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Market Reaction to Environmental Disasters

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Abstract

Despite the fact that environmental issues are coming to the fore today, the market reaction to environmental disasters is not strong enough. This article examines the impact of a number of major industrial disasters on the companies' stock performance, depending on financial health of the companies involved in an accident. We assessed the impact of financial indicators such as: financial leverage, profitability, balance value per share, capital expenditures, market capitalization and revenue on the amplitude of cumulative average abnormal returns (CAAR). The sample consists of 32 companies from the oil, chemical, mining and energy industries of developed countries involved in 80 major accidents between 2000 and 2020. The majority of disasters occurred in North America (47.5%) and in Europe (26.3%). Using the event study method to assess shareholders' reaction and regression analysis, we proved that the financial leverage, profitability and book value per share has a positive impact on the amplitude of CAAR, while the ratio of capital expenditures to revenue has a negative impact on cumulative returns. The results showed that market capitalization and revenue growth do not affect the dynamics of stock prices after industrial disasters. In general, our study shows that the impact of all financial indicators on CAAR is small (<1%). That is, despite the mandatory publication of climate risk reports, investors did not actively sell shares of companies guilty of industrial disasters. The results of the study are useful in several areas. On the one hand, by forming a diversified investment portfolio, investors taking into account the type of companies that are more sensitive to disasters. On the other hand, knowing such a market reaction, the state should provide financial players with strict rules and penalties for companies responsible for accidents.

Keywords: environmental issue, stock performance, cumulative average abnormal return, financial indicator, shareholders' reaction

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Introduction

Nowadays environmental problems are coming to the fore on the global agenda. Under Paris Agreement 193 countries set specific emission targets to reduce the influence of business activity on climate change and mobilize financial resources to make existing production technologies more sustainable. At the company level in European Union and the UK, it is mandatory to publish reports on climate risks; the mcfrost popular framework is the Task Force on Climate-related Financial Disclosures (TCFD)[1]. However, even though the ESG topic is currently integrated into the investment process of the majority of financial institutions, environmental disasters still happen and the market reaction to such accidents is not strong enough.

The threat of severe market response can complement government regulation by providing incentives to comply with safety and environmental standards and/or to introduce innovations to prevent accidents[2]. Without large financial losses for unscrupulous companies, green regulation is not efficient. Market actors use climate risk disclosure for marketing reasons without significantly changing their business processes as it is costly. While green regulation needs to become much more precise itself: provide financial players with accurate definitions and strict rules, market punishment for industrial disasters should be also damaging for the companies responsible for the accidents. This paper is dedicated to the investigation of the impact of various industrial disasters on companies' stock performance and the influence of balance sheet metrics on the amplitude of cumulative average abnormal returns (CAARs).

While event studies are well-represented in scientific literature, the market reaction to environmental disasters has not been fully investigated yet. In most cases, research is dedicated to a single event study that is not representative (R. Ferstl et al., S. Kawashima and F. Takeda, A. Betzer et al., K. Lopatta and T. Kaspereit, Y. Koda, F. Heflin and D. Wallace [1–6]). However, several researchers have already gathered extended samples for more general analyses, but mostly they are focused on one specific industry (J. Feria-Domínguez et al., S. Katsikides et al., R. Makino, O. Kowalewski and ´P. Spiewanowski, T. Huynh and Y. Xia [7–11]). The research studies of O. Kowalewski and ´P. Spiewanowski, T. Huynh and Y. Xia [10; 11] investigated the relationship between the financial health of companies and their performance after an accident.

The aim of this research is to investigate the financial markets' response to industrial disasters depending on the previous performance and financial health of the companies involved in an accident. The object of research is the companies' performance after an industrial disaster. The original sample comprises 32 companies from the petroleum, chemical, mining, and energy industries involved in 80 accidents in 2000–2020.

Based on the latest empirical research and available data we propose to test the relationship between the amplitude of cumulative average abnormal stock return after an industrial accident and the company's financial metrics (Market Capitalization, CAPEX to Revenue, Book Value per Share, Leverage and Profit Margin). Also, we check whether there is a trend in the data and if shareholders started reacting stronger to industrial accidents after the adoption of the Paris Agreement in 2015.

The research makes several scientific contributions. Firstly, we gathered an original updated sample of 80 industrial accidents that occurred in companies from various industries. According to our literature review, it is the most extensive sample of industrial disasters in petrochemical, mining, and energy industries for the time period starting in 2000. Secondly, we estimated the influence of many metrics on stock price's cumulative average abnormal return after an industrial disaster. Thus, we contribute to the scientific literature focused on both the synthesis of market response to environmental disasters in various industries (G. Capelle-Blancard et al. [12]) and the research of financial metrics that influence stock price performance after an accident (T. Huynh and Y. Xia, [11]).

The results of the paper might be useful for both companies at risk and investors: the former will gain a better understanding of the market behavior after an industrial disaster and the specific financial metrics that help to mitigate losses after an accident. The latter will be able to better diversify their portfolio by taking into account the type of companies that are more sensitive to industrial disasters and to adjust their trading strategy right after an accident.

Literature review

Empirical Research Papers

There are many empirical studies on the influence of a single industrial accident on the stock performance. Most of them prove a negative shareholder's reaction by estimating cumulative average abnormal returns. In this literature review, we focus on papers dedicated to the analyses of samples of various accidents (nuclear disasters, oil spills, chemical disasters, accidents in mining industry etc.).

M. Grand and V. D'Elia [13] gathered a sample of 61 environmental news in 1995–2001 in Argentina to check market reactions to positive and negative environmental news. The authors revealed that while positive environmental news had no impact on the publicly traded companies in the sample, negative news had a harmful effect on average rates of return a few days following its appear-

[1] European Commission. Corporate disclosure of climate-related information. URL: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/corporate-disclosure-climate-related-information_en

[2] European Commission. Initiative on substantiating green claims. URL: https://ec.europa.eu/environment/eussd/smgp/initiative_on_green_claims.htm

ance. The most powerful news was those linked to citizen complaints and government rulings. S. Katsikides et al. [8] also investigated the relationship between corporate social responsibility and stock market performance. The authors chose 5 events: two from the oil industry (BP and Exxon oil spills) and three from the banking industry (HSBC – money laundering; Barclays and Royal Bank of Scotland – Libor scandal). Apart from the HSBC money laundering event, all other events had statistically significant negative effects on stock performance. Moreover, the results were more pronounced over a longer timeframe (from 10 days) as information on some events was not fully available for the market during the first days.

C. Carpentier and J. Suret [14] investigated the influence of 161 major environmental and non-environmental accidents (reported on the front page of the New York Times during the last 50 years) on stock performance. On average, the market reacts negatively to the announcement of an accident. However, this average effect is largely driven by the airline industry and by government interventions. The authors showed that significant negative CAAR estimated immediately after an environmental accident does not persist a year later. That is why the authors came to the conclusion that in markets driven mostly by institutional investors, the negative effect on companies' equity value is likely to be weak in medium term.

J. Feria-Domínguez et al. [7] gathered a small sample of 5 oil-and-gas companies listed in the New York Stock Exchange that were involved in 7 different major environmental accidents between 2005 and 2011. The authors revealed statistically significant negative CAR after the accidents, the effect was more pronounced 10 days after the disasters. The authors identified and measured reputational risk by adjusting ARs by a certain loss ratio. A new metric, CAR(Rep), is then proposed to distinguish operational losses from the reputational damage caused by an oil spill. The reputational effect is more pronounced in the longest event window that the authors used (41 days after the event). Nowadays, a company's reputation significantly depends on its environmental risk disclosure. However, while the obligatory disclosure of information on accident risks was supposed to motivate management to improve workplace safety and equipment maintenance, it is still costly; thus, many companies avoid implementing risk reduction measures due to their low direct effect on stock performance.

R. Makino [9] investigates whether firms with high accident risks experience share the price drop when the market receives this new information after the issuance of risk disclosure or the market punishment arrives only after a realized risk, e.g., an industrial accident. On the sample of 18 chemical accidents that occurred in publicly traded Japanese companies in 2005–2012, the author shows that estimated CAAR was negative after all events and that risk information is not reflected in the stock price. Thus, there are not enough incentives for management to significantly decrease accident risks while the market stays indifferent.

O. Kowalewski and ´P. Spiewanowski [10] examine the stock market reaction to natural and industrial disasters in potash mines. The authors gathered a sample of 44 mining accidents worldwide for the period of 1995–2016. 50% of the events are work accidents often associated with serious injury or death, 25% of the sample are natural disasters, such as flooding, and the remaining part consists of accidents caused by human error. On average, mining firms experience a drop in their market value of 0.89% on the day of a disaster. The authors estimate a significantly stronger response of the stock market to natural events. They proved that the firm's market loss is significantly related to the seriousness of the accident. The authors could not find any other micro- or macro-level factors that would determine the stock market reaction following a disaster.

G. Capelle-Blancard and M. Laguna [15] examine the stock market reaction to chemical disasters. The authors consider a sample of 64 accidents at chemical plants and refineries worldwide from 1990 to 2005. On average, petrochemical firms in the sample experience a drop in their market value of 1.3% over the two days right after the disaster. The authors show that this loss is significantly related to the gravity of the disaster as measured by the number of casualties and by chemical pollution: each casualty corresponds to a loss of $164 million and toxic release – to a loss of $1 billion.

T. Huynh and Y. Xia [11] investigate a firm's exposure to physical climate risk and examine investors' reaction to natural disasters in both the U.S. corporate bond and stock markets. The authors find that, when a firm is exposed to disasters, investors overreact by depressing the current bond and stock prices, causing future returns to be higher. However, firms with a strong environmental profile experience lower selling pressure on their bonds and stocks, even though their fundamentals weakened following disasters. The evidence suggests that corporate investment in improving environmental profiles pays off when climate change risk is materialized.

Finally, G. Capelle-Blancard et al. [12] provide a synthesis of four decades of empirical research regarding the reaction of shareholders to more than 100 environmental events. One of the main contributions of this paper is that the authors reveal that stock market penalties in the event of environmental concerns are likely to be quite low: on average there is a temporary drop of about 2% in the excess stock market return to events that are harmful to the environment and the median is −0.6.

Hypotheses

According to the above-discussed empirical research papers, the financial performance metrics of a company can indeed influence the amplitude of shareholders' reactions after an industrial disaster. After careful analyses of the models presented in the relevant papers, we formulated the hypothesis for our own research. We anticipate that if the influence of any single factor is positive, a higher financial metric will counteract the negative effects of an industrial disaster that might otherwise cause a decline in stock prices.

Conversely, if the influence is negative, it will further amplify the negative impact of an event, pushing the stock's abnormal return into an even more negative territory.

H1: Larger companies experience a more drastic drop in returns after an industrial disaster.

On the one hand, firms that have greater market capitalization are likely to experience a more dramatic drop in share price after an accident as such companies draw more attention from investors than small ones (M. Khanna et al. [16], G. Capelle-Blancard and M. Laguna [15]). Indeed, large companies, especially public ones included in indices are coved by a higher number of brokers/financial analysts as one of their responsibilities is to monitor the companies in the portfolio. In this case, the news about an industrial disaster will spread very quickly from the initial source to brokers and then to institutional and individual investors. Thus, as many more market players become aware of this news, market response to a disaster might be greater. On the other hand, larger firms are more diversified, and it would be easier for them to absorb losses incurred due to an industrial accident (O. Kowalewski and P. Spiewanowski [10]). An industrial disaster of the same range can significantly disrupt the activity of a small firm and has minimal impact on the operational performance of a larger firm that can compensate for lost capacity with additional sources of production or supply.

H2: Companies with higher leverage experience a more dramatic decrease in return after an industrial disaster.

Debt financing allows a company to grow faster by attracting capital for new investments and benefiting from tax shields. When the ratio gets too high or major new investments prove to be unsuccessful, the company with a significant share of debt financing will face problems with meeting financial obligations. That is why after a certain threshold debt becomes very expensive, as the risk of bankruptcy gets higher. Thus, companies tend to maintain an efficient Leverage ratio, benefitting from extra capital for development and tax efficiency with a relatively low debt burden. The impact greatly depends on the median Leverage of the sample, as very low Leverage might be a sign of lack of access to debt financing due to higher risks associated with the business, and does not characterize a company as financially healthier than the one with a higher but efficient Leverage ratio that allows it to grow faster with a moderate debt burden (O. Kowalewski and P. Spiewanowski [10]).

H3: Higher profitability has a positive influence on cumulative average abnormal returns after an industrial disaster.

The stock price of less profitable firms, by gross margin, is likely to fall more drastically as investors consider such companies riskier because they don't have enough financial inflows to quickly absorb the losses (O. Kowalewski and P. Spiewanowski [10]). Indeed, in order to generate positive cash flows the company needs to be profitable. If the gross margin is rather low and unsustainable, an accident can bring much more harm to a company's economy and push cash flows into a negative zone. These can influence a company's future dividend policy and interest payments. Thus, we suppose that share price of more profitable companies will drop less significantly than that of less profitable ones.

H4: Companies with higher Revenue Growth experience a smaller decrease in returns after an industrial disaster.

The increase in Sales Growth leads to a smaller drop in CAAR. Such companies grow faster than the industry average and thus are traded at a relatively high multiple. They do not pay dividends as profits are reinvested and investors earn money through capital gains after an exit in a couple of years in case of a realized company's growth. Hence, investors are ready to pay more for companies if they grow fast and if investors believe they will keep growing further (T. Huynh and Y. Xia [11]). Therefore, we suggest that share price of companies with higher Revenue Growth will be less sensitive to an environmental disaster – it still has a catalyst for expected growth after an accident.

H5: The returns of companies with higher Book Value per share decreases less after an industrial disaster.

We want to check if Book Value (BV) per share has a positive influence on CAAR (T. Huynh and Y. Xia [11]). Companies with higher BV per share are less risky and should absorb any losses more easily. Market value depends on what people are willing to pay for a company's stock, while book value is similar to a firm's net asset value, which is less volatile than stock price and market capitalization. In case of a major disruption or bankruptcy, the investors of a company with a large share of tangible assets will be relatively less affected as they would be able to partially get their investments back through the restructuring process while investing in a company with a "lite balance sheet", with a small share of tangible assets is generally riskier as it is much harder to sell intangible assets if they are illiquid. Thus, we suggest that the value of companies with a higher Book Value per share will drop less after an accident than those with relatively lower ratio.

H6: Higher Capex to Revenue ratio has a positive influence on company's cumulative average abnormal returns after an industrial accident.

Capex to Revenue ratio shows to what extent the company is re-investing its revenue back into productive assets such as property, plant, equipment, etc. Since the companies in our sample operate in petrochemical, mining and energy industries, they need expensive production assets. They should be renovated and replaced regularly. Equipment failures have a major effect on the number and severity of accidents (D. Bourassa et al. [17]). Thus, we expect a positive influence of a higher Capex to Revenue ratio on a company's return after an accident as high capital expenditures mean that the company invests a lot in its fixed assets, i.e., on average the equipment/pipes/factories should be in good condition and up to date. However, it is necessary to keep in mind that a very high Capex to Revenue ratio compared to peers might be a sign of inefficient use of capital as earnings should also be reallocated to strategic investments to maintain the growth pace, to dividends, etc.

H7: After the Paris Agreement in 2015, market losses after an industrial disaster became bigger for companies.

We intend to check if the conclusion of Paris Agreement[3] has strengthened the reaction of shareholders to an industrial accident, thus pushing the CAARs further into negative zone. The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at Conference of the Parties 21 in Paris, on 12 December 2015. In order to align with long-term temperature strategy, countries tend to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate-neutral world by mid-century. The conclusion of the Paris Agreement is a milestone in the global climate change because, for the first time, an agreement unites all nations to decrease the impact of human activity on the environment and to adapt to climate changes that are currently underway. That is why we chose this specific event as a starting point of active work on the energy transition of the economy. We expect that after the conclusion of the Paris Agreement investors will gradually become less tolerant to even small industrial accidents, selling related stocks more aggressively in case of a disaster.

H8: The reaction of shareholders to industrial events strengthens with time.

Continuing the idea of a higher role of climate change agenda in the investment process, we tend to increase the time frame compared to the previous hypothesis and check if during the investigated period between 2000 and 2020 there is a negative time trend in CAAR after the industrial disasters as investors are becoming more sensitive to environmental problems[4].

Research Design and Data

In order to measure the shareholders' reaction to industrial disasters, we decided to apply the event study methodology, calculating the market model using the ordinary least square (OLS) method. This type of model assumes a stable linear relationship between *the market return* and *the individual stock return*:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t}, \quad (1)$$

where $R_{i,t}$ and $R_{m,t}$ are the returns of company i and the corresponding market index in period t.

We estimate the stock price reaction to various industrial accidents by calculating *cumulative average abnormal returns* (*CAAR*).

$$CAAR(t_1, t_2) = \sum_{t=t_1}^{t_2} AAR_t, \quad (2)$$

where *CAAR* is cumulative average abnormal return, *AAR* – average abnormal returns, t_1 – the first period of the event window and t_2 – the last period of the event window.

Using a *control variable* allows to check if there is a statistically significant difference in market reaction to an accident by adding a trend or/and a dummy identifying a specific period. Then, it is necessary to control for the country of listing of a responsible company and/or for a country and industry where the disaster happened (G. Capelle-Blancard and M. Laguna [15]). Table 1 shows the control variables and their effect on CAAR.

Based on the literature review and business news agencies, we formed a sample of 80 events of industrial disasters from 2000 to 2022. It is possible to divide the sample by industry: petroleum, chemical, mining, and energy. The event selection process is rather tough due to several reasons: the fact that the majority of oil spills happen with non-public companies that we cannot analyze due to the lack of data, and our exclusion of small oil spills (less than 1,000 tons) as this loss is not significant for big public companies and cannot greatly affect the stock price. Then we also excluded oil spills that occurred not due to a company's fault. We excluded such events because when the company is not guilty, there will be no fine after the disaster, moreover, the losses may be reimbursed by insurance, thus there should not be a great impact on stock price. According to these criteria, we selected 80 events around the world from 2000 to 2020.

The data for independent variables were gathered in the Bloomberg terminal. All financial metrics are taken as of December 31 of the year preceding the event in order to avoid the reverse causality problem. We checked all the variables for quadratic fit. Estimated CAAR [0;10] for the 80 events becomes a dependent variable in the regression. Based on the results, we decided to choose this event window out of the five windows examined before.

In the sample there are companies that are listed in many countries: the USA, Canada, the UK, France, Netherland, Spain, Germany, Japan, South Africa, Norway, China, Israel, Russia and Brazil. Some of them have a double listing. However, the majority of them originate in either North America (47.5%) or Europe (the EU, 26.3%) categories, which is why we added only two dummies to control for the county of listing. Oil spills account for 25% of the sample, chemical disasters for – 25%, and accidents in the mining industry for – 47.5%. To test our hypotheses, we use the following regression equation:

$$CAAR010_i = \beta_0 + \beta_1 MarketCap_i + \beta_2 CapexRevenue_i + \\ + \beta_3 RevenueGr_i + \beta_4 BVpershare_i + \beta_5 Leverage_i + \\ + \beta_6 ProfitMargin_i + \beta_7 Controls_i + \varepsilon_i, \quad (3)$$

where $CAAR010_i$ – Cumulative Average Abnormal Return [0;10], %; Market Cap – Market Capitalization, m USD; CapexRevenue – Capex to Revenue, %; RevenueGr – Revenue growth, %, BVpershare – Book Value per share, USD; Leverage – Total Debt to Total Assets, %; ProfitMargin –

[3] United Nations Climate Change. The Paris Agreement. URL: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[4] Ernst & Young. Why investors are putting sustainability at the top of the agenda. URL: https://www.ey.com/en_gl/power-utilities/why-investors-are-putting-sustainability-at-the-top-of-the-agenda

Net Income to Revenue, %; *Controls:* NorthAm – dummy variable: 1 – if a company is registered in the North America (the USA, Canada), 0 – otherwise; Europe (UK, France, Spain, Germany or Netherland) – dummy variable: 1 – if a company is registered in the EU, 0 – otherwise; OilSpill – dummy variable: 1 – if an event is an oil spill, 0 – otherwise; ChemicalDis – dummy variable: 1 – if an event is a chemical disaster, 0 – otherwise.

Table 2 shows the descriptive statistics for all variables.

Table 1. Summary of model inputs and expected results

	Source	Expected influence on CAAR
Financial metrics		
Market Capitalization	M. Khanna et al. [16]; G. Kaplanski and H. Levy [18]; G. Capelle-Blancard and M. Laguna [15]; O. Kowalewski and P. Spiewanowski [10]	Negative
Capex to Revenue	Not investigated yet	Positive
Revenue Growth	T. Huynh and Y. Xia [11]	Positive
BV per share	Not investigated yet. Inspired by T. Huynh and Y. Xia [11]	Positive
Leverage	G. Kaplanski and H. Levy [18]; O. Kowalewski and P. Spiewanowski [10]	Negative
Profitability	G. Kaplanski and H. Levy [18]; O. Kowalewski and P. Spiewanowski [10]; T. Huynh and Y. Xia [11]	Positive
Non-Financial variables		
Paris Agreement	Not investigated yet, inspired by G. Capelle-Blancard and M. Laguna [15]	Negative
Trend	G. Capelle-Blancard and M. Laguna [15]	Negative
Controls (countries and industries)	G. Capelle-Blancard and M. Laguna [15]; O. Kowalewski and P. Spiewanowski [10]	

Source: Authors' analysis.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CAAR [0;10]	80	–.82	8.66	–32.37	30.25
Market Capitalization	80	61234.92	92390.94	56.48	394611.00
Capex to Revenue	80	12.64	11.22	1.74	72.48
Revenue Growth	79	15.40	34.85	–57.90	146.39
BV per share	80	104.70	788.51	.05	7067.66
Leverage	80	23.26	12.33	3.47	58.31
Profit Margin	80	11.46	11.16	–18.53	42.63
North America	80	.48	.50	0	1
Europe	80	.26	.44	0	1
Oil Spill	80	.25	.44	0	1
Chemical Disaster	80	.25	.44	0	1

Source: Authors' calculations.

Results

Cumulative average abnormal return after disasters

In order to estimate CAAR by market approach, we gathered daily firms' stock prices and the corresponding market index prices. Then we calculated daily returns. Table 3 reveals the results of CAAR estimations for the events in oil industry with different event windows. For all the events in the sample, the event day is the first day of the environmental disaster whether the market reacted promptly or not. The majority of the events didn't have a statistically significant effect on companies' stock prices. The main reason is that the scale of a disaster has a strong influence on stock performance (G. Capelle-Blancard and M. Laguna [15]; O. Kowalewski and P. Spiewanowski [10]), and major industrial accidents do not happen that often. If we used only events with a strong market response, the sample would not be sufficient for comprehensive research.

Table 3. CAARs for oil spill events

Date	Security	CAAR [–10,10]	CAAR [0,2]	CAAR [0,5]	CAAR [0,10]	CAAR [0,20]
31/08/2005	Murphy Oil Corp.	–12.00% (0.1074)	0.21% (0.9412)	–1.98% (0.5417)	–6.93% (0.1617)	–7.96% (0.2843)
13/02/2006	Chevron Corp.	–8.69% (0.1040)	–2.46% (0.2328)	–1.05% (0.6941)	–3.59% (0.3219)	–6.35% (0.2357)
02/03/2006	BP	–1.24% (0.8750)	0.26% (0.7227)	0.26% (0.7917)	2.25% (0.4997)	3.61% (0.6850)
01/06/2006	Valero Energy Corp.	–3.69% (0.6841)	–1.41% (0.7097)	–4.78% (0.3935)	–3.21% (0.6461)	1.34% (0.9705)
01/08/2008	Royal Dutch Shell	–2.69% (0.1565)	–2.33% (0.1303)	–3.82% (0.2279)	–1.03% (0.1561)	6.87% (0.5095)
20/04/2010	BP	–11.47%* (0.0548)	–1.39% (0.7318)	–4.68% (0.1923)	–10.42%** (0.0325)	–12.98%*** (0.0681)
01/05/2010	ExxonMobil	–2.65% (0.6458)	–0.93% (0.5967)	0.14% (0.9584)	–2.47% (0.5344)	–3.80% (0.5031)
11/06/2010	Chevron Corp.	–3.92% (0.5127)	–1.50% (0.4962)	–1.48% (0.6390)	–5.21% (0.2194)	–3.03% (0.5715)
01/07/2011	ExxonMobil	0.76% (0.8864)	–0.67% (0.5401)	–0.21% (0.8559)	2.36% (0.5470)	–0.08% (0.9533)
29/04/2011	Plains All American Pipeline	–6.44% (0.3325)	–3.84% (0.1298)	–4.22% (0.2363)	–6.47% (0.1804)	–4.44% (0.4980)
21/12/2011	Royal Dutch Shell	2.01% (0.7524)	1.13% (0.9359)	2.50% (0.9154)	1.01% (0.9870)	–4.27% (0.3435)
30/03/2013	ExxonMobil	–3.77% (0.5376)	–0.74% (0.7852)	–1.50% (0.8834)	–3.86% (0.4270)	–4.80% (0.4517)
22/03/2014	Kirby Corp.	–6.62% (0.3840)	–2.64% (0.2699)	–4.17% (0.2710)	–6.31% (0.2393)	–4.21% (0.5801)
13/10/2014	Sunoco	–19.02%** (0.0282)	1.32% (0.6801)	9.34%** (0.0406)	–0.08% (0.9900)	–5.05% (0.5594)

Date	Security	CAAR [–10,10]	CAAR [0,2]	CAAR [0,5]	CAAR [0,10]	CAAR [0,20]
24/12/2014	Transneft	24.49%** (0.0000)	–3.61% (0.1160)	2.68% (0.6285)	12.16%*** (0.0002)	12.28% (0.0227)
16/11/2017	TransCanada Corp.	–0.34% (0.5191)	0.38% (0.7231)	–0.88% (0.1836)	–2.59% (0.7327)	–2.76% (0.5688)
29/10/2019	TransCanada Corp.	–1.58% (0.5191)	–0.39% (0.7231)	–2.50% (0.1836)	0.02% (0.7327)	–1.23% (0.5688)
29/05/2020	Nornickel	–3.97% (0.3163)	–1.71% (0.5999)	–10.61%** (0.0149)	–15.11%*** (0.0073)	–12.26%* (0.0954)
01/10/2021	Amplify Energy	7.15% (0.3163)	–37.51%*** (0.0001)	–30.43%** (0.0279)	–25.07% (0.1817)	–35.22% (0.1763)
27/12/2021	PBF Energy	27.05%* (0.0799)	2.74% (0.5828)	8.46% (0.2044)	30.25%*** (0.0069)	35.71%*** (0.0176)
15/01/2022	Repsol	7.07% (0.3163)	–0.75% (0.5999)	–3.87% (0.1849)	2.04% (0.6273)	5.67% (0.3354)

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: Authors' calculations.

Regression results

Estimated CAAR [0;10] for these 80 events becomes a dependent variable in the regression. Based on the results, we decided to choose this event window out of five previously tested windows (we have more statistically significant results using this event window) and literature review. Before interpreting the results, we run the tests and improved the quality of the model. According to Table 4, we can see that the majority of correlation coefficients are rather small. The highest correlation coefficients are –0.561 between Europe and North America and Chemical Disasters and Mining.

Table 4. Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) CAAR [0;10]	1.000											
(2) Market Capitalization	0.050	1.000										
(3) Capex to Revenue	–0.161	–0.202	1.000									
(4) Revenue Growth	0.054	0.120	–0.073	1.000								
(5) BV per share	0.170	–0.070	0.170	–0.098	1.000							
(6) Leverage	0.079	–0.548	0.204	–0.115	0.038	1.000						
(7) Profit Margin	–0.072	–0.124	0.376	–0.242	0.094	–0.032	1.000					
(8) North America	0.072	0.014	0.078	–0.104	–0.103	–0.032	0.063	1.000				
(9) Europe	0.173	0.292	–0.215	0.084	–0.064	–0.214	–0.197	–0.561	1.000			
(10) Oil Spill	–0.010	0.401	0.038	0.179	0.204	0.016	–0.100	0.229	–0.055	1.000		
(11) Chemical Disaster	0.261	0.153	–0.296	0.074	–0.066	–0.111	–0.281	–0.386	0.531	–0.328	1.000	
(12) Mining	–0.142	–0.448	0.175	–0.306	–0.112	0.104	0.405	0.138	–0.386	–0.542	–0.561	1.000

Source: Authors' calculations.

According to the VIF test, the values of Mining, Chemical Disasters and Oil Spill factors are rather high (above 6), so we decided to sequentially exclude each of these variables to check which specification will have the lowest mean VIF. Then we need to test our model for heteroskedasticity. According to the result of the White test, we cannot reject the null hypothesis about homoskedasticity because p-value is higher than 10%. That means that the least squares estimator is linear, unbiased, and has the smallest variance among all estimators. Also, the standard errors computed for the least squares are correctly estimated, so we can rely on estimated confidence intervals and test the hypotheses. Then in order to improve the quality of the model we decided to exclude studentized residuals below –2 and above 2. After the exclusion we can interpret the results of the statistically significant coefficients in regression (Table 5).

Table 5. Regressions' results

VARIABLES	(1) CAAR [0;10]	(2) CAAR [0;10]	(3) CAAR [0;10]
Market Capitalization	0.0000156	0.0000169	0.0000153
	(0.0000102)	(0.0000104)	(0.0000103)
Capex to Revenue	–0.174**	–0.155*	–0.181**
	(0.075)	(0.079)	(0.078)
Revenue Growth	0.025	0.019	0.026
	(0.022)	(0.023)	(0.023)
BV per share	0.00311***	0.00317***	0.00315***
	(0.000865)	(0.000872)	(0.000878)
Leverage	0.198**	0.219**	0.191**
	(0.0815)	(0.0866)	(0.0848)
Profit Margin	0.190**	0.182**	0.191**
	(0.0864)	(0.0873)	(0.0872)
North America	4.975***	4.872***	4.994***
	(1.772)	(1.785)	(1.786)
Europe	4.577**	4.395**	4.567**
	(2.102)	(2.125)	(2.118)
Oil Spill	–2.720	–3.105	–2.661
	(2.190)	(2.260)	(2.213)
Chemical Dis	4.511**	2.914	4.635**
	(1.992)	(2.956)	(2.041)
Trend		–0.0434	
		(0.0592)	
Paris Agreement			0.735
			(2.226)
Constant	–11.16***	–9.505**	–11.10***
	(3.048)	(3.805)	(3.075)
Observations	73	73	73
R-squared	0.378	0.383	0.379
Adjusted R-squared	0.278	0.272	0.267

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: Authors' calculations.

The Market Cap coefficient is not statistically significant so we cannot make any conclusions on the influence of a company's size on CAAR. We did not find any evidence that firm size is related to abnormal returns similar to the results of O. Kowalewski and P. Spiewanowski [10]. Thus, we can neither accept Hypothesis 1 *nor reject* it. Leverage is statistically significant at the 5% significance level: if Leverage increases by 10%, the CAAR increases by 1.98%, ceteris paribus. According to Corporate Finance theory, financial leverage increases a company's profit through the interest tax shield, and when the assets are purchased with the debt capital, they earn more than the cost of the debt that was used to finance them. Meanwhile, if the company does not have sufficient taxable income to shield or if its operating profits are below a critical value, financial leverage will reduce equity value and thus reduce company value, making it riskier. Thus, it seems that there are more companies in the sample with efficient financial leverage that give positive signals to shareholders. Based on our sample, we came to the opposite result (positive instead of negative relationship) than G. Kaplanski and H. Levy [18] and O. Kowalewski and P. Spiewanowski [10] in their research dedicated to aviation and mining industries. Hence, Hypothesis 2 about the negative influence of Leverage on CAAR *is rejected*. Profit margin also proved to be significant at the 5% significance level. The results correspond to our expectations: the influence on the dependent variable is positive. If the Profit Margin increases by 1%, it will lead, ceteris paribus, to a 0.19% increase in CAAR. That means that shareholders react less negatively to industrial accidents that happened through the fault of a more profitable company. We can suggest that the investors believe that more profitable companies can absorb the losses related to the accident more easily, and can thus show better financial performance after the industrial disaster than less profitable firms. The obtained result matches the results described in previous research of T. Huynh and Y. Xia [11], and O. Kowalewski and P. Spiewanowski [10]. We do *not reject* Hypothesis 3.

Revenue Growth does not have a statistically significant influence on CAAR. That means that in our sample the investors were indifferent to the previous growth pace of a company when they made a trading decision after the accident. On the one hand, a high growth pace can mean an active development of an already established company (new big clients, M&A etc.) that could help to absorb the losses from the accident by generating new cash flows. However, on the other hand, high growth pace might be explained by the low base effect: the initial revenue was too small, so even a slight increase in revenue in absolute terms leads to a relatively high Revenue Growth metric value. Hence, we can neither *accept* Hypothesis 4 nor reject it.

We proceed with BV per share. The coefficient is statistically significant at the 1% significance level, and the sign of the coefficient matches our expectations: an increase in net asset value makes the company less risky for investors, and the stock price drops less after an industrial disaster. Thus, we can conclude that financially healthy companies benefit from a less aggressive share price decline after an industrial accident as investors do not consider losses related to the accident crucial for the company's future performance. And even if losses are significant and a company cannot absorb them, valuable tangible assets (high BV per share as a proxy) can be strong collateral for rising debt capital to help the company to recover and to stimulate its performance. Hence, Hypothesis 5 *is not rejected*.

As for the influence of Capex to Revenue ratio on CAAR, it is proven to be negative, while we expected a positive relationship. Our logic was that the higher the investments in fixed assets, the smaller the effect on the stock price of an industrial disaster (a loss of a fixed asset in case of an accident is not very significant for a company that invests a lot in new equipment). The opposite effect might be explained as follows: the companies have a high Capex to Revenue ratio either if they invest a lot in capital expenditures or have relatively small Revenue. In the sample, many companies with a high Capex to Revenue ratio have negative revenue growth that can discourage investors more than relatively high investment in CAPEX. Moreover, if a company generates relatively high revenue and keeps investing in capital expenditures, the ratio will be rather small, despite investments that are large in absolute terms. Another explanation can be the sample specifics: around 40% of the sample consists of events with positive and/or insignificant CAAR [0;10], i.e., an industrial accident didn't influence the stock performance. That also can bias the obtained results. If we use only major events with strong market response, the sample would be very small (less than 20 observations). Thus, Hypotheses 6 *is rejected*.

Then we need to check the hypothesis about the change in shareholders' behavior related to an industrial disaster after the adoption of the Paris Agreement. We compare the events before 2016 (29% of the sample) and after (71%). According to the results presented in Table 6, the coefficient of the Paris Agreement is not significant, i.e., there is no statistically significant influence of the Paris Agreement on the market reaction to an industrial accident. That means that the market did not adjust its behavior despite the active promotion of the energy transition. Thus, Hypotheses 7 *is rejected*. Moreover, we come to the same conclusion based on the results of the trend test. The coefficient proved to be insignificant, which means that investors did not become more sensitive to environmental problems during the last 20 years despite the integration of climate risk disclosure in the investment process and green strategies at country level. Hypotheses 8 *is rejected*.

As for control variables, if a company from our sample is listed in North America (either the USA or Canada), ceteris paribus, the CAAR will be 4.98% higher at the 1% significance level. Unexpectedly listing in Europe has a positive influence on CAAR as well. That means that investors do not sell American/Canadian or European stocks after an industrial disaster as aggressively as those in other markets. In the case of Europe, it is unexpected because green legislation and energy transition play a very important role in these markets. Such a result might be explained

by the very recent progress in implementing green strategy in Europe, while the sample cover events from as early as 2000. As for the industry control variable, investors are less sensitive to industrial disasters in the chemical industry. It is explained by the specifics of the sample: the majority of the events in the chemical industry were minor, and CAARs were generally insignificant. Thus, there was no pronounced market reaction to the event.

Conclusion

We estimated the cumulative average abnormal return (CAAR) for the updated sample of 80 events and tested the influence of companies' financial metrics on the amplitude of their CAARs after industrial disasters. We estimated the CAAR in several event windows for all the events in the sample. Leverage, Profitability and BV per share proved to have a positive influence on CAAR, i.e., an industrial accident has a smaller effect on the stock performance of financially healthy companies with tax-efficient Debt to Equity ratio, relatively high profitability and a high share of valuable tangible assets. Higher Capex to Revenue ratio proved to have a negative influence on CAAR in our sample, i.e., it leads to a stronger market reaction. Such a result is explained by the nature of the ratio (if Revenue is high and investments in equipment are also elevated in absolute terms, the ratio will be rather small) and the bias of the sample. However, the effect of all independent variables on CAAR is rather negligible. Market capitalization and Revenue Growth do not influence investors' trading decisions after accidents. Moreover, based on our results, shareholders didn't change their attitude towards industrial disasters after the adoption of the Paris Agreement in 2015 and did not start reacting more strongly to industrial accidents since 2000 despite the promotion of green economy and energy transition strategies.

The obtained results depend a lot on the sample. The event selection process is rather tough due to several reasons: the majority of oil spills happen with non-public companies that we cannot analyze due to the lack of data; we also excluded small oil spills (less than 100,000 tons) as this loss is not significant for big public companies and cannot significantly affect the stock price. Then we also excluded oil spills that occurred not due to a company's fault (for instance, due to military actions: on 6 October 2002 the French double hull oil tanker was hit by explosives from a small craft in Yemen[5], or due to shooting: a man fired a bullet into the Trans-Alaska Pipeline in 2001)[6]. We excluded such events because when the company is not guilty, there will be no fine after the disaster, moreover, losses may be reimbursed by insurance, thus there should not be a great impact on stock price. According to these criteria, we selected 80 events around the world from 2000 to 2020 from various industries.

It is the most extensive sample of industrial disasters in petrochemical, mining, and energy industries over the course of twenty years. However, the sample still consists of events of different scale as major industrial disasters happen rarely and thus the number of observations would be very low. The CAARs after minor events proved to be positive and/or insignificant. As this accounts for almost half of the dependent variable values (mean CAAR value is –0.82%), it can also have an impact on the results of the models. Another limitation of the research is that we focused mostly on the effect of financial metrics, while the extent of damage and the number of casualties could influence stock performance after an accident as well. The main conclusion of the papers devoted to the stock performance after the industrial disasters is that the company's returns are not significantly affected by an event. In the context of the increasing importance of the green economic transformation, the authorities need to create a financial tool to stimulate investors to opt for clean energy projects and make brown production less attractive. Future research is needed to better understand the drivers of the market reaction to industrial disasters and find the economic incentives to strengthen this reaction.

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