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RESEARCH ARTICLE

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Stock price reactions to climate science information from the Intergovernmental Panel on Climate Change: A mitigation function of corporate and sector emissions responsibility?

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Abstract

This research investigates the influence of climate science information released by the Intergovernmental Panel on Climate Change (IPCC) on the European stock market, with a particular emphasis on differentiating the stock price reactions based on sector climate sensitivity and corporate emissions responsibility. Performing an event study on Stoxx Europe 600 constituents, we analyse stock price reactions to the sixth IPCC assessment report published between 2018 and 2023. Results show that climate-sensitive sectors respond more intensely to climate news. We find greater volatility in stock prices for climate-sensitive sectors than in corporate emissions-graded portfolios. Cumulative average abnormal returns range from 26.442% for the alternative energy sector to −6.416% for the construction sector. For the corporate emissions responsibility portfolios, we generally observe negative stock price reactions disregarding firms' level of emissions responsibility. Firms with higher emissions responsibility outperform peers only during the synthesis report release. Our study enriches the literature on stock price reactions to climate science news, which is limited to the analysis of the first five IPCC reports and to sector analyses.

KEYWORDS
climate risk, climate sensitivity, environmental responsibility, event study, IPCC, stock market reaction

1 | INTRODUCTION

In the era of post-Paris climate policy, assisting in the implementation of climate policy action has become a central function of scientific knowledge (Beck & Mahony, 2018). Governments are taking decisive steps to reduce carbon emissions, while shareholders' interest in understanding and incorporating climate factors into their investment decisions is rising (Engle et al., 2020; Krueger et al., 2020). This raises the question of whether the newest climate science information and the derived advice are causing investors to align their investments with a low-carbon transition. The substance of this research lies in answering whether and how the European stock market reacted to the sixth assessment report by the Intergovernmental Panel on Climate Change (IPCC).

Abbreviations: AR, abnormal return; CAR, cumulative abnormal return; CAAR, cumulative average abnormal return; EW, event window; GHG, global greenhouse gas; IPCC, Intergovernmental Panel on Climate Change; U.S., United States.

The IPCC is the United Nations body for assessing scientific knowledge on climate change (IPCC, 2022) with a mandate to provide 'policy relevant' but not 'policy prescriptive' information (Bjurström & Polk, 2011; IPCC, 2022). This makes the IPCC a credible source of information and an ideal research object to understand how scientifically rigorous climate information may affect financial markets. The sixth assessment report consists of six sub-reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks and options for adaptation and mitigation, followed by a synthesis report (IPCC, 2022). The publication of policy-relevant climate science signals the need for stricter climate regulations to governments, investors, firms and the public. Creating a common sense of urgency, this large-scale climatic information event may prompt inevitable policy responses. This might take the form of an abrupt and unanticipated increase in carbon prices or highly restrictive regulation (Ilhan et al., 2021).

Since the IPCC reports are a globally influential benchmark for climate science communication and might even prompt regulatory change, it appears plausible that their release would affect stock prices to some degree. However, it is uncertain whether investors could anticipate climate policy risk, and/or to which degree they would perceive the regulations to be detrimental to firms operating in carbon-intensive sectors or those with high emissions (Battiston et al., 2017). Investigating the effects of the IPCC's releases of reports might also help in better understanding regional and sector-specific implications. Veith et al. (2009), for example, reveal that climate policies might not create the desired effect in the sense that the European energy sector can pass on regulation-triggered costs to consumers. Moreover, Dai et al. (2021) and Ng et al. (2023) suggest that multinational firms can conceal their emissions by shifting their carbon-intensive activities to subsidiaries and suppliers operating in countries with weaker environmental regulations. While the extant research on the impact of new scientific environmental information on the stock market reveals significant investor reactions (Griffin et al., 2015; Rogova & Aprelkova, 2020), the research field is limited to sector analyses targeting the United States (U.S.) market. Considering the research findings by Birindelli et al. (2023) on stock price reactions to climate conferences, it is conceivable that investors reward companies within carbon-intensive sectors that demonstrate strong performance in emission reduction. Similarly, Schuster et al. (2023) find that increased transition risk can lead to market renumeration of firms with strong corporate environmental performance. Consequently, it is uncertain if the European market would react to the IPCC publications and, if the European market were to react, whether sector affiliation and individual performance play a significant role. To address this debate, we pose the following research question: *How does the European stock market react to climate science information, taking into account sectors' climate sensitivity and corporate emissions responsibility?*

Utilising event study methodology, this research examines stock price reactions to the sixth assessment report by the IPCC, which was published between 2018 and 2023. Based on the Stoxx Europe 600, the study analyses the significance of abnormal returns (ARs) using five event windows (EWs). Investor reactions are evaluated using two categories: first, according to whether the sample firms operate in climate-sensitive sectors, and second, according to their emissions responsibility, as measured via LSEG's (formerly named Refintiv) emissions score grading.

We find that the stock market reacted to all releases of the sixth assessment report. The findings reveal that new scientific information significantly impacts the stock valuation of firms, especially those in climate-sensitive sectors. Cumulative average abnormal returns (CAARs) range from 26.442% for the alternative energy sector to −6.416% for the construction sector for EW [−10, +10]. Since the publication of the fifth sub-report, issued shortly after the Russian invasion of Ukraine, firms operating in a low-emitting sector appear to be protected against climate risk. However, we find no clear trend in stock market reactions for carbon-intensive sectors. For the emissions responsibility portfolios, we observe negative stock price reactions disregarding firms' level of emissions responsibility. An outperformance of superior corporate emissions responsibility is only observable in the synthesis report. Potentially, the compressed character of the synthesis report results in investors perceiving the publication differently compared to the sub-reports. Overall, we observe a higher volatility of the CAARs for the climate-sensitive sector portfolios compared to the emissions score grade portfolios.

The study makes substantial contributions to research on the financial effects of scientific climate information. First, our finding of significant price reactions to the synthesis report contributes to research on market efficiency. Our results prove that already released information, published at a different time or with a different appearance, can still trigger stock price reactions. Second, previous literature extensively examined whether normative pressure by governments and regulatory authorities caused stock price reactions (e.g., Guo et al., 2020; Pham et al., 2019a). The findings of this study, however, prove that climate science can also have disciplining effects on the stock market. Third, this study initiates debate on a topic that has not yet been examined: the comparison of the mitigating roles of a firm's sector affiliation and its emissions commitment in the context of the impact of climate science information on stock valuation. Fourth, we extend knowledge about European stock price reactions to the IPCC releases.

For practitioners, this study reveals pivotal insights into which climate-sensitive sectors are affected by climate-related events and whether the market rewards superior corporate emissions responsibility. As corporate emissions responsibility only partially protects portfolios, we cannot provide reliable (trading) advice. Our results suggest that investors may need clearer guidance on how to identify green firms regardless of their sector affiliation. Policymakers should be aware of the polyvalent stock price reactions as the stock market recognises events that carry new information about climate change, and investors adjust their risk and growth expectations.

2 | LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

An investor reaction to the publication of the sixth IPCC assessment report can only be expected if investors assume global climate science information to signal legislative or non-legislative change. In terms of regulatory governance, previous research provides evidence that climate assessment reports can pave the way for the creation of environmental policies (Capelle-Blancard et al., 2021; Schütze et al., 2020). As the IPCC is the primary source for sound and authoritative international science, its climate science is routinely embraced by political actors at national and international levels (Howarth & Painter, 2016; Pascoe et al., 2019). Examples of IPCC's manifestation in global climate governance include resolutions of the Conferences of the Parties and the resultant 2015 Paris Agreement. In terms of non-legislative change, there is evidence that environmental news can be a significant driver of firms voluntarily strengthening their environmental strategy (Khanna, 2001; Maxwell et al., 2000).

Research in climate finance shows that scientific information that carries imminent climate risk can significantly influence investor behaviour. Numerous studies examining the effects of climate-related news on the stock market (e.g., Antoniuk & Leirvik, 2021; Hamilton, 1995; Klassen & McLaughlin, 1996; Pham et al., 2019b) find that information about increasing climate risk predominantly tends to cause negative stock price effects. However, the results further suggest that sophisticated corporate environmental management would lead to positive stock price effects. A considerable portion of research also focuses on the impacts of regulatory climate risk on the stock market, using various measures of carbon intensity or environmental proactivity as proxies for firm-level exposure to climate risks (Krueger et al., 2020). Recent studies have shown that environmental regulations tend to result in negative (positive) stock price reactions for carbon-intensive (low-emitting) firms (e.g., Guo et al., 2020; Pham et al., 2019a; Ramiah et al., 2015; Shen et al., 2023). Using event study methodology, Rogova and Aprelkova (2020) examine the effect of IPCC publications on U.S. stock prices. They find abnormal stock market reactions for various sectors, regardless of the sector's carbon intensity. Nevertheless, a stock market reaction to global climate science can only be expected if the associated climate risk has not yet been adequately priced into the stock market. Although there is growing empirical evidence that investors recognise climate risks as having profound financial implications (Krueger et al., 2020), investor attention to climate risks is a novel phenomenon (Giglio et al., 2021). As a result, a large proportion of investors underestimates or does not integrate climate risks into investment processes (Krueger et al., 2020; Stroebel & Wurgler, 2021). Consequently, stock markets appear inefficient in pricing climate change-induced systematic risk (Liesen, 2015). According to a report by the World Bank, only 20% of global greenhouse gas (GHG) emissions are priced at all, and less than 5% of these are currently priced at levels congruent with meeting the Paris Agreement targets (Ramstein et al., 2019). However, research suggests that climate hedge portfolios outperform in scenarios with adverse climate news (Engle et al., 2020; Giglio et al., 2021; Pástor et al., 2021).

The following observations may be drawn from the literature strands analysed above: First, research shows that climate science information can catalyse legislative and non-legislative change. Second, research on climate science news shows that investors react abnormally to news of increased climate risk and reward firms with a strong environmental performance. Third, climate change is not yet adequately priced into the stock market. Anticipating that investors perceive climate science information as a signal of increased climate risk and legislative and non-legislative change, we presume that investors responded to the releases by the IPCC.

Sectors with disproportionately high emissions are the most affected by regulatory interventions that aim at curbing emissions, such as emissions limits, cap-and-trade schemes or carbon taxes (Bolton & Kacperczyk, 2021; Ilhan et al., 2021; Venturini, 2022). A growing body of literature analyses high-carbon physical assets at risk of stranding (Bauer et al., 2016; Fleischman et al., 2013; Griffin et al., 2015; Meinshausen et al., 2009). The findings suggest that carbon-intensive firms are more exposed to climate risk and, thus, affected shareholders react negatively to environmental news such as climate policy announcements (Birindelli & Chiappini, 2021; Guo et al., 2020; Jiang & Luo, 2018), climate negotiations (Antoniuk & Leirvik, 2021; Pham et al., 2019b) or environmental science publications (Griffin et al., 2015). Following other researchers in the field of environmental news (Antoniuk & Leirvik, 2021; Pham et al., 2019b), we assume that the stock market shows a sector-by-sector reaction to climate science information. In this study, we limit the analysis of sectors to the following: transport, construction, utilities, fossil fuels and alternative energy. If investors revise their perceptions about climate risk after the IPCC announcements, they may buy low-carbon stocks and sell high-carbon ones, such that the former outperform the latter. Given that climate science news provided by the IPCC aims to pave the way for a low-carbon transition, carbon-intensive climate-sensitive sectors, such as transport, construction, utilities and fossil fuels, should be affected negatively by the IPCC's publications. In contrast, low-emitting climate-sensitive sectors, such as the alternative energy sector, are supposed to benefit from such events (Antoniuk & Leirvik, 2021).

Consequently, we hypothesise that investor reactions to the sixth IPCC report will differ among climate-sensitive sectors in the following way:

> **H1a.** The sixth IPCC report had a significant negative effect on the stock prices of firms belonging to a carbon-intensive sector.

> **H1b.** The sixth IPCC report had a significant positive effect on the stock prices of firms belonging to a low-emitting sector.

Figure 1 illustrates the proposed relationships.

Investors are increasingly tracking individual emissions of listed firms and forming coalitions, such as Climate Action 100+, to ensure that large corporate emitters curb their carbon emissions (Climate Action 100+, n.d.; Bolton & Kacperczyk, 2021). Previous research mainly documents a positive relationship between proactive corporate environmental responsibility and the creation of economic wealth (Jung et al., 2018; Nakao et al., 2007; Plumlee et al., 2015; Sharfman & Fernando, 2008). Demonstrated proactive awareness of carbon-related risks may signal economic resilience (Sharfman & Fernando, 2008), reduced information deficiency (Jung et al., 2018) and reduced probability of firm value penalties following announcements of environmentally harmful events (Flammer, 2013, Hossain et al., 2023). Another possible scenario may be that investors assume that environmentally responsible firms will be the first to comply with new regulatory requirements (Capelle-Blancard et al., 2021). Previous research confirms that firms with higher environmental commitment seem to be increasingly rewarded by investors (Konar & Cohen, 2001; Menguc & Ozanne, 2005). As a low level of corporate emissions may be rewarded in response to increasing climate risk, particularly during climate risk-related events, we hypothesise the following investor reaction:

H2a. The sixth IPCC report had a significant positive effect on the stock prices of firms with superior emissions responsibility.

H2b. The sixth IPCC report had no significant effect on the stock prices of firms with ordinary emissions responsibility.

H2c. The sixth IPCC report had a significant negative effect on the stock prices of firms with substandard emissions responsibility.

Figure 2 presents a visual representation of the proposed hypotheses.

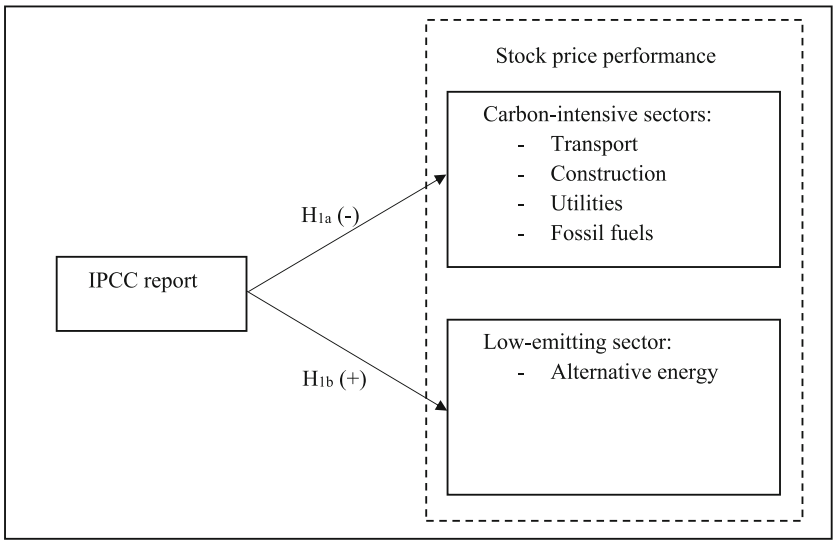

FIGURE 1 Stock price reaction based on climate-sensitive sector affiliation. Figure 1 depicts the hypothesised influence of IPCC publications on the investigated climate-sensitive sectors, separated according to carbon intensity.

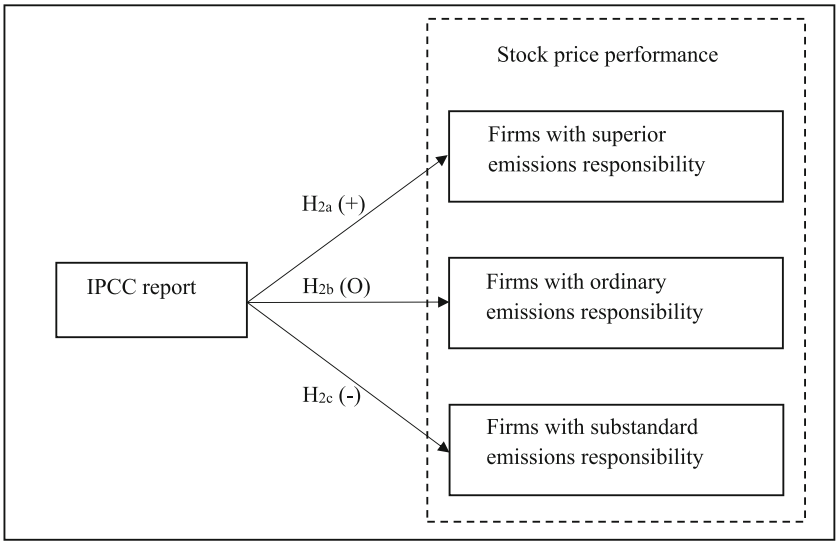

FIGURE 2 Stock price reaction based on corporate emissions responsibility. Figure 2 depicts the hypothesised influence of IPCC publications on firms based on corporate emissions responsibility.

TABLE 1 Reports on the sixth IPCC assessment cycle.

Publishing date	Report
8 October 2018	Special Report—Global Warming of 1.5°C
8 August 2019	Special Report—Climate Change and Land
25 September 2019	Special Report—The Ocean and Cryosphere in a Changing Climate
9 August 2021	The Physical Science Basis
28 February 2022	Impacts, Adaptation and Vulnerability
4 April 2022	Mitigation of Climate Change
20 March 2023	Synthesis Report

Note: Table 1 depicts the list of reports that were published within the sixth IPCC assessment cycle (IPCC, n.d.). The publishing dates of the reports are used as announcement dates for each corresponding event.

3 | RESEARCH DESIGN

3.1 | Event study methodology

Fama (1991) proposes that the cleanest evidence of investor reaction to new information comes from event studies. Event study methodology is a standard method for measuring stock price effects of specific economic events in economics, finance and accounting research (Binder, 1998; MacKinlay, 1997). In this paper, we apply the event study methodology proposed by MacKinlay (1997) and accordingly (1) define events and EWs, (2) estimate normal returns, (3) calculate ARs and (4) test the sample for statistical significance.

As a first step, we limit this study to the sub-reports and synthesis report published within the sixth IPCC assessment cycle. The dates and titles of each report are listed in Table 1.

We include five EWs to ensure the robustness of our results. Two EWs are used to capture short-term effects ([0, +1]; [−1, +1]) (McWilliams & Siegel, 1997), one to capture long-term effects [−10, +10] (Bouzzine & Lueg, 2020), one to capture potential information leakages [−10, −1] (Bouzzine & Lueg, 2020; McWilliams & Siegel, 1997) and another to capture potential lagged effects [+1, +10] (Bouzzine & Lueg, 2020).

Second, we compute normal returns, defined as the expected returns if the event had not occurred (MacKinlay, 1997). To calculate the normal returns, we use the market model,[1] which assumes a linear relationship between the security and the market return (Brown & Warner, 1980; MacKinlay, 1997):

$$E(R_{it}) = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$
$$E(\varepsilon_{it} = 0),\ var(\varepsilon_{it}) = \sigma^2_{\varepsilon_i}, \quad (1)$$

where $E(R_{it})$ represents the expected return on security i on day t; R_{mt} the return on the market portfolio; α_i the alpha as the mean return over the period not explained by the market; β_i the beta of firm i; and ε_{it} the zero mean disturbance term. Model coefficients are estimated from the estimation window, which, as proposed by MacKinlay (1997), ranges from −120 to −21 days preceding the first IPCC sub-report. The estimation window of the first sub-report is also used for the analysis of the following sub-reports. By doing this, we prevent the inclusion of sub-reports in estimation windows of subsequent events, which could otherwise bias the results. To apply the market model, we run an ordinary least squares regression[2] with daily stock returns for each firm i, R_{it}, on the market return, R_{mt}, which is proxied by the Stoxx Europe 600. Third, we calculate the AR for each firm i, which is defined as the residual between expected normal and actual stock return at time t (MacKinlay, 1997):

$$AR_{it} = E(R_{it}) - R_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}) \quad (2)$$

where AR_{it} represents the AR of i on day t. Next, ARs need to be aggregated to obtain statistical inferences to evaluate the events' impact. We accumulate the ARs for each firm i to produce cumulative abnormal returns (CARs) with t_1, t_2 referring to the EW thresholds:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{it}, \quad (3)$$

Fourth, given both distributions of ARs and CARs, the null hypothesis H_0 can be tested (MacKinlay, 1997). To test the statistical significance of the CARs, we perform a two-sided t-test following Curran and Moran (2007). The parametric test examines H_0 by assuming that the CARs are zero:

$$\theta_t = \frac{CAR_t}{\sqrt{var(CAR_t)}\sqrt{n}} \sim N(0,1), \quad (4)$$

where n is the number of days in the respective EW. To evaluate the average effect of the six IPCC sub-reports on the sample's sector and emissions grade portfolios, we compute the mean of the firms' CARs (Kothari & Warner, 2007), the CAAR:

$$CAAR_t = \frac{1}{N}\sum_{i=1}^{N} CAR_t, \quad (5)$$

where N represents the number of firms in each portfolio. We consider each portfolio as an individual security as we focus on evaluating the CAAR at the end of each EW.

[1] Recognising that the market model may be prone to industry biases, especially for small portfolios like the climate-sensitive sector portfolios, we adhere to Gong's (2009) and MacKinlay's (1997) recommendation to employ a multifactor model. Consequently, as a robustness check mitigating the potential correlation of abnormal returns due to industry commonality, we additionally use the three-factor model by Fama and French (1992) to calculate normal returns for the sector portfolios.

[2] According to Lee and Varela (1997), the use of ordinary least squares models, such as the market and three-factor model estimations, is the most appropriate choice in event studies.

To assure the robustness of our findings, we perform the non-parametric Wilcoxon signed-rank test, which caters to non-normality by accounting for both the sign and magnitude of ARs (Wilcoxon, 1992).

3.2 | Data collection and portrayal

To conduct the event study, data from the six IPCC sub-reports and the synthesis report were hand-collected from the IPCC's website (see Table 1). The publishing dates of the reports were used as the announcement dates for each corresponding event. The sample is based on firms from the Stoxx Europe 600. As the firms included exhibit a high level of market capitalisation, salient market visibility can be ensured. Data about daily stock returns were extracted from the Thomson Reuters DataStream. We used the total return index as it provides stock returns adjusted for dividends, tax effects and brokerage fees. Firms that did not provide stock price information for the defined estimation window and EWs were excluded. Following Dyckman et al. (1984), we screened for confounding macroeconomic events via news research. Additionally, we checked for confounding events at the firm level for small portfolios ($N \leq 15$ firms) using the Thomson Reuters Newsticker. Confounding events at the firm level could be the declaration of dividends, the announcement of an impending merger or the announcement of unexpected earnings (McWilliams & Siegel, 1997). Firms with such confounding events were excluded from the portfolios of the respective EW.

In line with Antoniuk and Leirvik (2021), we assume that stock price reactions to climate science news depend on carbon sensitivity, measured via climate-sensitive sectors. To incorporate sector-specific information, we limited this study to the following five sectors: transport, construction, utilities, fossil fuels and alternative energy. While the first four sectors belong to carbon-intensive sectors, the latter represents a low-emitting sector. Thereby, we follow Battiston et al. (2017), who identified climate-sensitive sectors based on their GHG emissions, their role in the energy supply chain and the existence of climate policies. The FTSE Industry Classification Benchmark was used to assign all sample firms to the appropriate subsectors of specific climate-sensitive sectors.

We selected LSEG's emissions score grade as a proxy for firms' emission responsibility. The grade measures a company's commitment to and effectiveness in reducing environmental emissions (LSEG, 2022). The score is a weekly updated, forward-looking assessment of 135 data points related to a firm's emissions responsibility in terms of policies (e.g., adoption of ambitious emissions reduction targets), monitoring (e.g., active monitoring of emissions reduction) and evolution of key performance indicators (e.g., CO_2 equivalent emissions) (LSEG, 2022). If no information has (yet) been published on specific data points, firms receive a score of zero for the respective point. The raw data points can be updated by LSEG a posteriori for the last 5 years (LSEG, 2022). LSEG uses a percentile rank scoring methodology to calculate the emissions score, which is then converted into a grade from A to D. Scores for all data points are calculated by relating a firm's performance to peer performance. After deriving percentile scores at a data point level, they are summed up at the firm level and further compiled as category scores (LSEG, 2022). Following Birindelli and Chiappini (2021), we define grade 'A' as a 'high score', 'B' as a 'medium score' and 'C' and 'D' as a 'low score'.

4 | RESULTS

4.1 | H_{1a}–H_{1b}: Stock price reactions of climate-sensitive sectors

Table 2 displays the event study results for the climate-sensitive sector portfolios grouped according to the examined EWs and IPCC sub-reports.

For the first special report in the IPCC's sixth assessment cycle (8 October 2018), a report focusing on global warming of 1.5°C above pre-industrial levels, a clear sector-specific reaction can be observed. While we see insignificant results for the transport, utilities and alternative energy sectors, investors in the construction and fossil fuel sectors reacted abnormally to the sub-reports publication. As expected, we observed significant abnormal stock losses for the construction sector for almost all EWs, with CAARs amounting to −6.416% for the long-term EW [−10, +10]. Contrary to our assumption, positive stock market reactions for almost all EWs were observed for the fossil fuel sector, with the strongest response (CAAR: 4.729%) in the anticipation EW [−10, −1].

The second sub-report (8 August 2019), on climate change and land, is more devoted to scientific reporting on desertification, land degradation and food security and less to the adoption of mitigation opportunities. For this sub-report, we report significant negative stock market reactions for the sectors fossil fuels and transport.

The third special report, on the ocean and cryosphere (25 September 2019), reveals mixed results. While we observe significant negative stock market reactions for transport and construction, the utilities sector is affected positively in the anticipation EW [−10, −1] with CAARs amounting to 2.306%. The third sub-report does not provide climate adaptation plans for the infrastructure of utilities, thus being less harmful than expected for the utilities sector.

For the fourth IPCC sub-report on the physical science basis of climate change (9 August 2021), we find significant stock market reactions for all sectors except alternative energy. While we mainly obtain significant negative CAARs for the construction and fossil fuel sectors, we report significant positive stock market reactions for the transport and utilities sectors. CAARs amount to 7.843% for utilities in the short-term EW [−1, +1] and 2.206% for transport in the lagged effect EW [+1, +10].

The fifth IPCC sub-report on impacts, adaptation and vulnerability (28 February 2022) appears to be a relevant watershed for investors' expectations regarding the transition to a low-carbon economy. Following its release, we see significant positive stock market reactions for all sectors except for transport which yields insignificant results. In line with the hypothesis development, notably highly significant

TABLE 2 CAARs for climate-sensitive sector portfolios.

		Anticipation EW [−10, −1]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018							
Transport	13	−3.219%	0.177	0.221	−3.102%	0.213	0.311
Construction	24	−1.389%	0.133	0.068	−0.901%	0.344	0.290
Utilities	29	−0.801%	0.216	0.157	−1.062%	0.120	0.078
Fossil fuels	16	4.729%**	0.000	0.002	5.024%**	0.000	0.001
Alternative energy	2	7.144%	0.713	0.655	7.952%	0.683	0.655
Special Report on Climate Change and Land: 08.08.2019							
Transport	12	0.545%	0.583	0.583	−1.511%	0.125	0.136
Construction	24	−1.124%	0.335	0.511	−3.133%**	0.010	0.009
Utilities	29	0.821%	0.406	0.035	−0.647%	0.504	0.820
Fossil fuels	16	−2.087%	0.068	0.098	−4.484%**	0.002	0.004
Alternative energy	2	−5.309	0.391	0.180	−5.080%	0.244	0.180
Special Report on the Ocean and Cryosphere: 25.09.2019							
Transport	13	−3.040%**	0.002	0.009	−2.436%**	0.005	0.013
Construction	24	−1.107%	0.114	0.103	−0.466%	0.498	0.424
Utilities	29	2.306%**	0.000	0.001	3.025%**	0.000	0.000
Fossil fuels	16	−1.264%	0.293	0.501	−0.517%	0.630	0.877
Alternative energy	3	6.652%	0.223	0.109	6.661%	0.191	0.109
The Physical Science Basis of Climate Change: 09.08.2021							
Transport	12	−1.541%	0.263	0.239	−0.987%	0.439	0.480
Construction	24	−1.037%	0.142	0.046	−0.393%	0.524	0.3313
Utilities	29	−1.355%*	0.040	0.050	−0.601%	0.332	0.538
Fossil fuels	16	0.463%	0.691	0.163	0.592%	0.589	0.255
Alternative energy	2	−8.137%	0.620	0.655	−9.181%	0.609	0.655
Impacts, Adaption and Vulnerability: 28.02.2022							
Transport	11	−2.487%	0.157	0.131	−3.722%	0.077	0.091
Construction	24	−1.988%	0.066	0.081	−3.174%*	0.011	0.022
Utilities	29	3.096%**	0.003	0.008	1.530%	0.281	0.127
Fossil fuels	16	−0.316%	0.846	0.642	−1.203%	0.474	0.959
Alternative energy	3	11.227%	0.097	0.109	11.407%*	0.047	0.109
Mitigation of Climate Change: 04.04.2022							
Transport	13	−4.446%	0.068	0.087	−3.979%	0.088	0.101
Construction	24	−4.169%**	0.000	0.000	−3.549%**	0.001	0.001
Utilities	29	1.433%	0.096	0.068	2.120%*	0.011	0.007
Fossil fuels	16	5.681%**	0.000	0.001	5.525%**	0.000	0.001
Alternative energy	3	−9.548%	0.181	0.109	−9.931%	0.192	0.109
Synthesis Report: 20.03.2023							
Transport	13	−0.228%	0.886	0.753	−2.949%	0.087	0.101
Construction	24	−1.211%	0.111	0.170	−3.886%**	0.000	0.000

TABLE 2 (Continued)

		Anticipation EW [−10, −1]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Utilities	29	1.244%	0.113	0.133	−1.080%	0.228	0.247
Fossil fuels	18	−4.919%**	0.000	0.003	−7.019%**	0.000	0.000
Alternative energy	2	−8.683%	0.425	0.180	−7.291%	0.287	0.180
		Short-term EW [0, +1]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018							
Transport	13	0.198%	0.748	0.507	−0.349%	0.547	0.701
Construction	24	−0.896%*	0.025	0.035	−1.281%**	0.005	0.002
Utilities	29	0.403%	0.198	0.020	−0.444%	0.209	0.325
Fossil fuels	16	1.235*	0.001	0.001	0.502%	0.155	0.211
Alternative energy	3	−1.456%	0.672	1.000	−1.440%	0.652	1.000
Special Report on Climate Change and Land: 08.08.2019							
Transport	13	0.008%	0.991	0.701	0.079%	0.921	0.972
Construction	24	−0.066%	0.818	0.909	0.011%	0.971	0.932
Utilities	29	−0.797%	0.054	0.112	−0.882%*	0.027	0.039
Fossil fuels	16	−0.327%	0.365	0.278	−0.008%	0.982	0.796
Alternative energy	3	−0.379%	0.791	0.593	−0.364%	0.821	1.000
Special Report on the Ocean and Cryosphere: 25.09.2019							
Transport	13	0.182%	0.470	0.553	0.315%	0.343	0.345
Construction	24	−0.587%	0.112	0.110	−0.329%	0.381	0.441
Utilities	29	0.268%	0.464	0.112	−0.045%	0.900	0.689
Fossil fuels	16	−1.157%	0.094	0.098	−0.748%	0.222	0.408
Alternative energy	3	−2.891%	0.120	0.109	−2.423%	0.130	0.109
The Physical Science Basis of Climate Change: 09.08.2021							
Transport	13	−0.609%	0.166	0.173	−0.259%	0.561	0.553
Construction	24	−0.120%	0.664	0.627	0.231%	0.397	0.441
Utilities	29	7.177%**	0.004	0.003	1.043%**	0.000	0.000
Fossil fuels	16	−0.428%*	0.028	0.044	0.084%	0.650	0.717
Alternative energy	3	0.595%	0.671	0.593	0.757%	0.567	0.593
Impacts, Adaption and Vulnerability: 28.02.2022							
Transport	13	−0.597%	0.493	0.382	0.060%	0.947	0.916
Construction	24	−0.153%	0.792	0.607	0.419%	0.512	0.199
Utilities	29	5.742%	0.566	0.358	1.437%	0.170	0.074
Fossil fuels	16	3.582%*	0.043	0.063	5.189%**	0.006	0.013
Alternative energy	3	12.975%*	0.012	0.109	14.220%*	0.010	0.109
Mitigation of Climate Change: 04.04.2022							
Transport	13	−3.994%**	0.000	0.002	−2.828%**	0.006	0.009
Construction	24	−2.416%**	0.000	0.001	−1.273%*	0.024	0.032
Utilities	29	1.578%**	0.008	0.010	2.471%**	0.000	0.000
Fossil fuels	16	−1.730%**	0.002	0.002	0.454%	0.281	0.255
Alternative energy	3	4.742%*	0.036	0.109	5.807%*	0.025	0.109

(Continues)

TABLE 2 (Continued)

		Short-term EW [0, +1]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Synthesis Report: 20.03.2023							
Transport	13	0.924%	0.106	0.133	0.418%	0.531	0.650
Construction	24	1.347%**	0.000	0.001	0.665%	0.073	0.110
Utilities	29	0.496%	0.151	0.191	−0.221%	0.542	0.393
Fossil fuels	18	0.571%	0.193	0.078	−0.730%	0.155	0.130
Alternative energy	2	2.421%	0.104	0.180	1.123%	0.249	0.180
		Short-term EW [−1, +1]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018							
Transport	13	0.166%	0.812	0.753	−0.742%	0.344	0.311
Construction	24	−0.857%	0.067	0.072	−1.562%**	0.006	0.003
Utilities	29	0.580%	0.312	0.015	−0.621	0.301	0.567
Fossil fuels	16	0.837%	0.085	0.148	−0.368%	0.457	0.605
Alternative energy	3	−3.202%	0.389	0.285	−3.252%	0.335	0.285
Special Report on Climate Change and Land: 08.08.2019							
Transport	13	0.222%	0.802	0.701	0.164%	0.871	0.807
Construction	24	−0.081%	0.856	0.819	−0.142%	0.775	0.710
Utilities	29	−0.579%	0.301	0.552	−0.887%	0.106	0.170
Fossil fuels	16	−1.866%**	0.000	0.001	−1.483%**	0.002	0.003
Alternative energy	3	−0.703%	0.161	0.109	−0.712%	0.181	0.109
Special Report on the Ocean and Cryosphere: 25.09.2019							
Transport	13	−0.031%	0.961	0.807	0.062%	0.928	0.861
Construction	24	−0.803%*	0.023	0.010	−0.614%	0.087	0.068
Utilities	29	0.943%*	0.044	0.017	0.661%	0.164	0.074
Fossil fuels	16	−1.846%	0.082	0.088	−1.395%	0.157	0.196
Alternative energy	3	−0.682%	0.526	0.285	−0.281%	0.771	0.593
The Physical Science Basis of Climate Change: 09.08.2021							
Transport	13	−0.357%	0.518	0.507	0.223%	0.675	0.972
Construction	24	−0.592%*	0.023	0.037	0.092%	0.710	0.842
Utilities	29	7.834%**	0.008	0.005	1.110%%**	0.000	0.000
Fossil fuels	16	0.066%	0.828	0.756	0.784%*	0.030	0.030
Alternative energy	3	3.147%	0.275	0.109	3.597%	0.194	0.109
Impacts, Adaption and Vulnerability: 28.02.2022							
Transport	13	0.011%	0.992	0.917	1.332%	0.234	0.311
Construction	24	0.281%	0.561	0.511	1.436%**	0.007	0.012
Utilities	29	2.961%**	0.007	0.004	4.464%**	0.000	0.002
Fossil fuels	16	1.588%	0.336	0.301	4.047%*	0.014	0.026
Alternative energy	3	14.672%*	0.031	0.109	15.606%*	0.027	0.109
Mitigation of Climate Change: 04.04.2022							
Transport	13	−4.982%**	0.000	0.002	−3.519%**	0.001	0.005
Construction	24	−2.789%**	0.000	0.000	−1.326%*	0.019	0.009
Utilities	29	0.954%	0.142	0.214	2.108%**	0.002	0.003

TABLE 2 (Continued)

		Short-term EW [−1, +1]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Fossil fuels	16	−1.559%*	0.027	0.006	0.926%	0.074	0.056
Alternative energy	3	5.877%*	0.020	0.109	7.020%*	0.017	0.109
Synthesis Report: 20.03.2023							
Transport	13	1.015%	0.089	0.101	0.087%	0.886	0.946
Construction	24	0.834%*	0.016	0.024	−0.269%	0.404	0.199
Utilities	29	−0.716%	0.121	0.043	−1.677%**	0.001	0.001
Fossil fuels	18	1.642%**	0.002	0.004	−0.163%	0.753	0.913
Alternative energy	2	0.453%	0.787	0.655	−0.833%	0.701	0.655
		Lagged EW [+1, +10]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018							
Transport	12	1.001%	0.538	0.388	−0.225	0.888	0.875
Construction	24	−4.764%**	0.000	0.001	−5.878%**	0.000	0.000
Utilities	29	0.661%	0.393	0.370	−0.797	0.278	0.336
Fossil fuels	16	−1.520%	0.101	0.088	−3.150%**	0.005	0.003
Alternative energy	3	1.979%	0.688	1.000	1.914%	0.656	0.593
Special Report on Climate Change and Land: 08.08.2019							
Transport	11	−1.950%*	0.018	0.041	−1.559%	0.046	0.062
Construction	24	−1.233%	0.247	0.346	−0.585%	0.581	0.819
Utilities	29	−0.808%	0.147	0.170	−0.468%	0.386	0.456
Fossil fuels	16	−1.036%	0.316	0.278	−0.466%	0.668	0.501
Alternative energy	2	−5.039%	0.200	0.178	−4.761%	0.278	0.180
Special Report on the Ocean and Cryosphere: 25.09.2019							
Transport	13	−0.076%	0.925	0.972	−1.095%	0.198	0.279
Construction	24	0.064%	0.955	0.954	−0.846%	0.460	0.346
Utilities	29	0.353%	0.581	0.315	−0.432%	0.505	0.888
Fossil fuels	16	−0.235%	0.744	0.959	−1.393%	0.096	0.088
Alternative energy	3	−8.960%	0.079	0.109	−9.441%	0.060	0.108
The Physical Science Basis of Climate Change: 09.08.2021							
Transport	13	2.206%*	0.048	0.039	2.752%	0.019	0.028
Construction	24	0.551%	0.531	0.648	1.093%	0.222	0.087
Utilities	29	3.089%**	0.000	0.000	3.937%**	0.000	0.000
Fossil fuels	16	−1.844%*	0.018	0.034	−1.285%	0.061	0.070
Alternative energy	1	3.373%	0.439	0.317	3.903%	0.858	0.317
Impacts, Adaption and Vulnerability: 28.02.2022							
Transport	13	2.940%	0.056	0.101	3.350%*	0.031	0.023
Construction	24	3.889%**	0.001	0.001	4.663%**	0.000	0.000
Utilities	29	−2.050%	0.071	0.043	−1.817%	0.107	0.039
Fossil fuels	16	5.957%**	0.000	0.001	6.087%**	0.000	0.001
Alternative energy	3	−0.881%	0.809	0.593	0.186%	0.948	1.000
Mitigation of Climate Change: 04.04.2022							
Transport	13	3.518%	0.142	0.087	3.397%	0.119	0.101

(Continues)

TABLE 2 (Continued)

		Lagged EW [+1, +10]					
		Market model			3-factor model		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Construction	24	−0.038%	0.963	0.977	0.210%	0.793	0.607
Utilities	29	1.822%*	0.026	0.048	1.570%*	0.046	0.071
Fossil fuels	16	4.878%**	0.000	0.001	3.969%**	0.000	0.001
Alternative energy	3	0.653%	0.317	0.285	0.265%	0.833	1.000
Synthesis Report: 20.03.2023							
Transport	10	−2,520%	0.221	0.386	−3.083%	0.109	0.114
Construction	24	−1.904%*	0.012	0.001	−2.898%**	0.000	0.001
Utilities	29	0.099%	0.878	0.642	−0.697%	0.302	0.456
Fossil fuels	18	2.424%	0.057	0.043	1.120%	0.347	0.420
Alternative energy	2	3.208%	0.479	0.180	−5.052%	0.298	0.180
		Long-term EW [−10, +10]					
		Market model			**3-factor model**		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018							
Transport	12	−3.000%	0.275	0.480	−4.386%	0.140	0.239
Construction	24	−6.416%**	0.000	0.000	−7.319%**	0.000	0.000
Utilities	29	0.103%	0.919	0.482	−2.153%*	0.036	0.027
Fossil fuels	16	3.347%*	0.032	0.039	1.539%	0.245	0.326
Alternative energy	2	8.452%	0.505	0.655	9.752%	0.502	0.655
Special Report on Climate Change and Land: 08.08.2019							
Transport	10	−1.135%	0.497	0.647	−2.272%	0.178	0.169
Construction	24	−2.102%	0.157	0.253	−3.135%*	0.034	0.072
Utilities	29	−0.654%	0.644	0.496	−1.658%	0.248	0.642
Fossil fuels	16	−3.273%	0.054	0.026	−4.482%*	0.013	0.015
Alternative energy	1	−11.173%	0.553	0.317	−9.542%	0.538	0.317
Special Report on the Ocean and Cryosphere: 25.09.2019							
Transport	13	−3.131%*	0.017	0.023	−3.512%*	0.011	0.016
Construction	24	−1.705%	0.197	0.162	−1.833%	0.174	0.137
Utilities	29	1.773%	0.140	0.078	1.479%	0.213	0.139
Fossil fuels	16	−2.093%	0.272	0.301	−2.416%	0.201	0.234
Alternative energy	3	−4.296%	0.178	0.109	−4.416%	0.156	0.109
The Physical Science Basis of Climate Change: 09.08.2021							
Transport	12	−0.013%	0.994	0.875	1.077%	0.560	0.480
Construction	24	−0.799%	0.513	0.170	0.476%	0.678	0.607
Utilities	29	2.343%*	0.018	0.021	4.018%**	0.000	0.000
Fossil fuels	16	−2.217%	0.200	0.605	−1.237%	0.418	0.959
Alternative energy	0	/	/	/	/	/	/
Impacts, Adaption and Vulnerability: 28.02.2022							
Transport	11	0.261%	0.918	0.859	0.169%	0.949	0.929
Construction	24	1.899%	0.208	0.331	2.116%	0.201	0.209
Utilities	29	3.923%	0.103	0.039	3.690%	0.129	0.053
Fossil fuels	16	5.870%*	0.032	0.039	6.588%*	0.017	0.025
Alternative energy	3	26.442%**	0.004	0.109	28.267%**	0.005	0.109

TABLE 2 (Continued)

		Long-term EW [−10, +10]					
		Market model			3-factor model		
Mitigation of Climate Change: 04.04.2022							
Transport	13	−0.272%	0.504	0.345	−1.744%	0.641	0.507
Construction	24	−4.781%**	0.002	0.001	−3.324%*	0.018	0.009
Utilities	29	3.116%*	0.030	0.043	4.099%**	0.003	0.005
Fossil fuels	16	9.257%**	0.000	0.000	9.354%**	0.000	0.000
Alternative energy	3	−10.229%	0.077	0.109	−10.547%	0.102	0.109
Synthesis Report: 20.03.2023							
Transport	10	−2.990%	0.366	0.445	−6.020%	0.086	0.114
Construction	24	−2.586%*	0.032	0.046	−6.797%**	0.000	0.000
Utilities	29	2.201%*	0.043	0.050	−1.510%	0.223	0.417
Fossil fuels	18	−2.633%	0.107	0.102	−6.808%**	0.001	0.002
Alternative energy	2	−10.113%	0.490	0.180	−11.082%	0.301	0.180

Note: Table 2 shows CAARs sorted by estimation model on the last trading day of each EW. We draw the average from individual CARs of *N* firms and perform the parametric two-sided *t*-test and the nonparametric Wilcoxon signed-rank test. The *p*-values are listed in this table. If the significance levels differ between the two tests, we rely on the parametric *t*-test to indicate the significance level. The direction and significance of results based on the estimations using the market model and the three-factor model are predominantly in line. In case of differences, we rely on the results yielded via the market model.

*Statistical significance at 5% level.

**Statistical significance at 1% level.

positive stock market reactions can be observed for the alternative energy sector, with CAARs amounting to 26.442% for the long-term EW [−10, +10]. Contrary to expectations, we also observe significant positive stock market reactions for the construction (CAAR: 3.889%) and the fossil fuel sectors (CAAR: 5.957%) for the lagged effect EW [+1, +10]. Stock market reactions for the utilities sector amount to 3.096%% for the anticipation EW [−10, −1].

The sixth IPCC sub-report on the mitigation of climate change (4 April 2022), in turn, reveals a mixed pattern. We report significant stock losses for the transport and construction sectors for various EWs. The sector utilities shows positive stock market reactions for the short-term EW [0, +1], the lagged EW and the long-term EW. Mixed results can be observed for the fossil fuel sector, with significant positive results for the anticipation, lagged effect and long-term EWs and negative results for the short-term EWs. In line with our expectations, we report significant positive results for the alternative energy sector for the two short-term EWs.

The synthesis report (20 March 2023) draws together the key messages from sub-reports 1 to 6 and provides guidelines for policymakers (IPCC, 2023). Regarding this report, we obtain significant effects only for the construction, utilities and fossil fuel sectors. While we find mixed CAAR directions for the construction and fossil fuel sectors depending on the EW, the utilities sector faced a positive market effect in the long-term EW (CAAR: 2.201%). The strongest effect, of −4.919%, is observable for fossil fuel firms in the anticipation period.

Figure 3 displays a summary of results based on the number of significant stock price reactions. The transport and construction sectors, for which negative stock price reactions were anticipated, mainly react in line with the expectations. For both sectors, only few positive outliers are observable. Contrary to our expectations, we report mainly positive results for the utilities sector and mixed results for the fossil fuel sector. Potentially, firms operating in the utilities sector have been protected due to a lack of climate adaptation plans for the utilities sector's infrastructure in the respective sub-reports. The partially positive stock market reactions for the fossil fuel sector might have been triggered by the fact that some energy firms operating in the fossil fuel sector are diversified and own alternative energy sources. The alternative energy sector only yields positive stock price reactions. However, it was only rewarded after the fifth sub-report, which was published shortly after the Russian invasion of Ukraine. Thereby, a general congruence with Rogova and Aprelkova's (2020) findings can be observed as various sectors, regardless of their carbon intensity, react abnormally to IPCC announcements. Concluding, H_{1a} is only confirmed for the sectors transport and construction since we report predominately negative stock price reactions. For the utilities and fossil fuels sectors, H_{1a} must be rejected, given the predominance of positive over negative stock price reactions. H_{1b} is confirmed, as indicated by exclusively positive stock price reactions in the alternative energy sector.

4.2 | H_{2a}–H_{2c}: Mitigating effect of firms' emissions responsibility

Table 3 displays the event study results for the emissions responsibility portfolios grouped according to the examined EWs and IPCC sub-reports.

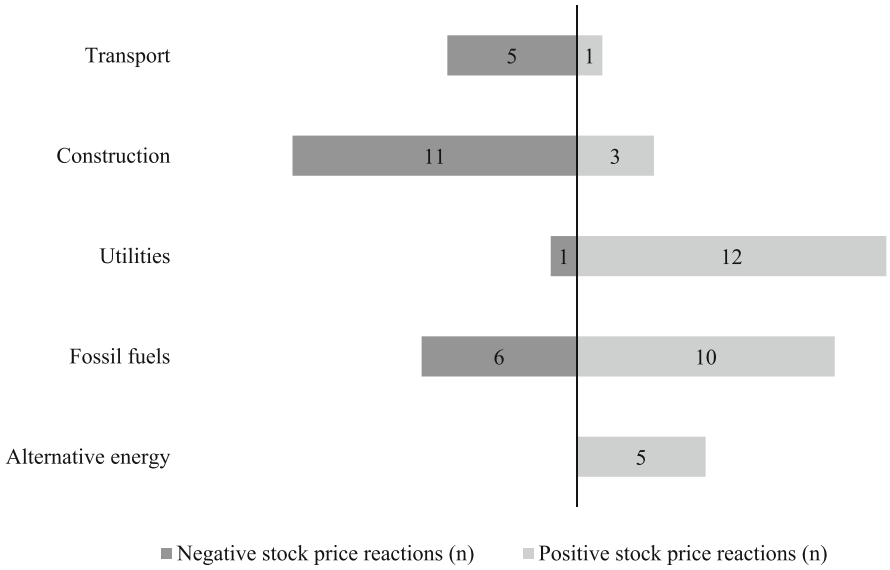

FIGURE 3 Aggregated stock price reactions grouped by sectors. Figure 3 shows the aggregated statistically significant stock price reactions, based on the market model estimation, according to sector portfolios across all events and EWs. Statistically significant negative CAARs are listed as negative stock price reactions. Statistically significant positive CAARs are listed as positive stock price reactions.

For the first IPCC sub-report in the sixth assessment cycle (8 October 2018), we report significant negative stock price reactions across the whole sample, indicating that new climate science information impacts the stock market. However, investors do not assume high emissions responsibility to be a driver of outperformance.

The following three sub-reports (8 August 2019; 25 September 2019; 9 August 2021) elicit only isolated stock price reactions with significant abnormal stock losses regardless of grade affiliation. We report the strongest stock price reaction for the fourth sub-report for low-scoring firms, with CAARs amounting to −0.895% for the EW [−1, +1].

Unexpectedly, the IPCC's fifth sub-report (28 February 2022) caused significant positive stock market reactions for low-scoring firms.

For the sixth sub-report (4 April 2022), no statistically significant results can be observed.

The synthesis report (20 March 2023) indicates an outperformance of firms with superior emissions score grades. In the majority of EWs, the stock market effects are negative. Only for the short-term EW [0, +1], we observe positive stock market reactions. Regardless of the effect direction, we derive the pattern that the better the emissions score grade, the better the stock performance.

Figure 4 displays a summary of results based on the number of significant stock price reactions. Overall, we observe a strong market penalisation of all firms disregarding their emissions responsibility. The findings oppose the general assumption that environmentally responsible firms would be positively affected by climate science shocks. For reports 1 to 6, we cannot identify any clear trend in investment preferences regarding emissions score grading. On the contrary, and in line with our expectation, the synthesis report reveals an investment preference towards less-polluting firms. While the synthesis report aligns with prior research that has found that climate-related events reward environmentally responsible firms and penalise environmentally harmful firms (Heflin & Wallace, 2017; Patten & Nance, 1998), the findings of sub-reports 1 to 6 do not indicate that investors attach relevance to superior emissions score grades. Consequently, H_{2a}, which hypothesises positive effects of the IPPC releases on stocks of firms with superior emissions responsibility, must be rejected. H_{2b}, hypothesising insignificant effects on stock prices with ordinary emissions responsibility, is rejected due to the presence of multiple statistically significant stock price reactions for firms with ordinary emissions responsibility (Table 3). H_{2c} is confirmed as we report predominately negative stock price reactions for firms with substandard emissions responsibility.

5 | DISCUSSION

5.1 | Synthesis

This study aims to answer the research question: *How does the European stock market react to climate science information, taking into account sectors' climate sensitivity and corporate emissions responsibility?* We conducted an event study capturing stock market reactions to the sixth assessment report published by the IPCC. We divided the sample into portfolios of climate-sensitive sectors and corporate emissions responsibility. This paper provides evidence that new climate science information diffused by the IPCC affects European stock market valuations. We observe statistically significant stock market reactions to each report published as part of the sixth IPCC assessment cycle, the negative effects being more common than positive effects.

Our results reveal that the climate-sensitive portfolios are more affected than the corporate emissions responsibility portfolios. We observe a higher stock price volatility for the climate-sensitive sector portfolios than the emissions-grade portfolios. Contradicting previous research, we find no evidence of stringent stock market penalisation of carbon-intensive sectors (Bolton & Kacperczyk, 2021). While the transport and construction sectors experience mainly negative stock

TABLE 3 CAARs for corporate emissions responsibility portfolios.

	Anticipation EW [−10, −1]				Short-term EW [0, +1]		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018							
High score	276	−1.525%**	0.000	0.000	−0.241%	0.054	0.403
Medium score	144	−1.515%**	0.000	0.000	−0.578%**	0.001	0.006
Low score	145	−1.593%**	0.000	0.000	−1.171%**	0.000	0.000
Special Report on Climate Change and Land: 08.08.2019							
High score	313	−0.350%	0.108	0.325	−0.138%	0.091	0.737
Medium score	139	−0.111%	0.075	0.176	0.031%	0.316	0.645
Low score	145	0.362%	0.172	0.175	0.004%	0.849	0.185
Special Report on the Ocean and Cryosphere: 25.09.2019							
High score	313	−0.684%**	0.000	0.000	−0.004%	0.960	0.013
Medium score	123	0.015%	0.646	0.650	−0.096%	0.324	0.650
Low score	56	0.029%	0.679	0.660	0.000%	0.986	0.660
The Physical Science Basis of Climate Change: 09.08.2021							
High score	309	−0.006%	0.909	0.373	−0.001%	0.968	0.375
Medium score	123	0.337%	0.135	0.606	0.081%	0.301	0.688
Low score	56	−0.754%	0.303	0.538	−0.221%	0.446	0.193
Impacts, Adaption and Vulnerability: 28.02.2022							
High score	312	−0.021%	0.762	0.369	−0.066%	0.298	0.132
Medium score	123	−0.069%	0.840	0.435	0.282%	0.126	0.206
Low score	56	−0.550%	0.266	0.264	1.509%**	0.004	0.002
Mitigation of Climate Change: 04.04.2022							
High score	312	0.002%	0.969	0.372	−0.026%	0.221	0.133
Medium score	123	−0.279%	0.239	0.634	0.033%	0.761	0.993
Low score	56	−0.890%	0.332	0.314	0.209%	0.673	0.951
Synthesis Report: 20.03.2023							
High score	368	−2.540%**	0.000	0.000	0.799%**	0.000	0.000
Medium score	141	−2.665%**	0.000	0.000	0.612%**	0.008	0.002
Low score	65	−3.141%**	0.000	0.001	0.733%*	0.025	0.003
	Short-term EW [−1, +1]				**Lagged EW [+1, +10]**		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018							
High score	276	−0.378%*	0.012	0.104	−0.986%**	0.003	0.002
Medium score	144	−0.185%**	0.000	0.001	−1.046%*	0.012	0.011
Low score	145	−1.477%**	0.000	0.000	−0.900%	0.077	0.043
Special Report on Climate Change and Land: 08.08.2019							
High score	313	−0.111%	0.333	0.945	−0.803%**	0.000	0.000
Medium score	139	0.030%	0.292	0.641	−0.023%	0.455	0.184
Low score	145	0.016%	0.622	0.182	−0.035%	0.476	0.185
Special Report on the Ocean and Cryosphere: 25.09.2019							
High score	313	−0.104%	0.323	0.519	0.017%	0.909	0.462
Medium score	123	−0.093%	0.323	0.650	−0.096%	0.284	0.645
Low score	56	−0.039%	0.076	0.175	−0.017%	0.691	0.182
The Physical Science Basis of Climate Change: 09.08.2021							
High score	309	0.004%	0.843	0.763	−0.014%	0.795	0.759
Medium score	123	0.050%	0.589	0.458	0.065%	0.732	0.719
Low score	56	−0.895%*	0.019	0.016	−0.459%	0.486	0.280

(Continues)

TABLE 3 (Continued)

	Short-term EW [−1, +1]				Lagged EW [+1, +10]		
	N	CAAR	*T*-test	Wilcoxon	CAAR	*T*-test	Wilcoxon
Impacts, Adaption and Vulnerability: 28.02.2022							
High score	312	−0.071%	0.165	0.358	0.022%	0.727	0.772
Medium score	123	0.361%	0.076	0.106	0.286%	0.125	0.020
Low score	56	1.455%**	0.009	0.008	0.944%	0.068	0.192
Mitigation of Climate Change: 04.04.2022							
High score	312	−0.037%	0.120	0.356	0.060%	0.118	0.130
Medium score	123	−0.057%	0.610	0.664	0.016%	0.956	0.701
Low score	56	0.283%	0.662	0.990	−1.807%	0.110	0.169
Synthesis Report: 20.03.2023							
High score	368	0.239%	0.228	0.002	0.285%	0.204	0.516
Medium score	141	−0.152%	0.506	0.963	−1.161%*	0.032	0.120
Low score	65	0.113%	0.739	0.365	−1.358%*	0.027	0.025

	Long-term EW [−10, +10]			
	N	CAAR	*T*-test	Wilcoxon
Special Report on Global Warming: 08.10.2018				
High score	276	−2.661%**	0.000	0.000
Medium score	144	−2.991%**	0.000	0.000
Low score	145	−3.095%**	0.000	0.000
Special Report on Climate Change and Land: 08.08.2019				
High score	313	−1.118%**	0.000	0.001
Medium score	139	−0.075%	0.272	0.182
Low score	145	0.334%	0.135	0.025
Special Report on the Ocean and Cryosphere: 25.09.2019				
High score	313	−0.671%**	0.008	0.016
Medium score	123	−0.087%	0.389	0.645
Low score	56	0.025%	0.803	0.660
The Physical Science Basis of Climate Change: 09.08.2021				
High score	309	−0.026%	0.743	0.134
Medium score	123	0.484%	0.164	0.619
Low score	56	−1.439%	0.229	0.155
Impacts, Adaption and Vulnerability: 28.02.2022				
High score	312	−0.030%	0.790	0.370
Medium score	123	0.511%	0.241	0.423
Low score	56	1.919%	0.053	0.129
Mitigation of Climate Change: 04.04.2022				
High score	312	0.054%	0.395	0.366
Medium score	123	−0.197%	0.645	0.789
Low score	56	−2.248%	0.142	0.097
Synthesis Report: 20.03.2023				
High score	368	−2.134%**	0.000	0.000
Medium score	141	−3.654%**	0.000	0.000
Low score	65	−4.239%**	0.000	0.001

Note: Table 3 shows CAARs on the last trading day of each EW. We draw the average from individual CARs of *N* firms and perform the parametric two-sided *t*-test and the nonparametric Wilcoxon signed-rank test. The *p*-values are listed in this table. If the significance levels differ between the two tests, we rely on the parametric *t*-test to indicate the significance level.

*Statistical significance at 5% level.

**Statistical significance at 1% level.

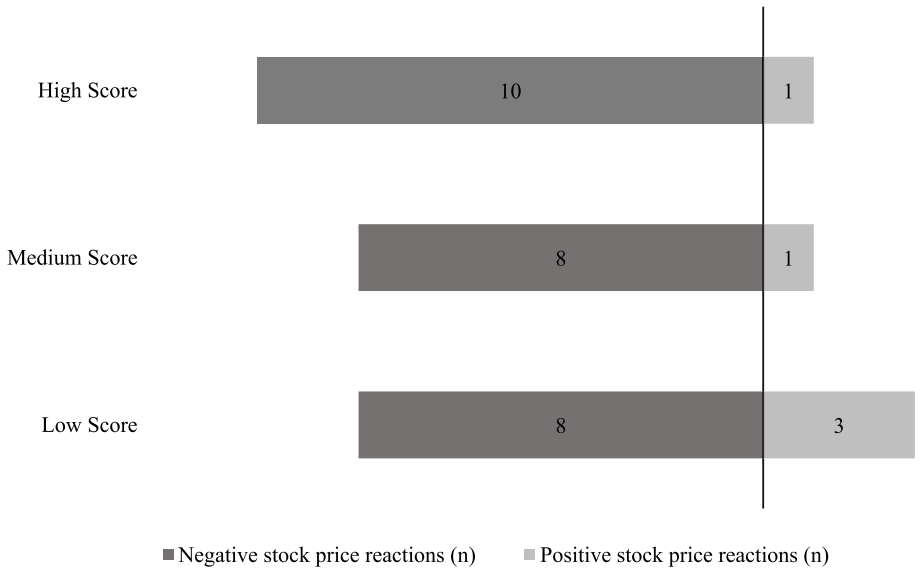

FIGURE 4 Aggregated stock price reactions grouped by corporate emissions responsibility. Figure 4 shows the aggregated statistically significant stock price reactions, based on the market model estimation, according to corporate emissions responsibility portfolios across all events and EWs. Statistically significant negative CAARs are listed as negative stock price reactions. Statistically significant positive CAARs are listed as positive stock price reactions.

price reactions, utilities and fossil fuels firms yield mixed to positive stock price reactions. For the alternative energy sector, the results show a tendency of positive wealth effects for this sector. However, when looking at the alternative energy sector, it is observable that market remuneration only occurred after the fifth sub-report, which was published shortly after the Russian invasion of Ukraine. This finding may indicate that the invasion acted as an accelerator for the renewable energy market. Our study, therefore, aligns with the findings by Umar et al. (2022) that alternative energy markets reacted positively to the war. Regarding the results of our emissions responsibility clustering, this study substantiates previous research that has found that firms' environmental commitment does not offer reliable protection against climate risk (Birindelli & Chiappini, 2021). Overall, we observe a strong market penalisation of firms disregarding their emissions responsibility. The remuneration of superior grading by investors is only observable for the final (i.e. synthesis) report. This change in investor behaviour may be rooted in the report's higher visibility and higher relevance for policymaking.

5.2 | Research contributions

The findings of this research provide four central research contributions in areas that have received little academic attention so far.

First, our research contributes to the knowledge about the efficient market hypothesis proposed by Fama (1991). According to the underlying market efficiency, investors should react immediately to events if they are associated with new and relevant information (Fama, 1980, 1991). The IPCC synthesis report is a summary of the previously published sub-reports. Our findings provide statistical evidence that investors also react to information from the synthesis report. Although only providing a summary of previous information, the synthesis report seems to still be perceived as relevant by investors. The reason for this might lie in higher visibility of the report, its compressed character being more accessible for investors or investors' expectations regarding the likelihood of this report triggering changes in environmental policies. Consequently, we contribute to research by showing that investor reactions are not only caused by new information. Surrounding circumstances, such as visibility, comprehensibility and appearance may play a role in whether and how investors react to the information.

Second, current academic research on climate risks tends to predominantly address whether and how normative pressure by governments and regulatory authorities affect the stock market (Bouzzine, 2021). This study highlights that, despite its non-binding nature, climate science news can also have disciplining effects on the stock market. Therewith, we follow the pioneering papers of Laplante and Lanoie (1994) and Klassen and McLaughlin (1996), who analyse broad samples of negative and positive environmental news.

Third, this study initiates debate on a topic that has not yet been examined: the comparison of the mitigating roles of a firm's environmental commitment and its sector affiliation in the context of the impact of climate science information on stock valuation. Our results suggest that sector affiliation seems to play a more decisive role in stock market reactions than corporate emissions responsibility. Interestingly, we document an investor preference for firms with superior emissions score grades only for the final, that is, the synthesis, report. One potential reason for this difference in investor reaction may be that the synthesis report serves as the current basis for climate change mitigation for policymaking. For this kind of publication, investors may rather refer to firms' abilities and attitudes towards reducing emissions. Since the grade given by LSEG measures a company's commitment to and effectiveness in reducing emissions, it might be considered important by investors in this context.

Fourth, this study focuses on a geographical region that has not been studied previously in terms of market responses to IPCC announcements and that has demonstrated a growing commitment towards climate change risks. The prior study investigating stock

market responses to IPCC reports by Rogova and Aprelkova (2020) assesses the U.S. stock market. The European Union has proven its commitment to climate action through an ambitious regulatory agenda backed by political support for targeting climate change and environmental degradation (Ziegler et al., 2011). Furthermore, the awareness and acceptance of environmentalism and climate change are commonly affirmed to be lower in the U.S. compared to Europe (e.g., Ciocirlan & Pettersson, 2012; Leonhardt, 2014). Choi and Luo (2021) find that carbon intensity has a stronger negative impact on firm value in countries with more stringent environmental regulations. Moreover, Reboredo and Ugolini (2022) provide evidence that European stocks are more sensitive to climate transition risks than U.S. ones. Thus, climate-related news should have a bigger effect in Europe. Our results on reactions based on sector affiliation show a general congruence with Rogova and Aprelkova's (2020) findings, as abnormal reactions to the IPCC reports can be observed for various sectors. In line with Rogova and Aprelkova (2020), we find no evidence of stringent market penalisation of carbon-intensive sectors. However, we do find that the European stock market has tended to remunerate low-emitting sectors since the Russian invasion of Ukraine.

5.3 | Practical contributions

Investors may benefit from this research as it reveals central insights into which climate-sensitive sectors are affected by climate science news and whether the market rewards superior corporate emissions responsibility. Relying on LSEG's superior emissions score grades does not seem to be a reliable investment strategy. Instead, investors should consider climate-sensitive sectors in their risk management, especially considering the spillover effect of the war in Ukraine on the energy market.

The insights from this research may be relevant for policymakers. We report stock market reactions to each investigated IPCC publication. Thus, policymakers can take away from our study that the stock market recognises non-binding events that carry new climate information, and investors are likely to price in both climate risks and expectations. Moreover, we provide evidence that the IPCC is effective in pushing investors towards stocks from greener industries. Therefore, we find that the capital market can serve as a functioning mechanism to support climate transition. This insight may be transferrable to stock market reactions to the introduction of new environmental regulations. However, investor preferences for firms with superior emissions responsibility are not observable for the six sub-reports. It is possible that investors do not rely on existing rating providers' grading of green investments and, therefore, turn to the classification of sustainability based on sector affiliation. Considering the inconsistent remuneration of firms with higher emissions responsibility, we would like to highlight that green investing lacks a rigorous definition in terms of global warming concerns. Since green firms in high-polluting industries are also relevant for successful climate transition, investors need a credible and unambiguous guideline by policymakers for how to invest in firms with high emissions score grades.

5.4 | Limitations and future research agenda

The findings of this study are subject to the following limitations and are accompanied by suggestions for future research.

First, we would like to emphasise that we only use two metrics of environmental emission performance: a selection of climate-sensitive sectors and LSEG's emissions score grade. Although the sectors analysed represent a consciously decided selection, future research may expand the scope of sectors. In particular, key financial sectors (e.g., banks, insurers, asset managers and pension funds) might be of high interest since these are directly affected by regulations imposed by supervisory authorities such as the European Banking Authority. While the emissions score grade represents a distinctive subcategory of LSEG's environmental performance grade, little is known about the salience, credibility and legitimacy ascribed to it by investors. Furthermore, the data provider LSEG has been criticised for its approach of ongoing input data rewriting, handling of lacking data and methodology changes (Berg et al., 2021; Sahin et al., 2022). Specifically, Berg et al. (2021) document the rewriting of the variable Scope 1 carbon emissions, which is an input variable that also feeds into the emissions score grading used in this paper. We suggest future research to investigate more metrics as proxies for corporate environmental performance.

Second, several information leakages have occurred before public releases (Hartz, 2022). In August 2021, for example, while the public was still reacting to the release of the sub-report on the physical science basis, the activist scientist group 'Scientist Rebellion' leaked segments of the sub-report on the mitigation of climate change before intergovernmental approval had been given (Hartz, 2022). The activists are not the first source to leak IPCC material. The organisation has been subject to leaks across multiple assessment cycles (e.g., Harvey, 2021; Hickman, 2012; King, 2013). However, our findings provide evidence that investors were not able to fully grasp the potential climate risk implications for their portfolios right from the outset.

Finally, we would like to highlight events coinciding with the publication of two sub-reports. The publication of the synthesis report overlapped with major uncertainty in the financial markets due to information on the liquidity shortage of the bank Credit Suisse (The Economist, 2023). Further, the fifth sub-report was published shortly after the invasion of Ukraine on 24 February 2022, which may have led to differences in the results. As a change of investor preferences has been observable since this date, it would be of great interest to extend this research to analyse stock market reactions to succeeding IPCC reports. As the climate crisis narrative drives the politicisation and responsibilities of scientists, future research on upcoming IPCC releases may serve to answer the question of whether the IPCC gains more scientific credibility and public trust over time.

5.5 | Conclusion

In response to the Paris Agreement, efforts to mobilise climate science to assist political decision-making have become increasingly frequent. This study provides evidence that climate science information has a signalling effect on the European stock market. Our results challenge the assumption that building portfolios upon superior corporate emissions responsibility is a reliable protection against climate risks. According to our findings, the alternative energy sector might represent an effective hedging opportunity against climate risk.

CONFLICT OF INTEREST STATEMENT

All authors declare that they have no conflict of interest.

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