regard them as important information, the urgency and severity of climate change conveyed by such flood events may cause investor emotions and anxiety and influence their reaction to extreme weather news, resulting in volatility that has the potential to affect energy sector stock prices in the short run.

Secondly, it is well known that climate change and human activities are major influences on the issue of natural disasters. In response, the government has introduced a variety of climate and environmental policies to mitigate climate change, strengthened the regulation of carbon emissions from traditional energy companies, and encouraged these companies to transform into low-carbon companies, such as the release of the EU ETS; the government has also provided more support for new energy companies, for example, according to EU 2030 climate targets, more resources from the ETS framework have been leveraged for the green transition to aid sectors in the decarbonization challenge. Christophers (2019) also pointed out that governments and regulators have appealed to institutional investors to consider the climate risks of investing in fossil fuel companies and to quantify these risks to facilitate the transfer of funds from high-carbon to low-carbon or zero-carbon assets to combat climate change. Investors may prefer to invest in renewable energy companies, while conventional energy investments may be impacted to some degree.

Moreover, the impact of flood events on the local energy sector may damage the infrastructure, affecting the production, transport, and sales of energy companies, increasing their operating costs, and affecting their profitability. Investors are concerned about the future profitability and valuation of energy companies in flooded areas, which would affect the stock price in return.

This study aims to investigate the impact of flooding events on the short-term volatility of stock prices in the energy sector and to analyze the theoretical mechanisms behind such volatility to understand investor reactions to extreme hydrological weather and its impact on financial market performance in the energy sector.

4 Empirical Strategy

4.1 Data Collection and Description

I collected data covering 11 selected flood events in the European region and financial indicators for 203 prominent European energy companies from 2019 to 2023. The flood event data comes from the EM-DAT database (https://public.emdat.be/), which provides important information including event classification, start and end dates, affected countries, inundated areas, and total damage. After removing data with missing important information, 26 flood events were recorded from 2019 to 2023. As can be seen from Figure 1, the most frequent occurrences are in France, Spain, Greece, and Italy. Table 1 shows the average total damage of floods in each country, and the floods in Germany, Italy, Spain, France, the UK, and Northern Ireland caused more loss than other places. The European energy companies' data is selected from FactSet provided stock code, locations, price returns, ROA, total asset, market value and net income which helped me to comprehensively examine the impact of flood events on stock markets.

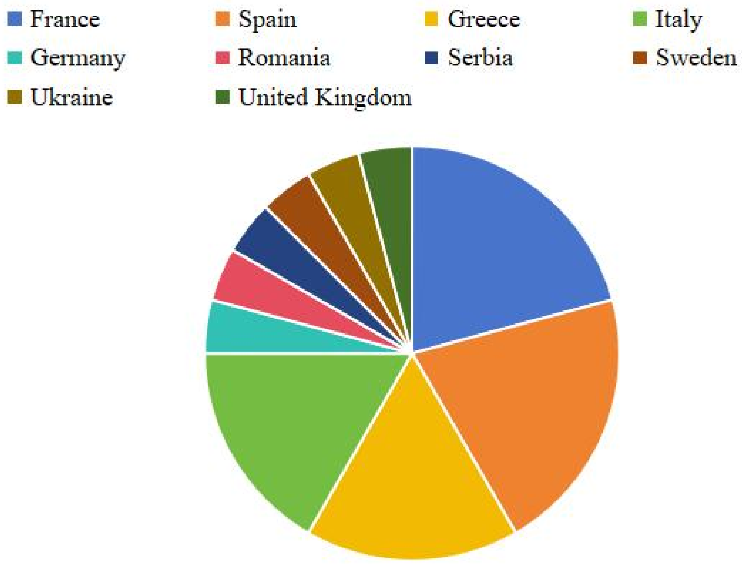

Figure 1 Percentage of flood events occurring in European countries, 2019 - 2023

Table 1 Average Total Damage of Flood Events in European Countries, 2019 - 2023

Country	Average Damage	Log_Damage
Germany	40000000000	10.60205999
Italy	2480000000	9.394451681
Spain	613800000	8.788026884
France	367200000	8.564902673
UK and Northern Ireland	170406000	8.231484882
Sweden	70000000	7.84509804
Greece	67500000	7.829303773

Table 2 Vital Information Statistics on 11 Flood Events

Country	Start Date	End Date	Total Affected	Total Damage($)
Italy	2023.05.16	2023.05.20	46000	9750000000
France	2023.11.06	2023.11.07	3500	1650000000
Greece	2023.08.19	2023.08.27	-	200000000
Germany	2021.07.12	2021.07.15	1000	40000000000
Sweden	2021.08.17	2021.08.18	13500	70000000
Spain	2021.11.22	2021.12.01	100	36000000
Greece	2021.09.27	2021.09.27	2336	30000000
Italy	2020.11.27	2020.11.28	250	60000000
Spain	2019.09.11	2019.09.16	3500	2500000000
UK	2019.11.07	2019.11.08	100	170406
France	2021.02.01	2021.02.10	305	10000

Table 2 provides critical data on 11 significant flood events across Europe, detailing their duration, the number of people affected, and the total economic damages. The most severe event in terms of economic damage occurred in Germany in July 2021, with $4 billion in damages. However, the May 2023 flood in Italy had the highest number of people affected, with 46,000 individuals impacted and $97.5 million in damages. Other notable events include the September 2019 flood in Spain, which affected 3,500 people and resulted in $2.5 billion in damages. The data underscores the substantial human and economic impact of these flood events, with Germany and Italy experiencing particularly severe consequences.

4.2 Hypothesis

Based on the core research idea, I developed the following hypotheses to guide my investigative approach:

1. Primary Hypothesis:

Null Hypothesis (H_0): During the flood events, the European energy company stocks do not have abnormal returns.

Alternative Hypothesis (H_1): During the flood events, the European energy company stocks do have abnormal returns.

This hypothesis focuses on the impact of flood events on stock returns and volatility of European energy companies. If the alternative hypothesis holds, i.e., that during flood events, investor expectations would change, the financial impact of flood risk on energy companies, and the importance of flood risk management for companies and investors.

2. Secondary Hypothesis:

Null hypothesis (H_0): The impact of the flood event on the returns of energy company stocks is similar for all European regions.

Alternative hypothesis (H_1): The impact of the flood event on the returns of local energy company stocks is different from the impact of energy companies in other European countries.

The main question posed by this hypothesis is whether energy businesses operating in the impacted region will experience the same effects from a flood as those operating in other European countries. The establishment of the alternative hypothesis will reveal the different impacts that floods may have on energy companies in distinct regions and countries, which will provide valuable information for regional flood risk management.

3. Additional Hypothesis:

Null hypothesis (H_0): The effect of flood event on the stock of energy companies is independent of the type of energy companies.

Alternative hypothesis (H_1): The effect of flood event on the stock of energy companies is related to the type of energy companies.

This additional hypothesis considers whether a flood event would have the same impact on the stocks of different types of energy companies. If the alternative hypothesis holds, i.e., that floods have different impacts on the two types of energy companies, one is traditional energy company and another one is renewable company. It would emphasize the need for companies to consider the importance of transitioning to new sources of sustainable energy and how to better address flood risk in their risk management and investment decisions.

4.3 Methodology

My research will mainly involve several widely used methods in financial economics, event studies, the Fama-French three-factor model, and multiple regression models. Among them, event studies aim to assess the impact of flood events on asset prices, including stock returns and volatility. The methodology compares the change in asset values before, during, and after the event to determine the magnitude of its influence. Meanwhile, the Fama-French model is the classic model used to explain stock returns, considering the impact of market factors, firm size, and value factors on stock returns. Also in the following analysis of other factors affecting cumulative abnormal returns, I will use the multiple regression model. These methods are valuable in understanding asset price volatility and investor behavior.

4.3.1 Event Study

I propose to utilize event study methodology based on MacKinlay (1997), a widely adopted approach in finance that has become a pivotal tool for measuring market reactions and efficiency. Choosing this method allows for effective capture and analysis of the short-term impact of specific events on asset prices, aiding in uncovering the potential effects of flood events on energy company stock prices. I will use the notation below to represent the time frames of a stock return model and completely unforeseen events:

T_0 signify the start of the estimation period $[T_0, T_1 - 1]$.
T_1 denote the event date.
T_2 be the end of the event window $[T_1, T_2]$.
T_3 denote the end of the post-event window $[T_2 + 1, T_3]$

Defining t = 0 as the event date, $t = T_1 + 1$ to $t = T_2$ represents the event window, $t = T_0$ to $t = T_1$ constitutes the estimation window, and the post-event window will be from $t = T_2 + 1$ *to* $t = T_3$. In my research, $[T_0, T_1 - 1]$ will be [-250, -11], $[T_1, T_2]$ will be [-10, 5], $[T_2 + 1, T_3]$ will be [6, 20]. Let $L_1 = T_1 - T_0$, $L_2 = T_2 - T_1$ and $L_3 = T_3 - T_2$ be the length of the estimation window, the event window and the post-event window, respectively.

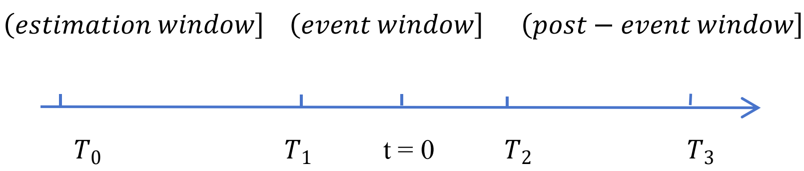

Figure 2.Timeline for an event study

The event study was based on the well recognizable Market Model, such as the one proposed by Fama and French (1993), in which the expected return R for stock i on day t is determined by the α coefficient, being the return of the stock when the market factor returns are equal to zero, the β coefficient, which indicates the sensitivity of the stock to the market returns, and an error term ε_{it}, which has the expected value of zero. The expected returns in the event window (from 10 trading days before the exclusion date to 20 trading days after the exclusion date) have been calculated for the 121 tested companies, based on their returns achieved in the estimation period (240 trading days before the event window), according to equation (1):

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{1}$$

$$ER_{it} = R_{it} - Rf_t = \alpha_i + \beta_i (R_{mt} - Rf_t) M_t + \varepsilon_{it} \tag{2}$$

In the above equations, for t = t_0, t_1, t_2, t_3, R_{it} is the return on stock i on day t, R_{mt} is the return on the market portfolio on day t, Rf_t is the risk-free return, $ER_{it} = M_t - Rf_t$ represents the excess return on the market portfolio of stock which is then subtracted from the risk-free rate Rf_t according to formula (2) to determine the excess return on the stock. The daily risk-free rate is based on the interest rate on 10-year Treasury bills issued by the UK government as equation (3). $\varepsilon_{i,t}$ is the error term with $E(\varepsilon_{i,t}) = 0$ and $Var(\varepsilon_{i,t}) = \sigma^2_{\varepsilon_i}$, α_i represents the portion of the excess return that cannot be explained by the market factor and the other two factors, β_i indicates the systematic risk exposure of a stock relative to the market portfolio.

$$Daily\ Yield = (1 + \frac{Annual\ Yield_{UK}}{100})^{\frac{1}{250}} - 1 \tag{3}$$

According to the equation (4), Given a flood event f and a stock i, I could calculate the abnormal return $AR_{f,i,t}$ for each of the flood events on day t during the event window. This abnormal return $AR_{f,i,t}$ is the difference between the actual excess return and the expected excess return estimated from the Fama-French model. In other words, I evaluate the performance of a stock during a specific event by comparing actual returns to expected returns to determine if they are in line with expectations:

$$AR_{f,i,t} = R_{f,i,t} - (\widehat{R_{f,i,t}} - \widehat{\alpha_{f,i}}) \qquad (4)$$

The average abnormal return for each event of day t in the event window (where t = T – 10 to T + 20) was then calculated by averaging the abnormal returns obtained by the tested stocks in time t against the number of exclusions N, as shown below:

$$AAR_{f,i,t} = \frac{1}{N}\sum_{i=1}^{N} AR_{f,i,t} \qquad (5)$$

Then, the cumulative average abnormal return is determined, compliant to the formula presented in equation (6). The cumulative average abnormal return from time 1 to T is obtained as a sum of average abnormal returns achieved by the tested stocks during this period. Particularly, as part of our event study, CAAR during the periods from T – 10 to T – 1, from T + 1 to T + 5, from T + 1 to T + 10 and from T + 1 to T + 20, is subject to examination.

$$CAAR_{f,i}(1,T) = \sum_{t=1}^{T} AAR_{f,i,t} \qquad (6)$$

After calculating the Cumulative Average Abnormal Return (CAAR), the statistical significance of the obtained results has been tested using conventional t-tests as well as the Z-tests, due to the relatively small size of the sample tested in the study. In line with that, t-tests of AAR and CAAR have been conducted according to formulas described in equations (7) and (8) respectively:

$$t - stat = \frac{AAR_{f,i,t}}{S(AAR_{f,i,t})} \tag{7}$$

$$t - stat = \frac{CAAR_{f,i,t}}{S(AAR_{f,i,t})\sqrt{N}} \tag{8}$$

where, n is the number of days between 1 and T, and S($AAR_{f,i,t}$) is the standard deviation of the average abnormal returns obtained during the estimation period. The Z-test (non-parametric test) for CAAR was conducted, in compliance with the following formula:

$$Z - stat = \frac{p - E(p)}{\sqrt{\frac{E(p)(1 - E(p))}{N}}} \tag{9}$$

where, p is the proportion of the negative average abnormal returns obtained during the tested period in the event window, E(p) is the estimated proportion of negative average abnormal returns during the period, and N is the number of trading days included in the specified period. Comparing the t-statistic with the critical value at the 5% significance level, if the absolute value of the t-statistic is greater than the critical value, the null hypothesis can be rejected, i.e., the flooding event had a significant impact on the stock price.

4.3.2 Regression Approach

I want to identify if there is a difference in the impact of some of the factors on stock returns, so create dummy variables for energy company type, energy company location to help me identify if there is a significant difference in the impact of these factors on stock returns. There will be 16 energy company locations, 2 different types of energy companies.

$$CAR_{f,i}(t_1, t_2) = \beta_0 + \beta_1 \times eventlocation_i + \beta_2 \times traditional\_energy_i + \beta_3 uk + \beta_4 italy + \beta_5 france + \beta_6 greece + \beta_7 spain + \beta_8 sweden + \beta_9 \sum_i C_i + \varepsilon_i \quad (10)$$

Where β_0 is the intercept term, β_1 is the coefficient on the dummy variable eventlocation_i. This variable represents whether the firm's geographical location is the same as the flood area, 0 indicates that the flood event and the company are not in the same place, while 1 indicates that they are in the same place. β_2 is the coefficient of the dummy variable $traditional\_energy_i$, which means energy firm type, 1 represents traditional oil, coal and gas energy firms and 0 represents renewable energy firms. β_3, β_4, β_5,..., β_8 represent the change in cumulative abnormal returns associated with the event for the corresponding country. β_9 is the sum of the coefficients of the other control variables, including log_totalasset, log_marketvalue, net_income, ROA in Table 4, and ε_i is the error term.

This study examined the impact of flood occurrences on energy firms in eight European countries (the United Kingdom, Germany, Italy, France, Greece, Sweden, Spain, and Italy) between 2019 and 2023. Table 3 shows the volatility and distribution of essential financial metrics for energy companies in various countries after flood disasters. The dataset depicts the financial state of flood-affected enterprises, including the number of observations, mean, standard deviation, minimum, and maximum values for each indicator. For example, the logarithms of total assets and market value show some consistency across most countries, with mean values ranging between 8.5 and 8.75, indicating that the companies investigated are similar in size. However, in Greece and Spain, the logarithm of market value varies more, potentially reflecting market valuation instability and the impact of changing market conditions. Extreme minimum and highest net income figures in Germany and Italy reflect substantial financial difficulty in specific years. The fluctuation of ROA from negative to positive values reflects the instability in operational efficiency and profitability under the impact of natural disasters. These extreme negative ROA values may indicate inefficient use of assets or financial difficulties faced by the companies, providing empirical data for assessing the economic impact of floods on the energy sector. These analyses not only enhance the understanding of the economic consequences of flood events but also provide a basis for developing more effective risk management and recovery strategies.

Table 3 Statistical description of the control variables

Event	Variable	Obs	Mean	Std. dev.	Min	Max
2019UK	log_totalasset	119	8.67	1.46	5.73	11.54
	log_marketvalue	119	8.49	1.37	5.65	11.36
	net_income	119	1064.86	2979.33	-951.22	19794.03
	ROA	119	-9.18	47.68	-477.00	55.36
2021Germany	log_totalasset	118	8.59	1.44	5.00	11.49
	log_marketvalue	118	8.43	1.25	6.32	11.10
	net_income	118	-1057.79	3583.39	-19017.97	1258.00
	ROA	118	-12.35	21.84	-135.36	33.38
2023Italy	log_totalasset	115	8.75	1.44	5.56	11.62
	log_marketvalue	115	8.43	1.35	6.12	11.26
	net_income	115	2209.13	7203.27	-2366.38	40256.93
	ROA	115	-3.55	28.19	-203.00	44.54
2023France	log_totalasset	115	8.75	1.44	5.56	11.62
	log_marketvalue	115	2.43	1.35	0.12	5.26
	net_income	115	2209.13	7203.27	-2366.38	40256.93
	ROA	115	-3.55	28.19	-203.00	44.54
2023Greece	log_totalasset	115	8.75	1.44	5.56	11.62
	log_marketvalue	115	2.43	1.35	0.12	5.26
	net_income	115	2209.13	7203.27	-2366.38	40256.93
	ROA	115	-3.55	28.19	-203.00	44.54
2021Sweden	log_totalasset	118	8.59	1.44	5.00	11.49
	log_marketvalue	118	2.43	1.25	0.32	5.10
	net_income	118	-1057.79	3583.39	-19017.97	1258.00
	ROA	118	-12.35	21.84	-135.36	33.38
2019Spain	log_totalasset	114	8.65	1.41	5.73	11.54
	log_marketvalue	114	2.45	1.33	-0.35	5.36
	net_income	114	1019.12	3255.04	-951.22	19794.03
	ROA	114	-9.06	48.68	-477.00	55.36
2020Italy	log_totalasset	116	8.66	1.44	5.72	11.56
	log_marketvalue	116	2.28	1.31	0.18	5.06
	net_income	116	575.45	2535.28	-3845.00	14154.14
	ROA	116	-10.32	32.78	-212.09	97.30

4.3.3 Robustness Test

1. Variation in event and estimation windows:
Consider event and estimation windows of different lengths and compare their effects on the results. For example, I may try different lengths of windows to capture the pre-event and post-event effects, as well as to compare the difference between short-term and long-term effects. Verify the robustness and robustness of different window lengths.
2. Alternative methodology:
Explore different methodologies and models to analyze data and compare their results and the robustness of hypothesis testing.

5 Results

5.1 Event Study

The divergent market responses in Italy, France, and Spain to similar environmental disasters highlight the complex interplay between natural events and financial markets, particularly within the energy sector. Each country's market reacted distinctly, reflecting differences in market structure, investor sentiment, and possibly regulatory environments.

As can be seen from Table 4, in the flood event that occurred in Italy on May 16, 2023, traditional energy companies displayed a notable negative cumulative abnormal return (CAAR of -1.43%) in the pre-event window [T-10, T-1], which was statistically significant (t-statistic of -2.02, p-value of 0.04). This significant decline reflects the market's anticipation of potential disruptions to production and increased operational costs due to the flood. However, it is important to note that post-event, all short-term windows (such as [T, T+3] and [T, T+5]) as well as longer time frames showed entirely non-significant CAAR for traditional energy, indicating that the market might have already fully adjusted to the anticipated impacts before this event, or the actual impacts of the event did not reach the negative extent expected by the market. Similarly, renewable energy companies also did not show any statistically significant abnormal returns in all these windows, suggesting that the market views these companies as having stronger resilience to such natural disasters, or that the flood had limited impact on them.

In contrast to Italy, market reactions in similar situations in France and Spain showed distinct patterns. In the short term, the flood in France on November 6, 2023 had a significant detrimental impact on traditional energy. CAAR of -2.10% at [T, T+2] (t-statistic of -6.68, p-value of 0.00), showing that the market expects significant direct damage from the flood. In the two events in Spain, both traditional and renewable energy sectors showed considerable positive anomalous returns in the short term, illustrating the market's fast and complex assessment of the events' consequences.

In France, the immediate aftermath of the November 6, 2023 flood resulted in a significant downturn in the traditional energy sector, as indicated by the cumulative abnormal return (CAAR) of -2.10% in the period [T, T+2], with a highly significant t-statistic of -6.68 and a p-value of 0.00. This stark negative response suggests that investors anticipated substantial direct damage to the assets and operations of traditional energy companies, perhaps due to the country's specific infrastructure vulnerabilities or the scale of the flood.

On the contrary, both traditional and renewable energy sectors saw significant positive abnormal returns following similar occurrences in Spain, indicating that the market quickly responded and adopted a more hopeful outlook on the long-term ramifications. The positive response in Spain may reflect a perception that these companies are more capable of recovering or even benefiting from the restructuring and innovation typically following such disasters. This could be due to many factors, including improved disaster preparedness, effective government response tactics, or a greater emphasis on shifting to renewable energy sources, which are perceived to be more resilient.

Table 4 Cumulative Abnormal Returns of Energy Companies for 11 events

Event		Traditional Energy			Renewable		
	Event window	CAAR%	t-stat	p-value	CAAR%	t-stat	p-value
Italy 2023.05.16	T-10,T-1	-1.43	-2.02	0.04	-2.81	-1.59	0.11
	T, T+3	-1.11	-1.32	0.19	0.10	0.05	0.96
	T, T+5	-0.97	-0.42	0.68	-0.90	-0.58	0.56
	T, T+10	-1.27	-1.16	0.25	-0.60	-0.31	0.75
	T,T+20	-0.01	1.13	0.26	-0.44	0.08	0.93
France 2023.11.06	T-10,T-1	-0.23	-1.42	0.16	0.43	0.44	0.66
	T, T+2	-2.10	-6.68	0.00	2.83	-0.78	0.43
	T, T+3	-1.66	-5.68	0.00	2.13	-1.02	0.31
	T, T+5	-0.33	-1.21	0.23	3.06	-0.61	0.54
	T, T+10	-0.72	-1.31	0.19	5.64	0.37	0.71
	T,T+20	-1.57	-3.21	0.00	14.65	0.51	0.61
Spain 2019.09.11	T-10,T-1	3.59	6.07	0.00	-3.81	-0.38	0.70
	T, T+3	1.34	4.16	0.00	4.04	2.18	0.03
	T, T+5	0.57	2.41	0.02	8.22	1.70	0.09
	T, T+10	-1.67	-0.60	0.55	9.04	2.21	0.03
	T,T+20	-2.40	-1.39	0.16	8.02	1.85	0.06
Spain 2021.11.22	T-10,T-1	-4.72	-7.98	0.00	-0.27	-0.21	0.83
	T, T+3	2.29	5.45	0.00	0.35	0.73	0.47
	T, T+5	0.25	0.36	0.72	0.27	0.61	0.54
	T, T+10	0.70	1.77	0.08	-3.20	-0.41	0.68
	T,T+20	-0.84	0.27	0.79	1.26	3.46	0.00

These findings are critical to understanding how different economies internalize the effects of natural disasters. They argue that while some markets may see such occurrences as chances to innovate or change to more sustainable methods, others may see them as substantial risks to stability and profitability. Comparing the data from these three countries reveals the various effects of flood events on energy companies in different countries, with the market's anticipation and actual reaction to the occurrence in Italy standing out. It implies that investors may have a high sensitivity and accuracy in forecasting and reacting to risks, with less uncertainty about the actual consequences of the occurrence. These assessments help energy businesses and policymakers obtain a better understanding of market dynamics and develop more effective responses to natural disasters.

Table 5 provides an analysis result of three specific events impacting energy companies in Greece, Sweden, and France. This table allows us to examine both the short-term and long-term cumulative abnormal returns (CAAR) for traditional and renewable energy sectors following these events. In the event of August 19, 2023, in Greece, the impact on energy companies showed clear differences between short and long-term periods, as illustrated in Table 6. In the short-term windows (such as [T, T+3] and [T, T+5]), both traditional and renewable energy sectors showed no statistically significant cumulative abnormal returns (CAAR), indicating an unclear or mixed immediate market response. However, in the longer-term window [T, T+20], traditional energy showed a significantly positive correlation (CAAR of 2.94%, t-statistic of 3.99, p-value of 0.00), which might reflect market optimism regarding potential opportunities such as benefits from reconstruction projects. Conversely, renewable energy showed a slightly negative impact in the same long-term window (CAAR of -1.77%, t-statistic of -2.00, p-value of 0.05), revealing possible market concerns or adverse factors.

Moreover, in Sweden's event on August 17, 2021, traditional energy also exhibited a clear positive correlation in the long-term window [T, T+20], with a CAAR of 4.08%, t-statistic of 4.91, and a p-value of 0.00, suggesting market expectations of sector recovery and growth potential. However, in the short-term windows, both energy sectors showed non-significant CAARs, reflecting market uncertainty about the immediate impacts. Additionally, renewable energy's performance in the longer term was non-significant (CAAR of -2.29%, p-value of 0.76), implying market caution regarding the long-term effects on this sector.

The event in France on February 1, 2021, saw traditional energy exhibiting a significant positive correlation in the long-term window [T, T+20], with a CAAR of

5.37%, t-statistic of 3.96, and a p-value of 0.00, as detailed in Table 6. It reflects optimistic market expectations for the sector benefiting from the disaster. However, renewable energy showed a significant negative CAAR (-12.47%) in the same window, although this result was not statistically significant (p-value of 0.14), revealing market pessimism about the recovery and growth potential of renewable energy after the disaster. In the short term, both types of energy showed non-significant CAARs, indicating a calm or inconsistent market reaction to the event's immediate impacts.

Table 5 Cumulative Abnormal Returns of Energy Companies for 3 events

Event		Traditional Energy			Renewable		
	Event window	CAAR%	t-stat	p-value	CAAR%	t-stat	p-value
Greece 2023.08.19	T-10,T-1	1.07	1.07	0.29	-6.28	-2.44	0.01
	T, T+3	-0.47	-0.97	0.33	-1.09	0.54	0.59
	T, T+5	-0.27	-0.13	0.90	0.22	-0.81	0.42
	T, T+10	1.61	2.89	0.00	0.63	-1.07	0.28
	T,T+20	2.94	3.99	0.00	-1.77	-2.00	0.05
Sweden 2021.08.17	T-10,T-1	-2.76	-3.04	0.00	-9.29	-2.60	0.01
	T, T+1	-0.39	-0.40	0.69	5.04	0.71	0.48
	T, T+3	-2.09	-1.36	0.17	1.54	0.18	0.86
	T, T+5	-0.13	0.42	0.67	0.27	0.25	0.80
	T, T+10	-0.57	-0.09	0.93	-0.27	-0.14	0.89
	T,T+20	4.08	4.91	0.00	-2.29	-0.31	0.76
France 2021.02.01	T-10,T-1	0.05	0.94	0.35	1.93	0.87	0.38
	T, T+3	-0.49	-1.31	0.19	-2.63	-0.44	0.66
	T, T+5	1.01	1.09	0.28	-0.85	-0.04	0.97
	T, T+10	1.95	1.87	0.06	-2.53	0.17	0.86
	T,T+20	5.37	3.96	0.00	-12.47	-1.48	0.14

In summary, when we look at the data from these three countries in Table 5, it's clear that market responses to both traditional and renewable energy sectors are usually not significant in the short term. It might be because the market needs more time to understand the real effects of the events or because responses vary. However, in longer event windows, the traditional energy sector often shows a significant positive trend. It suggests that the market has confidence in this sector's ability to recover and take advantage of new opportunities. However, for renewable energy companies, the results were non-significant across almost all observed periods, indicating that in various event analyses, the market reactions to these companies, both short-term and long-term, did not reach statistical significance, reflecting a high level of uncertainty and complexity in the market response to the renewable energy sector. These non-significant results could stem from several reasons, including market expectations about specific risks and opportunities in the renewable energy field already being reflected in the price, or the market needing more data and time to understand and evaluate how these companies perform in the face of specific environmental and economic challenges. Additionally, this may also suggest that the factors impacting the renewable energy industry are diverse and influenced by economics, policy, and technological changes, making their market performance more difficult to predict and analyze.

In Table 6, we see the cumulative abnormal returns (CAAR) of energy companies from four different countries during specific events. The data from Germany, the UK, Italy, and Greece illustrate market responses to traditional and renewable energy sectors over various time windows. In Germany, the event had a significantly negative long-term impact on traditional energy companies. Specifically, in the post-event window from T to T+20, the CAAR for traditional energy dropped to -16.33% with a t-statistic of -3.27, indicating a very pessimistic market outlook for traditional energy. Meanwhile, renewable energy also showed a negative impact in the same time window, but it was not statistically significant, with a CAAR of -2.12 and a p-value of 0.92, showing a relatively mild market reaction to renewable energy.

In the UK, the impact on the energy sector was more balanced, particularly in the traditional energy sector. In the [T, T+10] event window, the CAAR for traditional energy was 0.62% with a t-statistic of 2.47 and a p-value of 0.01, showing an optimistic market sentiment about the event's impact. However, although renewable energy reached a CAAR of 2.97% in the [T, T+10] event window, suggesting a potential positive trend, this result was not statistically significant (p-value of 0.67).

The data from Italy demonstrate that conventional energy was severely negatively impacted in the short term, particularly in the [T, T+3] time window, when the CAAR decreased to -2.81% with a t-statistic of -7.52 and a significance level of 0.00. However, by the [T, T+20] event window, the situation improved, with a CAAR rising to 1.41%, indicating a cautiously optimistic market outlook for the long-term impact. Meanwhile, renewable energy's performance in most time windows also did not show statistical significance.

In Greece, the event showed a strong positive impact on traditional energy across all observed time windows. In the [T, T+5] event window, the CAAR for traditional energy reached 7.73% with a t-statistic of 16.01 and a significance of 0.00, demonstrating a strong positive market response to the traditional energy sector. Although renewable energy showed a negative trend in some time windows such as [T, T+5] (CAAR of -1.30), these results were not statistically significant (p-value of 0.83).

These four events reflect the diversity of market reactions to different incidents in the energy industry. The markets in Germany and Italy showed a distinctly negative response to traditional energy, particularly with significant long-term impacts in Germany. Conversely, the event in Greece had a significantly beneficial influence on traditional energy, while the UK showed a more balanced market response. These varied market reactions reveal the differences in impacts on different types of energy and the complexity and uncertainty of market behavior in response to specific events.

Traditional energy companies generally experience significant changes in their CAAR following flood events, with outcomes varying between positive and negative depending on the specific event and its location. For example, while the 2021

Germany event had a severely negative impact on traditional energy companies, the 2019 UK event resulted in positive effects. In contrast, renewable energy companies did not exhibit significant changes in CAAR across the studied events. It suggests that the market perceives renewable energy companies as being less affected by the immediate physical and economic impacts of floods. This distinction in market response provides valuable insights for investors in understanding the differential impact of natural disasters on traditional versus renewable energy sectors.

Table 6 Cumulative Abnormal Returns of Energy Companies for 4 events

Event		Traditional Energy			Renewable	
	Event window	CAAR%	t-stat	p-value	CAAR%	t-stat	p-value
Germany 2021.07.12	T-10,T-1	-1.64	-2.40	0.02	-1.63	-0.41	0.68
	T, T+3	0.20	-2.35	0.02	-0.89	2.12	0.03
	T, T+5	-5.25	-5.10	0.00	-1.00	-0.17	0.87
	T, T+10	-13.82	-3.74	0.00	-3.12	-0.32	0.75
	T,T+20	-16.33	-3.27	0.00	-2.12	0.10	0.92
UK 2019.11.07	T-10,T-1	0.70	0.22	0.83	-1.69	-0.75	0.45
	T, T+3	2.22	1.57	0.12	1.90	0.04	0.97
	T, T+5	0.49	2.68	0.01	2.52	-0.25	0.80
	T, T+10	0.62	2.47	0.01	2.97	0.43	0.67
	T,T+20	-0.90	2.57	0.01	2.10	0.93	0.35
Italy 2020.11.27	T-10,T-1	7.98	10.10	0.00	-4.26	-0.14	0.89
	T, T+1	-1.29	-3.52	0.00	0.85	0.15	0.88
	T, T+3	-2.81	-7.52	0.00	-3.08	-1.17	0.24
	T, T+10	0.56	2.46	0.01	-5.97	-0.72	0.47
	T,T+20	1.41	1.94	0.05	-11.55	-0.59	0.56
Greece 2021.09.27	T-10,T-1	3.19	7.52	0.00	-0.95	0.03	0.98
	T, T+1	4.69	16.63	0.00	1.48	1.41	0.16
	T, T+3	5.68	13.79	0.00	0.34	0.49	0.62
	T, T+5	7.73	16.01	0.00	-1.30	-0.21	0.83
	T, T+10	6.90	11.21	0.00	-3.81	-0.90	0.37
	T,T+20	5.34	6.31	0.00	-4.58	-0.51	0.61

Figure 3 shows that the CAAR for the 11 conventional energy events is decreasing in the pre-event and early post-event periods, with a progressive reduction from [T, T-10] to [T, T+5]. However, a sluggish rebound process is observed subsequently, particularly at [T, T+20], which shows an increase in comparison to [T, T+10]. In contrast, the CAAR for renewable energy rises till [T, T+1], then falls dramatically before starting up again at [T, T+20], but the overall trend is downward from the peak.

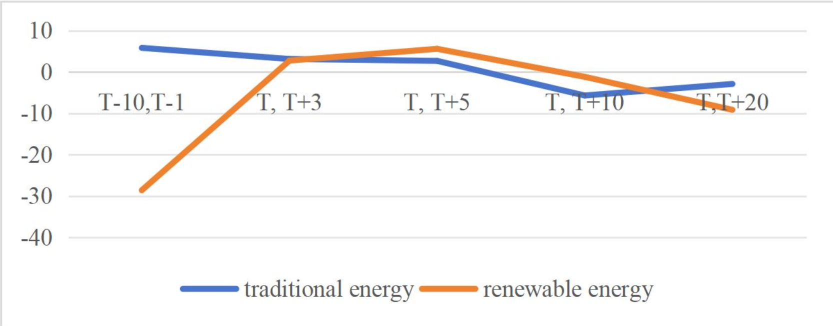

Figure 3 Total CAAR changes of Energy Companies for all 11 events

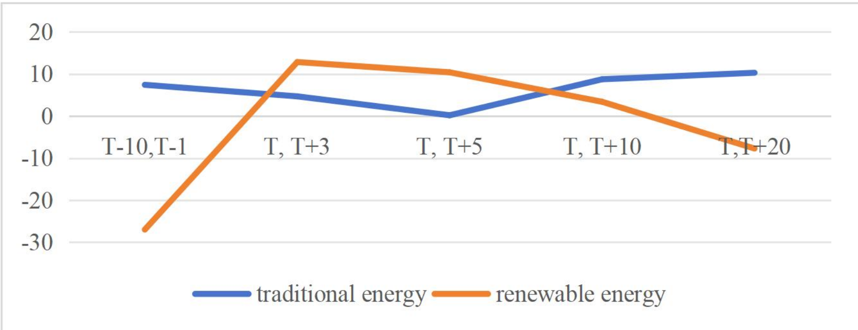

Figure 4 Total CAAR changes of Energy Companies for events except Germany

The data from Germany may be severe and skew the general trend, so Figure 4 shows the trend after deleting these data points. In the pre-event era, the CAAR for renewable companies increased fast in [T-10, T-1], peaking at [T, t+3], indicating a robust market response. However, beginning at [T, T+3], the CAAR for renewables declines dramatically, reaching a low of -30 by [T, T+10], before recovering slightly at [T, T+20] but still heading lower overall. In contrast, conventional energy gradually diminishes after [T, T+3], albeit to a lower extent, and plateaus at [T, T+20].

5.2 Regression analysis

In the results of regression model presented in Table 7, the variable "eventlocation" is a binary indicator that identifies whether a company is located in the same place as the flood event. The variables "uk", "italy", "france", "greece", "spain" and "sweden" represent the actual locations of the events, with Germany as the reference or baseline location.

Table 7 Regression Results of Calculative Abnormal Return of European Energy Companies

	(1)	(2)	(3)	(4)
	CAAR[0,3]	CAAR[0,5]	CAAR[0,10]	CAAR[0,20]
eventlocation	-3.052	-3.084	-4.653*	-8.480***
	(2.239)	(2.328)	(2.503)	(2.845)
uk	4.479	7.939**	9.865***	10.399***
	(3.389)	(3.392)	(3.525)	(3.861)
italy	0.371	2.837**	4.155***	4.482**
	(1.153)	(1.222)	(1.543)	(2.083)
france	1.132	3.358*	5.891**	5.039
	(1.601)	(1.713)	(2.530)	(3.348)
greece	2.376	3.562**	5.639***	4.092
	(1.488)	(1.640)	(2.163)	(2.843)
spain	3.886***	4.289***	4.787**	3.082
	(1.435)	(1.547)	(2.127)	(2.804)
sweden	0.806	4.188***	5.253***	8.818***
	(1.395)	(1.503)	(1.917)	(2.731)
energy	-0.602	0.224	-1.680	-0.482
	(1.145)	(1.292)	(2.009)	(2.364)
ROA	-0.003	-0.010	-0.008	0.001
	(0.013)	(0.013)	(0.016)	(0.018)
log_total asset	-0.196	0.485	0.533	0.620
	(0.261)	(0.330)	(0.412)	(0.531)
log_market value	0.239	0.046	0.154	0.149
	(0.146)	(0.191)	(0.235)	(0.323)
net_income	-0.000	-0.000	-0.000**	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.910	-8.702***	-8.966***	-10.174**
	(2.631)	(2.389)	(3.343)	(4.493)
Observations	930	930	930	930
Prob > F	0.0007	0.0006	0.0020	0.0002
R-squared	0.0214	0.0258	0.0259	0.0308
Root MSE	11.297	12.341	15.113	18.42

Note: Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The coefficients for "eventlocation" are negative and not statistically significant in CAAR[0,3] and CAAR[0,5], which shows that there is no significant difference in the

CAAR between companies located at the event site and those that are not, within these two event windows. Thus, there is generally no significant difference in CAAR between companies located at the event site and those that are not, especially in shorter event windows ([0,3] and [0,5]). However, at longer event windows ([0,10] and [0,20]), the negative and significant coefficients suggest that being located at the event site is disadvantageous.

From Table 7, which covers the event window [0,3], the coefficient for "eventlocation" is -3.0520 and not statistically significant (P > 0.1). This indicates that, within the first three days following the flood event, there is no significant difference in the cumulative abnormal returns between companies located at the event site and those that are not. Similarly, the coefficients for the specific event locations such as the UK, Italy, France, and Greece are also not significant, with the exception of Spain, which shows a significant and positive impact (coefficient of 3.8865, P<0.01). It indicates that the event in Spain had a significantly positive impact on companies during this period. Then, looking into the event window [0,5] shows a similar result to [0,3] for "eventlocation". It suggests that even within five days post-event, there is no significant difference in CAAR between companies at the event site and those elsewhere. However, the coefficients for "uk", "italy", "france", "greece", "spain", and "sweden" in Table 8 and Table 9 are all significant (P<0.05), showing that events in these countries had a significantly positive impact on companies during this period. Moving to a longer event window [0,10], the coefficient for "eventlocation" becomes -4.6531 and is statistically significant at the 10% level (P<0.1). This denotes a significant difference in CAAR, with companies located at the event site performing worse than those not at the site over this ten-day period. The positive and significant coefficients for countries like the UK, Italy, France, Greece, Spain, and Sweden during this window highlight that events in these locations generally had a positive impact on companies' CAAR. Finally, in the longest event window [0,20], the coefficient for "eventlocation" is -8.4801 and statistically significant at the 1% level (P<0.01). This strong negative coefficient underscores a pronounced disadvantage for companies situated at the event site over a twenty-day period following the flood event. During this extended period, positive and significant coefficients for the UK, Italy, and Sweden suggest that the flood events in these countries had a positive impact on the CAAR of companies located there. However, the coefficients for France, Greece, and Spain are not significant, indicating no significant impact on CAAR for companies in these countries during this longer window. Overall, the regression analysis indicates that in shorter event windows ([0,3] and [0,5]), there is generally no significant difference in CAAR between companies located at the event site and those that are not. However, as the event window lengthens to [0,10] and [0,20], the negative and significant coefficients for "eventlocation" suggest that being located at the flood event site becomes increasingly disadvantageous for companies. Conversely, specific events in certain countries, such as the UK, Italy, and Sweden, tend to have a significantly positive impact on companies' CAAR during longer periods, demonstrating the varied impact of flood events based on location and duration.

6 Discussion and Conclusion

When I examine the influence of flood events on the energy market in the event study, we find that traditional energy firms tend to have positive cumulative abnormal returns (CAAR) following disasters. This phenomenon can be explained by numerous variables, including price volatility against supply constraints. Natural catastrophes frequently cause interruptions in the energy supply chain, which is especially common in the oil and gas business. Floods or storms can destroy oil drilling and refinery infrastructure, reducing the supply of crude oil. This reduction in supply may lead to higher energy prices in the short term, which in turn raises the earnings expectations of energy companies, and this change in expectations is usually reflected in an increase in the company's share price. Additionally, greater demand for post-disaster recovery benefits conventional energy providers as well. Following a disaster, reconstruction activities typically require significant energy inputs, particularly for heavy industries that rely on traditional energy sources such as coal and oil, and this increased demand can directly boost energy prices and corporate earnings prospects, attracting more investors to pay attention to and buy these companies' stocks. Finally, during periods of high uncertainty, investor attitude and market dynamics might have an impact on stock market performance. During times of market volatility, investors may seek out "safer" assets, and conventional energy businesses, due to their size and history, are frequently viewed as safe havens in the market.

The event study also found that traditional energy companies had high negative cumulative abnormal returns (CAAR) during the 2021 flood in Germany and the 2023 flood in Italy due to several critical reasons. Firstly, these two disaster events had the greatest impact and financial losses among all the events I selected, possibly because they directly damaged critical energy infrastructure such as power grids and natural gas transmission systems, resulting in extended operational interruptions and halts in production activities. This damage required high recovery costs and severely affected the companies' immediate revenues and future profit expectations. Additionally, the market and investors held a pessimistic view of the prospects for businesses in the affected areas, raising doubts about the long-term sustainability of the industry, which led to capital withdrawal and further pressure on stock prices. In these situations, even though large energy companies usually have comprehensive insurance coverage, the insurance may not fully compensate for all losses in the face of such extreme natural disasters, and delays in insurance payouts could exacerbate the companies' financial pressures. At the same time, the government may strengthen energy policies and regulations after the disaster, increasing compliance costs for businesses or imposing new operational restrictions, further adding to the companies' burdens. All of these factors, taken together, resulted in a negative market reaction to traditional energy businesses following the two flood incidents, as evidenced by the stock market's negative CAAR. These assessments indicate the risk management and strategy adjustments that firms must make in the face of anticipated future disasters to strengthen their resilience and response capabilities.

Despite the similar risk of natural disasters, renewable energy companies' CAARs are generally stable. The reason for this may be the intrinsic nature of renewable energy initiatives. Renewable energy sources, such as wind and solar, often rely on a broad geographic dispersion and a more decentralized technological system, a structure that allows the influence of a single event to be localized, lessening the overall network impact. Furthermore, these projects frequently receive long-term government backing and market incentives, such as subsidies and tax breaks, which contribute to a consistent return on investment in the marketplace and relatively constant financial performance even in the face of calamities.

Traditional energy firms frequently confront more difficult risk management difficulties in catastrophe response and recovery operations. These businesses must develop more sophisticated emergency management systems to ensure that their production and supply can be restored rapidly in the event of a crisis. Furthermore, traditional energy businesses must boost critical infrastructure protection and implement innovative technologies to improve system resilience, such as adopting more durable materials and engineering to protect oil rigs and transmission networks.

Therefore, from the perspective of policymakers, there is a need to find a balance between disaster recovery and long-term energy policy planning. Policymakers should explore how to support conventional and renewable energy sources to ensure resilience and sustainability throughout the energy system. Setting stricter construction standards, encouraging green energy projects, and emphasizing sustainable energy solutions in disaster-prone areas are all possible options. Such a policy would assist in mitigating the effects of future natural disasters and push the energy sector in a greener, more sustainable direction.

In the early aftermath of a flood, regression analysis shows that there is no significant difference in cumulative abnormal returns (CAAR) between companies located at the event site and those that are not, especially for shorter event windows ([0,3] and [0,5]).

This finding implies a few possible explanations: Markets may require time to fully understand and react to the effects of a flood, including operational delays and financial consequences, resulting in a delayed response. Furthermore, following a tragedy, there is often tremendous uncertainty about the level of damage and its financial consequences, resulting in a neutral market response. As the event window expands to [0,10] and [0,20], the regression model shows that firms near the flood event location experience progressively negative effects. This graph demonstrates how the flood's initial disruptions—such as destroyed infrastructure, stalled activities, and disrupted supply chains—become more visible in financial assessments over time. Initially, investors may anticipate a speedy recovery, but when persisting obstacles and financial consequences become more apparent, their attitude becomes more gloomy. This shift in perspective is influenced by the realization that the road to recovery may be longer than originally anticipated. The regression analysis also demonstrates an unexpected contrast in how flood occurrences affect businesses based on location, with positive benefits in nations such as the United Kingdom, Italy, and Sweden during [0,5] and [0,10] event periods. This implies that geographic and structural differences between countries can have a substantial impact on financial results after disasters.

7 Limitations

This event study has various limitations and possibilities for development. First, the sample size is tiny, which reduces the results' robustness and generalizability. Increasing the data volume would help to make the results more representative and credible. Furthermore, the regression results show a low R-squared value, indicating that the model does not explain a significant fraction of the variance in cumulative anomalous returns (CAARs). It highlights the need for a more comprehensive model with other influential elements.

While the event location variable is valuable, it may oversimplify the intricate relationships between events and their locations, and typical energy variables alone do not fully capture sector-specific characteristics. To some degree, the model is useful because of country-specific dummy variables (e.g., UK, Italy, France, Greece, Spain, Sweden), but additional precise macroeconomic variables could provide a more complete picture of the economic, political, and market dynamics driving CAARs.

Here are some suggestions for several enhancements to the study. Increase the sample size by including more occurrences and extending the observation duration to improve robustness. Refining the model by including more explanatory variables, investigating nonlinear models, and examining interaction effects may improve model fit. Using the Fama-French Five-Factor Model to calculate abnormal returns would result in a more accurate estimate. Separate analysis for different industries can highlight sector-specific effects while integrating more detailed geographical and economic data provides a more comprehensive picture of the factors influencing CAARs. Finally, completing robustness checks using different event windows, alternative metrics of aberrant returns, and model parameters would confirm and ensure the results' reliability.

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Appendix:

A1 cumulative abnormal returns of energy companies for every event

		Energy			Renewable		
	Event window	CAAR%	t-stat	p-value	CAAR%	t-stat	p-value
Italy 2023.05.16	T-10,T-1	-1.43	-2.02	0.04	-2.81	-1.59	0.11
	T, T+3	-1.11	-1.32	0.19	0.10	0.05	0.96
	T, T+5	-0.97	-0.42	0.68	-0.90	-0.58	0.56
	T, T+10	-1.27	-1.16	0.25	-0.60	-0.31	0.75
	T,T+20	-0.01	1.13	0.26	-0.44	0.08	0.93
France 2023.11.06	T-10,T-1	-0.23	-1.42	0.16	0.43	0.44	0.66
	T, T+2	-2.10	-6.68	0.00	2.83	-0.78	0.43
	T, T+3	-1.66	-5.68	0.00	2.13	-1.02	0.31
	T, T+5	-0.33	-1.21	0.23	3.06	-0.61	0.54
	T, T+10	-0.72	-1.31	0.19	5.64	0.37	0.71
	T,T+20	-1.57	-3.21	0.00	14.65	0.51	0.61
Greece 2023.08.19	T-10,T-1	1.07	1.07	0.29	-6.28	-2.44	0.01
	T, T+3	-0.47	-0.97	0.33	-1.09	0.54	0.59
	T, T+5	-0.27	-0.13	0.90	0.22	-0.81	0.42
	T, T+10	1.61	2.89	0.00	0.63	-1.07	0.28
	T,T+20	2.94	3.99	0.00	-1.77	-2.00	0.05
Sweden 2021.08.17	T-10,T-1	-2.76	-3.04	0.00	-9.29	-2.60	0.01
	T, T+1	-0.39	-0.40	0.69	5.04	0.71	0.48
	T, T+3	-2.09	-1.36	0.17	1.54	0.18	0.86
	T, T+5	-0.13	0.42	0.67	0.27	0.25	0.80
	T, T+10	-0.57	-0.09	0.93	-0.27	-0.14	0.89
	T,T+20	4.08	4.91	0.00	-2.29	-0.31	0.76
Germany 2021.07.12	T-10,T-1	-1.64	-2.40	0.02	-1.63	-0.41	0.68
	T, T+3	0.20	-2.35	0.02	-0.89	2.12	0.03
	T, T+5	-5.25	-5.10	0.00	-1.00	-0.17	0.87
	T, T+10	-13.82	-3.74	0.00	-3.12	-0.32	0.75
	T,T+20	-16.33	-3.27	0.00	-2.12	0.10	0.92
UK 2019.11.07	T-10,T-1	0.70	0.22	0.83	-1.69	-0.75	0.45
	T, T+3	2.22	1.57	0.12	1.90	0.04	0.97
	T, T+5	0.49	2.68	0.01	2.52	-0.25	0.80
	T, T+10	0.62	2.47	0.01	2.97	0.43	0.67
	T,T+20	-0.90	2.57	0.01	2.10	0.93	0.35
Spain 2019.09.11	T-10,T-1	3.59	6.07	0.00	-3.81	-0.38	0.70
	T, T+3	1.34	4.16	0.00	4.04	2.18	0.03
	T, T+5	0.57	2.41	0.02	8.22	1.70	0.09
	T, T+10	-1.67	-0.60	0.55	9.04	2.21	0.03
	T,T+20	-2.40	-1.39	0.16	8.02	1.85	0.06
Italy 2020.11.27	T-10,T-1	7.98	10.10	0.00	-4.26	-0.14	0.89
	T, T+1	-1.29	-3.52	0.00	0.85	0.15	0.88

	T, T+3	-2.81	-7.52	0.00	-3.08	-1.17	0.24
	T, T+5	-0.45	1.46	0.15	-4.94	-1.40	0.16
	T, T+10	0.56	2.46	0.01	-5.97	-0.72	0.47
	T,T+20	1.41	1.94	0.05	-11.55	-0.59	0.56
Spain 2021.11.22	T-10,T-1	-4.72	-7.98	0.00	-0.27	-0.21	0.83
	T, T+3	2.29	5.45	0.00	0.35	0.73	0.47
	T, T+5	0.25	0.36	0.72	0.27	0.61	0.54
	T, T+10	0.70	1.77	0.08	-3.20	-0.41	0.68
	T,T+20	-0.84	0.27	0.79	1.26	3.46	0.00
Greece 2021.09.27	T-10,T-1	3.19	7.52	0.00	-0.95	0.03	0.98
	T, T+1	4.69	16.63	0.00	1.48	1.41	0.16
	T, T+3	5.68	13.79	0.00	0.34	0.49	0.62
	T, T+5	7.73	16.01	0.00	-1.30	-0.21	0.83
	T, T+10	6.90	11.21	0.00	-3.81	-0.90	0.37
	T,T+20	5.34	6.31	0.00	-4.58	-0.51	0.61
France 2021.02.01	T-10,T-1	0.05	0.94	0.35	1.93	0.87	0.38
	T, T+3	-0.49	-1.31	0.19	-2.63	-0.44	0.66
	T, T+5	1.01	1.09	0.28	-0.85	-0.04	0.97
	T, T+10	1.95	1.87	0.06	-2.53	0.17	0.86
	T,T+20	5.37	3.96	0.00	-12.47	-1.48	0.14