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IOP Publishing Environ. Res. Lett. 16 (2021) 123005 https://doi.org/10.1088/1748-9326/ac3c6e

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OPEN ACCESS

RECEIVED
18 May 2021

REVISED
19 November 2021

ACCEPTED FOR PUBLICATION
23 November 2021

PUBLISHED
14 December 2021

TOPICAL REVIEW

Shareholders and the environment: a review of four decades of academic research

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Keywords: CSR, industrial accidents, public disclosure, lawsuits, ESG news, policy, event study

Abstract

We provide a synthesis of four decades of empirical research regarding the reaction of shareholders to environmental events. This literature is at the crossroads of finance, environmental economics, management and corporate social responsibility (CSR). To set the stage, we first provide an account of the Brumadinho ecological disaster that occurred in Brazil on January 25th, 2019. Second, we provide a critical review of more than 100 event studies. These papers cover a diverse set of events, such as industrial accidents, public disclosure programs, legal actions following environmental violations, changes in environmental regulation, environmental news, and corporate initiatives. This review makes four contributions. First is the synthesis of a large strand of literature in a structured setting, so as to be readily handled by both experts and non-experts. Second is the observation that stock market penalties in the event of environmental concerns are likely to be quite low: on average there is a (temporary) drop in the excess stock market return to events that are harmful to the environment of about 2% and the median is −0.6%. Third is to highlight the limits of CSR as a business strategy towards a sustainable society. Fourth is to provide an open access bibliographic database.

1. Introduction

Over the last four decades, environmental policy and regulation underwent a complete revolution under the aegis of environmental economists. The paradigm shift has consisted of '*harnessing market forces to protect the environment*', to use the title of a 1989 report (Stavins 1989). The origin of this report was a bipartisan initiative from the US Congress entitled Project 88, which gathered 50 people from academia, industry, government and environmental non-governmental organizations (NGOs), and was directed by Robert Stavins. The ambition was '*to find innovative solutions to major environmental (…) problems*' (Stavins 1989, p 5); Cropper and Oates (1992) consider this moment as '*the most exciting time (—and perhaps a critical juncture—in the evolution of economic incentives for environmental protection*' (p 676). Not only does this seminal report warn against climate change with a strikingly visionary perspective, it also paves the way '*towards a new area*' of environmental policies based on market-oriented instruments: '*Although conventional regulatory policies have often worked well, they have also tended to pit economics and environmental goals against each other. These goals should complement one another in the long run*' (Stavins 1989, p 34). This report was not the first to highlight the potential of market incentives, but until then, these ideas were mostly confined to academics. The report was embraced by most decision-makers. In its wake, Thomas Tietenberg summarized the policy context as follows: '*The change in attitude has been triggered by a recognition that this former adversary, the market, can be turned into a powerful ally*' (Tietenberg 1990, p 17). He made this view the pillar of his textbook on natural resource and environmental economics that has been used to train legions of

students around the world (Tietenberg and Lewis 2018).

More than 30 years later, these ideas still play a major role in environmental protection policies[4]. In addition, the debate continues. In a column published in 2019 targeted at young climate activists, Daron Acemoglu uses precisely the same argument: '*Markets need not stand in our way. On the contrary, they could be a powerful ally*' (Acemoglou 2019). Actually, it is striking to see this debate reappear, whereas it seemed settled for good. In this regard, Joseph Stiglitz provides a meaningful snapshot of the issues at stake. He argues that between 1989 and 2019 we went from '*The End of History*' to '*An Age of Discontent*' (Stiglitz 2019). Indeed, after the initial promising experiences, there was disappointment regarding the capacity of markets to address environmental problems and to ensure social welfare. For Stiglitz, it is no longer a question of markets being the solution to environmental problems, but of environmental problems helping us to become aware of the problems posed by free markets: '*If the 2008 financial crisis failed to make us realize that unfettered markets do not work, the climate crisis certainly should*' (Stiglitz 2019). Moreover, it should be noted that the reference to the financial crisis is anything but trivial; it has reinforced distrust of anything that might look like market's control over society (Zingales 2015). At this stage, it is important to note that most environmental economists who advocate market-based instruments are anything but blind supporters of free markets. It is quite the opposite, since the idea is to use market schemes to address market failures. Along the same lines, discontent about the market does not mean that markets should be abolished: '*We need to exploit the benefits of markets while taming their excesses, making sure that markets work for people, and not the other way around*' (Stiglitz 2019).

The aim of this paper is to question the place and the role of financial markets today in the framing of environmental policy. This requires a better understanding of the relationship between shareholders and the natural environment. Many current environmental policies are based on Pigouvian taxes (a tax aimed at the producer of polluting products) or tradeable permits, without necessarily having a direct link with financial markets. These instruments already are well investigated (see Bergquist et al 2013, Schmalensee and Stavins 2019, Aldy et al 2020). In contrast, despite there being numerous studies regarding the financial markets' response to environmental events, there is no generally accepted understanding of the reaction of shareholders, the owners of the companies' stock, to these events. Therefore, we feel it timely and important to consolidate this research, to specify the underlying mechanisms, and to provide a meaningful interpretation of the results. In this regard, we review four decades of academic research devoted to the reaction of shareholders to environmental news. Be aware that our study is not a conventional meta-analysis as we want to provide an assessment of how and why academic research in this specific arena did develop over the course of four decades. Thus, ours is a synthesis of the literature and not a meta-analysis.

To set the stage, we start with an account of the Brumadinho ecological disaster of January 25, 2019. The rupture of a Brazilian mining dam, operated by the multinational company Vale, resulted in the death of hundreds of people and the pollution of an immense territory. The example illustrates the problematic relationship between environment, firms and shareholders. It highlights the limits of the voluntary approach to environmental protection, as well as how financial markets actually value environmental damage. Next, we detail the relationship between environmental events and the response from shareholders. To this extent, we focus on event studies, which are highly homogeneous in terms of their methodology (Salinger 1992, MacKinlay 1997, Kothari and Warner 2006). We compose a narrative of the empirical literature based on event studies to assess the impact of environmental events on firms' stock market value. We document more than 100 papers over a period of four decades. Here, the aim is to explore whether it is wise to entrust financial markets with the responsibility of disciplining companies for their environmental performance. We highlight three streams in the evolution of academic research: accidents, regulation, and social responsibility. The streams cannot be clearly differentiated from one each other, but the focus of attention shifts in each of them. The first stream of studies accompanies the occurrence of several dramatic industrial accidents. These studies sit in the finance literature driven by the efficient market hypothesis (EMH), which assumes that all new information is immediately reflected in asset prices. They provide a first estimate of the losses incurred by shareholders. Most of the literature from the 1980s can be grouped in this stream. In the second stream, it is predominantly environmental economists that contribute to and in fact take over the analysis of the potential impact of environment incidents. They propose to use market forces to incentivize firms to protect the environment. This literature suggests that the traditional 'command-and-control' instruments should be complemented by market-based incentives when public disclosure is warranted. Hence, it is up to the shareholders to sanction firms, instead of public authorities. The law and economics literature shows

[4] Examples include the US Environmental Protection Agency (www.epa.gov/environmental-economics/economic-incentives), the OECD (www.oecd.org/gov/regulatory-policy/35260489.pdf), the United Nations (https://unep.ch/etb/publications/EconInst/econInstruOppChnaFin.pdf) or the European Commission (https://ec.europa.eu/environment/pubs/pdf/Incentives_Ecorys.pdf).

that in some cases market penalties may be higher than fines. Most of the studies in this stream appear in the 1990s. The third stream takes off in the new millennium. Now, the focus is more business-oriented as the concept of market efficiency gives room to that of corporate social responsibility (CSR), and the tone of the debate becomes more positive. Further, there seemingly are less dramatic accidents than previously occurred, and the studies extend to all kinds of events that could have an environmental impact. The research in this stream also benefits from the advent of big data techniques and from reporting and monitoring innovations.

Our review of the academic literature on the interaction between the natural environment and shareholders highlights the intellectual processes by which environmental policy has moved from a regulatory approach, based on norms and taxes, to a market driven perspective that is based on the following conjecture: disciplining firms is not (only) the task of governments, but more broadly that of stakeholders (consumers, employees, creditors, shareholders). This conjuncture is based on two presuppositions: (a) government policy is prone to failures; (b) stakeholders have effective tools for action. We feel this approach provides a better understanding of how the literature regarding the stock markets' response to environmental events is framed and how it has evolved over time. While the environmental economics literature initially was motivated by the concept of market failure, recent approaches have been mainly justified by government failure. What is at stake is the balance between the two: market failures that legitimise public intervention, particularly in the area of environmental protection, are well known. These are mainly: public goods, market control, externalities, and imperfect and/or asymmetric information. Government failures are also well identified. These range from opportunism and short-termism on the part of elected representatives, lack of financial or human resources on the part of regulatory authorities, to pressure from vested interests. This is complemented by globalisation of supply chains as well as the lack of cooperation between states, which weakens the attempt of domestic regulation. Faced with this, it is easy to understand the temptation to involve other stakeholders. As nowadays reputation is one of the key assets of companies, anything that can damage this reputation can be used as a means of pressure—and therefore as a means of action. Boycotts and 'naming & shaming' campaigns can effectively dissuade consumers from buying a company's products. A good reputation can encourage employees or potential recruits to seek a position in a more responsible company, and to guide the capital of investors.

However, to be effective, information must be reliable, valid, relevant, timely, transparent, and public. Currently, it seems this goes missing in the case of most non-financial information as adequate reporting, monitoring and auditing standards are still emerging and evolving. Then, how to assure that the information is useful for all participants? Should disclosure of information be voluntary, encouraged, constrained? Should formats be harmonized or left to competition? This also raises questions about the actual effectiveness of environmental policy based on such disclosures. Are stakeholders capable of assimilating and assessing firms' non-financial conduct? Are the stakeholders (consumers, employees, investors) representative of the general interest? Do stakeholders indeed use their leverage to punish non-virtuous companies and to promote others? The answers to these questions are important for the analysis of environmental policies and strategies. They cover a broad spectrum of theoretical and empirical studies, to which the event studies synthesized in this paper are closely linked.

The key issue addressed in event studies is the penalty imposed by shareholders (or, where applicable, the premium granted) regarding non-financial corporate conduct. Our synthesis reveals that the penalty is often quite low (on average, the short-term response seems to be about −2% but with wide fluctuation variation). More importantly, we want to point out that such a penalty is far from sufficient to discipline firms. Apart from a few extreme cases, the market value of firms is only slightly affected by the public dissemination of environmental information. As such, it is highly unlikely that investors bring about the changes that would align corporate conduct with concepts as planetary boundaries or sustainable development goals (see also Bebbington *et al* 2020).

In addition, our analysis provides an alternative interpretation of CSR. At first glance, since the ambition is to temper shareholder primacy, it is tempting to interpret CSR as a way to curb the race for short-term profits, to dampen the almighty power of multinational corporations, and ultimately to soften the neoliberal model. However, it seems that CSR does not oppose the pro-market ideology, but rather complements it (e.g. Kinderman 2012, Roulet and Touboul 2015). In this paper, we interpret CSR as the belief in the proper functioning of markets and that markets can be entrusted with the responsibility to sanction and reward. In this regard, we find support for the notion of 'delegated penalty', in resonance with the concept of 'delegated philanthropy' (Bénabou and Tirole 2010). With delegated philanthropy, CSR spending represents firms' investments to the benefit of stakeholders that would otherwise be paid by the shareholders in full. However, with delegated penalty, CSR represents an assessment of firms' social and environmental policy by shareholders that would otherwise be made by public authorities. Overall, we

conclude that the market disciplining approach to environmental protection is limited and we advocate a critical look at the societal value of CSR practices. As such, our conclusions are in line with those of Freeman and Liedtka (1991, p. 93), who warn against a CSR concept that would '*promot[e] incompetence by leading managers to involve themselves in areas beyond their expertise—that is repairing society's ill*'[5].

The paper is organized as follows. Section 2 details the example of the Brumadinho accident. Section 3 provides a typology of environmental event studies and briefly presents our narrative. Furthermore, this section informs about how to account for the impact of environmental events on shareholders, the conceptual underpinnings and the methodology of event studies and the sources used to detect the events. The following sections discuss the empirical papers. Section 4 focuses on high-profile industrial accidents and their impact on shareholder value. Section 5 investigates with the stock market response to policy events. Section 6 addresses the impact of CSR events on shareholder value. Section 7 concludes the paper. An open access bibliographic database is provided as supplementary material online. It holds all the information used in the paper and allows researchers to work with it[6].

2. Environmental disaster, stock markets, and deterrence

On 25 January 2019, a terrifying mudslide, launched at over 70 km h^{-1}, carried 13 million cubic meters of toxic industrial waste (equivalent to 5000 Olympic swimming pools). It resulted from the rupture of the Brumadinho dam in Brazil. This accident killed more than 250 people (as of January 2020)[7]. It was both an ecological disaster and a human tragedy. The images immediately made it to social networks and 24/7 news channels. There is nothing natural about this disaster: It is the direct result of the mining activities of the Brazilian multinational company, Vale, the world's largest producer of iron ore. The Brumadinho dam disaster vividly illustrates the current societal and academic debates about CSR. We use it to describe the complex relationships between environment, firms and shareholders. The accident displays the limitations of the market disciplining approach to environmental protection, as well as how financial markets value environmental damage. We conclude that the Brumadinho dam disaster casts doubt on the societal value of CSR practices.

To what extent is Vale responsible for the accident and its consequences? According to its president, Fabio Schvartsman, Vale followed the safety recommendations of international experts[8]: '*i am not a mining technician. I followed the technicians' advice and you see what happened. It did not work (..). We are 100% within all the standards, and that did not work.*' Schvartsman also promises '*to go beyond any national or international standards.*' This seems a highly challenging promise: should we trust companies that promise to go beyond international standards? Would it not be more appropriate to tighten the standards and to enforce them? 'To go beyond the standard' is exactly what Project 88 (see previous section) considered 30 years before this accident as a novel tool to protect the environment: '*The report's recommendations are designed to increase environmental protection and economic productivity by providing incentives for businesses and individual to go beyond what regulators can require*' (Stavins 1989, p 2).

Like all multinationals, Vale publishes annual CSR reports. In 2017[9], Vale prides itself on being in full compliance with the global reporting initiative, supported by the United Nations Global Compact programme. The report also highlights the protection of 8500 km^2 of land around production sites, the recycling of 82% of its wastewater, and several partnerships with indigenous populations. However, such efforts appears meaningless in the perspective of the tragic human loss, the extent of the area ravaged by the mudslide, the contamination of the Paraopeba River, which feeds about 50 towns in the state of Minas Gerais downstream and over a million inhabitants, and the irreparable damage to the ecosystem on which the Pataxó tribe depends[10]. The Brumadinho event challenges the reputation of the concept of CSR. Encouraging companies to be more concerned about stakeholders is obviously commendable as this allows for a broader interpretation of value maximization (Hart and Zingales 2017). However, in practice, CSR too often is an instrument of greenwashing, which casts doubt on the role of CSR in the arsenal of social and environmental measures (Lyon and Maxwell 2011). Further, it is unlikely that shareholders are able and willing to act in the interest of stakeholders (Tirole 2006).

The Brumadinho disaster is not the first accident which involves Vale. It echoes a similar tragedy

[5] It should be noted that Milton Friedman himself considers that if the social responsibility of managers is to make profits, their action must be bound by rules: the responsibility of corporate executives is 'to make as much money as possible while conforming to their basic rules of the society, both those embodied in law and those embodied in ethical custom' (Friedman 1970).

[6] https://adriendesroziers.com/data-and-databases/.

[7] www.wsj.com/articles/brazils-vale-vowed-never-another-dam-collapse-then-an-even-worse-one-11577809114.

[8] www.nytimes.com/reuters/2019/01/27/world/americas/27reuters-vale-sa-disaster.html.

[9] www.vale.com/StyleLibrary/RelatorioSustentabilidade17/EN/VALE_SustainabilityReport_2017.pdf. See also www.youtube.com/watch?reload=9%26v=PiA8lUdn6pE.

[10] www.correiobraziliense.com.br/app/noticia/brasil/2019/01/25/interna-brasil,733048/lama-de-tragedia-em-brumadinho-ja-provoca-morte-de-peixes-no-rio-parao.shtml.

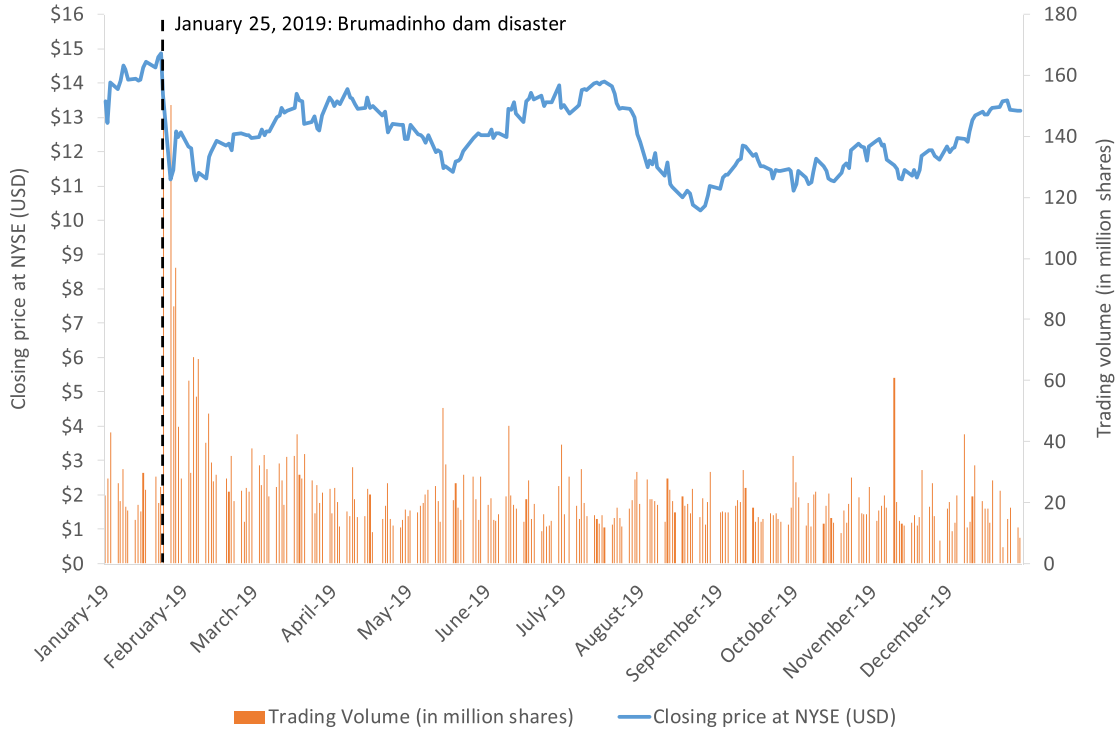

Figure 1. The stock market appreciation of Vale in 2019. This figure shows the closing prices of the Vale share (in US$) as well as the volume in million shares traded in 2019. A dashed line indicates the date at which the disaster at Brumadinho occurred.

that occurred a 100 km away at the Samarco mine—co-owned by Vale and BHP, an Australian mining company—just three years before. Then, toll was 'only' 19 deaths, with several million cubic meters of mud submerging the local town of Mariana and dumped over 650 km into the Atlantic Ocean[11]. This accident was, until then, considered the most serious ecological accident in Brazil's history. When Mr. Schvartsman was appointed chief executive at Vale in May 2017, he mentioned the tragedy to the staff[12]: '*We must all adopt a motto: 'Mariana never again' (…). This is the last time that this company is involved, directly or indirectly, in an ecological and social disaster on the scale of Mariana*'. Legal proceedings were initiated against the firm and its managers, but Vale still denies the toxic nature of thegigantic mudslide. Vale reached an agreement with the government for a fine of around 6.8 billion reais ($1.8bn)[13].

CSR might compensate for the weaknesses in regulations and controls, and it might be that financial markets discipline companies. Several scholars have advocated this view to legitimize CSR, particularly in developing countries (for example, Lanoie *et al* 1998, Dasgupta *et al* 2001). The idea is appealing: if regulatory bodies cannot effectively control and sanction companies, they should ensure that disciplining comes from the market. In this logic, it is up to shareholders—who are supposed to have more influence, incentives, and impact than public authorities—to put pressure on company managers to care about environmental and social consequences of their activities. However, this idea only works if the market sanctions are strong enough.

So, what about the stock markets' response to the Brumadinho dam disaster? This is reflected in figure 1, which shows the closing price of Vale's deposit receipts at the NYSE and the transaction volume in 2019. Vale is cross-listed on several stock exchanges: São Paulo, New York, Madrid and Paris. On the NYSE, following the accident, the stock lost 8% in market value on January 25, and 18% on January 28. Figure 1 also shows the transaction volume is seven times higher than usual. The loss for shareholders due to the accident is estimated around 60 billion reals. This loss is supposed to take into account the costs that the company will incur. Six months after the accident, Vale publishes its financial results with a 7% increase of the total turnover ($9 bn). This increase was due to a surge in the price of iron (+51% Q2:2019) caused by a shortage of supply, which in fact resulted from the Brumadinho dam disaster. In July, Vale's stock price returned to the same price range as it was before the disaster. From this, we conclude that the Brumadinho accident did not substantially or structurally affect the financial value of Vale or the wealth of its shareholders. Only those who sold their

[11] www.bbc.com/news/world-latin-america-34915405.
[12] www.ft.com/content/895daefa-2604-11e9-b329-c7e6ceb5ffdf.
[13] www.bbc.com/news/world-latin-america-47031583.

shares in the wake of the disaster will have been likely to have made a loss.

The state's justice system in Minas Gerais immediately blocked 11 billion reals ($2.9bn) in Vale's accounts, half of which was to compensate victims and the other half to cover the cost of environmental damages[14]. The cost to the company is of course higher, as it has to include legal costs, and the firm might also increase the safety of its other sites, etc. However, is this sufficient to compensate for the loss of all stakeholders, and to restore the environmental damage? Capelle-Blancard and Laguna (2010) suggest that market sanctions are too low. In particular, they observe sanctions are far from posing a serious threat to the managers, do not allow for full compensation of the damage to the planet, and do not provide sufficient incentives to improve the safety of industrial sites in most cases. In addition, there is no resolution mechanism regarding the transfer of the market value lost to relatives and communities and to restore natural habitats. Because the effects are external to the firm and its owners, the private and social accounts are unbalanced.

The Brumadinho dam disasters highlights the issues at stake. An international company, complying with the highest standards and committed to social responsibility, faces a major accident with more than 250 casualties and vast and heavy pollution. The authorities imposes a fine, the shareholders face a (temporary) loss on their wealth. But after a couple of months, it is business as usual.

3. Event studies on environmental events

3.1. Four decades of research

In the past four decades, a large number of event studies on environmental events have been undertaken, and we establish that this literature is quite homogenous. We identify 139 studies with a very steady publication rate, as can be seen in figure 2[15].

Although there are no important methodological differences between the studies, the nature of the events investigated has substantially changed over the period studied. For the purpose of our narrative, we draw a typology based on three different types of negative ('eco-harmful') or positive ('eco-friendly') events: industrial accidents with environmental concerns (high profile single-event studies or studies with a sample of accidents), environmental regulation (public disclosures, legal actions following environmental violation, and (changes in) environmental policy—including events related to new emission trading schemes), and CSR news (various environmental news, corporate practices). We use this categorization to detail the empirical findings and analysis. We follow a chronological reading of the literature to discuss how the debate has evolved over time. As such, we put the development of this event study literature in a socio-economic and academic context.

In this regard, table 1 provides a condensed overview of the main categories of events studied, the main papers, as well as the main academic outlets. Initially, studies simply show that firms causing environmental disasters encounter substantial financial losses to their shareholders. Since the 1980s, dozens of articles have examined the consequences of the main industrial catastrophes, whether it was nuclear accidents Three Mile Island (TMI, Chernobyl, Fukushima), oil spills (Exxon Valdez, BP DeepWater Horizon), or workplace accidents (Bhopal, Rana Plaza, Brumadinho). In general, it shows that the initial market response is substantial. Therefore, it is no surprise to find that it was mainly finance scholars who took up this issue (e.g. Bowen *et al* 1983, Hill and Schneeweis 1983), often influenced by the efficient market theory, which was at its zenith at that time. Most of these papers are case studies, but there are also some global impact assessments with more than one event (Capelle-Blancard and Laguna 2010, Carpentier and Suret 2015, 2021).

The event studies on the impact of industrial accidents nurtured the idea that financial markets could be a powerful tool to overcome struggles in implementing environmental regulations and to incentivize companies to adopt eco-friendly behaviour. Gradually, such environmental regulation has shifted from command-and-control policies to corporate disclosure strategies. An example is the toxic release inventory (TRI) promoted in the US by the Emergency Planning and Community 'Right to Know Act' of 1986. Hamilton (1995) examine the first publication of the TRI and show that the most polluting firms experienced negative abnormal returns (ARs) after the disclosure of their performance in this regard. Several studies followed (e.g. Konar and Cohen 1997), supporting Hamilton's findings. This gave rise to the idea that financial markets should be entrusted with the task of disciplining and sanctioning firms, especially in developing countries with poor regulatory quality (e.g. Lanoie *et al* 1998, Dasgupta *et al* 2006a). The literature in law and economics took this up by showing that companies were

[14] www.reuters.com/article/us-vale-sa-disaster-damages/brazil-court-freezes-further-13-billion-in-vale-accounts-over-dam-burst-idUSKCN1PL0IJ.

[15] We have searched for studies that use event study methodology to assess the impact of environmental news; therefore, we have excluded studies, which consider other methodologies to examine the relationship between CEP and CFP, and studies which consider other extra-financial issues, not strictly environmental. The search for articles was carried out using the usual search engines in economics (Econlit, SSRN, JSTOR, ScienceDirect), successively with the JEL codes G14 and Q5, or the keywords 'event studies', 'environment', 'industrial accidents', 'environmental disclosures', 'environmental regulation' or 'CSR news'. We have also used the references of the selected articles. The list of papers (with the abstract and its DOI) is available in the Online Appendix.

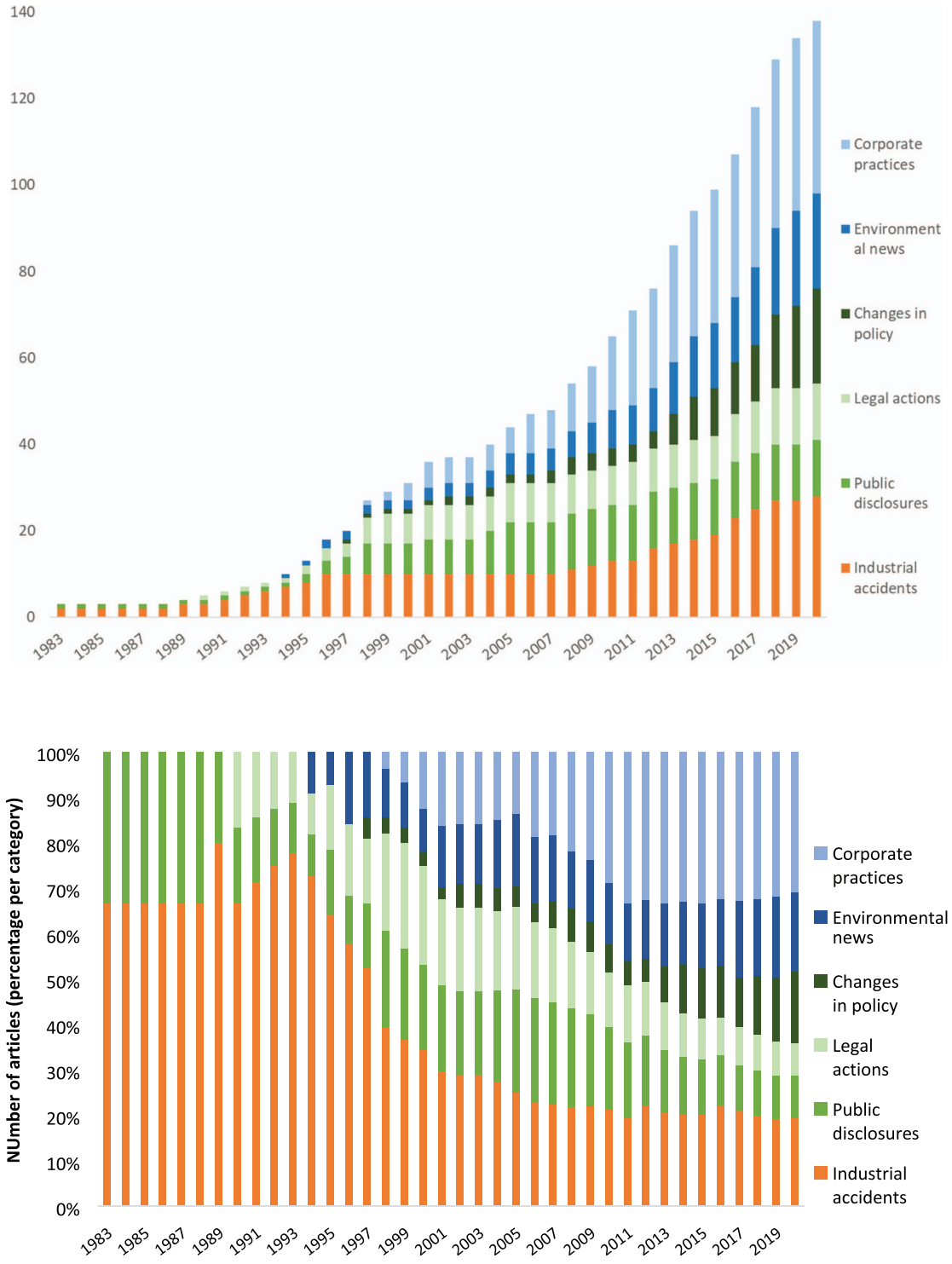

Figure 2. Studies about stock market reaction in relation to environmental events. This figure shows the number of studies about the stock market response to environmental events. The upper panel gives the amount and type of these studies, whereas the lower panel shows the composition of the literature along the different strands in the literature. Panel A. Number of studies. Panel B. Composition of the literature.

subject to penalties that could exceed the cost of litigation and the amount of fines (e.g. Muoghalu *et al* 1990, Dasgupta *et al* 2001, Karpoff *et al* 2005). Cañón-de-francia *et al* (2007) show that upstream changes in environmental policy rules were taken into account by investors and embedded in stock prices.

With the course of time, the literature gradually started paying attention to increasingly diverse kinds of environmental news. Highly relevant in this regard are the papers of Laplante and Lanoie (1994) and Klassen and McLaughlin (1996) that examine both negative and positive environmental events.

Table 1. Shareholders and environment: 40 years of academic research in a snapshot.

	Main publications	Main academic journals	Negative/ positive	Ssngle/ multiple	No. of studies	Avg. publi. year	Avg. no. citations
Industrial accidents (Industrial accidents environmental concerns)							
Major accidents (high profile)	Bowen *et al* (1983), Hill and Schneeweis (1983), Blacconiere and Patten (1994)	J. Financ. & Quantitative Analysis, J. Finance, J. Accounting & Eco.	Negative events	Single-event	19	2001	100
Sample of accidents (global assessment)	Capelle-Blancard and Laguna (2010), Carpentier and Suret (2015)	J. Environmental Eco. & Management	Negative events	Multiple events	8	2013	31
Environmental regulation							
Public disclosures (public disclosure of environmental news, including the TRI)	Hamilton (1995), Konar and Cohen (1997), Khanna *et al* (1998)	J. Environm. Eco. & Management, Ecological Eco.	Negative events	mMostly single	13	2001	353
Legal actions (lawsuits and settlements following environmental violations)	Muoghalu *et al* (1990), Dasgupta *et al* (2001), Karpoff *et al* (2005)	J. Environm. Eco. & Management, J. Law & Eco.	Negative events	Multiple events	10	2001	142
Changes in policy (change or new environmental policy, including ETS)	Cañón-de-francia *et al* (2007), Bushnell *et al* (2013)	Environm. and Resource Eco., American Eco. J.	Mostly positive	Mostly ingle	22	2014	48
CSR (CSR news, with a green perspective)							
Environmental news (various set of green news)	Laplante and Lanoie (1994), Klassen and McLaughlin (1996), Flammer (2013), Krueger (2015)	Management Science, Academy of Management Journal, J. Financial Eco.	Positive and negative	Multiple events	24	2011	210
Corporate practices (including green awards and certification, as well as green investments)	Gilley *et al* (2000), Knowles-Mathur and Mathur (2000), Jacobs *et al* (2010), Foster and Gutierrez (2013)	J. Management, J. Business Research, J. Operations Management American Eco. Review	Mostly positive	Multiple events	43	2011	71

This table classifies the literature about shareholders response to environmental news into three categories, depending on the nature of event. For each category, the table reports the main studies, the main academic journals in which these studies have been published, whether they examine negative (eco-harmful) or positive (eco-friendly) events, whether they consider single or multiple events, the number of studies identified (as of September 2020), the average year of publication, and the average number of citations from Google Scholar as per January 2020.

From there on, the literature gradually moves beyond the scope of environmental economics to a more business-oriented approach, with a specific focus on CSR. In particular, voluntary firm initiatives, investments for environmental protection, certifications and green awards have been studied (e.g. Gilley *et al* 2000, Jacobs *et al* 2010). Finally, the expansion of environment, social, governance (ESG) information, combined with advances in ('big') data processing has provided opportunities to deepen the knowledge of the integration of environmental factors in shareholders' strategy (Flammer 2013, Krueger 2015, Capelle-Blancard and Petit 2019).

The remainder of this paper informs how and why the literature about shareholders and environment has moved from finance to environmental economics, law and economics, management, and business ethics. These fields, which are generally compartmentalized, offer complementary perspectives. In this regard, we think the academic journal where the study has been published is a useful indicator of these evolutions. The first studies on the impact of environmental events on stock markets in the 1980s were published in finance journals (e.g. *The Journal of Finance, The Journal of Financial and Quantitative Analysis*). Then, from the mid-1990s onwards, the most influential papers were published in environmental economics and ecological economics academic journals (e.g. *Journal of Environmental Economics and Management, Ecological Economics*). In addition, several influential papers were published in law and economics (e.g. *Journal of Law and Economics*). Finally, in the 21st century, the literature has become more widespread in the academic business literature (e.g. *Management Science, Academy of Management Journal, Journal of Business Ethics*). In the next three sections, we consecutively present the results of the main studies for all three types of events (i.e. accidents, environmental policy regulation, and CSR in sections 4–6 respectively).

3.2. Shareholders and unexpected environmental events

Unexpected events can influence the value of the firm. This value usually is calculated as the net present value. Net present value relates the revenues and costs with regard to the firm's operations over the project's lifetime to the discount rate. This discount rate usually is made up of the risk-free market rate and a mark-up to reflect industry and/or firm-specific risk. The event may have an impact on one or several of these constituting elements.

Most of the valuation effect results from changes in costs and risks. The environmental events can result in costs to the firm, as showcased in the Brumadinho dam accident. The range of potential costs in relation to adverse environmental events is very broad. For instance, after an accident it includes damages to fixed assets (including property), losses of inventories, raw materials and finished products, as well as business interruptions. Those costs are obvious and much-publicized. However, as firms carry insurance against several of these, not all of them will be considered as relevant by investors. The decline in firm value is partly related to costs that are uninsured. The motives for corporate insurance purchases include risk aversion (that of the manager and/or the shareholders), taxes, bankruptcy costs and underinvestment (Mayers and Smith 1982, Smith and Stulz 1985). As such, environmental events also affect the risk perception of the firm, or even that of the industry as a whole. Further, many risks are still unknown and/or cannot be insured. In addition, the events can influence the firm's reputation: Investors might come to regard the firm as more risky, consumers might see it as less responsible, and prospective employees might view it as less attractive as an employer. Reputation is a relative matter, as investors, consumers and workers will compare between different opportunities to allocate their resources.

In practice, firms seldom are fully insured against the wide range of costs related to adverse events. This is because of several reasons. First, the cost to cover each possible state of nature is prohibitive. Second, the probability of some type of events can be very low, and firms are likely to be prone to cognitive bias (risk underestimation). Third, insurance is poorly designed to cover for penalties and fines from enforcement actions (Shavell 2007). Fourth, firms are not willing to be fully insured against clean-up costs or third party claims (legal expenses and tort liability) due to incidental pollution, as liability is often limited in insurance contracts (Biais *et al* 2010). Governments, at the expense of taxpayers, are most of the time committed to be the insurer of last resort. In addition, risk can materialize beyond the horizon of the firm, investors, and governments.

In case of environmental events, stakeholders are likely to update their beliefs about the safety and responsibility of a particular plant, firm or the specific industry. For example, insurance companies may increase insurance premiums and require more stringent safety standards after a particular incident. Public authorities may reinforce the regulations and raise the cost of regulatory compliance for firms. In addition, customers and suppliers may want to steer clear from doing business with these firms. Further, financial analysts and investors may regard the expected earnings of firms riskier than before. Then, their market valuation can be affected by investment portfolio rebalancing, due to a shift in systematic risk (i.e. the sensitivity of the firm's stock to changes in the overall financial market) or investor taste. As a result, firms may increase their efforts to enhance a better image towards meeting the preferences of

consumers, investors, and of the community and environmental pressure groups. Kotchen and Moon (2012) argue that it is especially firms and industries that face controversies who invest most in CSR to accommodate the demands of stakeholders (see also Heal 2008).

3.3. How to measure costs and benefits for shareholders? The event study methodology

From the discussion above, the question arises how to measure costs and benefits for shareholders. In this regard, a substantial number of studies use the event study methodology. This methodology is developed to investigate the reaction of the stock market to news or events concerning a firm, an industry or the complete stock market (Brown and Warner 1980, 1985, MacKinlay 1997).

The theoretical underpinning of event studies is the EMH (Fama *et al* 1969), which states that when new information becomes available it is fully taken into account by investors assessing its current and future impact. Under this hypothesis, changes in stock prices (i.e. stock returns) reflect the discounted value of current and future firm performance. Thus, the stock price of a particular firm is assumed to reflect the discounted value of current and future cash flows of the firm. From a more tangible perspective, market prices are considered to result from the behaviour of heterogeneous shareholders' reaction when new information comes available. Then, unexpected changes in stock returns caused by a specific event can inform about investors' expectations regarding the impact of this event on the value and viability of the firm (Malkiel and Fama 1970). Therefore, if different categories of events have different impacts on companies' stock returns, it informs to which event type firms are most sensitive in terms of their market value and their viability.

An event study measures the impact of a specific event on the value of a firm using financial market data (MacKinlay 1997). The usefulness of such a study results from the fact that, given rationality in the marketplace, the valuation effect of an event immediately reflects in stock returns (MacKinlay 1997). Using stock prices, it is possible to measure the economic impact of an event over a short time period (Brown and Warner 1985). The general flow of analysis in an event study is as follows (based on MacKinlay 1997, pp 14–15): '… *[first] define the event of interest and identify the period over which the security prices of the firms involved will be examined—the event window. […] The period of interest includes the day of the announcement of the event and the day after. This captures the price effects of announcements, which occur after the market closes on the announcement day. […] After identifying the event, it is necessary to determine the selection criteria for the inclusion of a firm in the event study. […] The appraisal of the event's impact requires a measure of the abnormal return. […] The abnormal return is the actual ex post return of the security over the event window minus the normal return of the firm over the event window. The normal return is defined as the expected return without conditioning on the event taking place…*'.

The event study methodology has been widely used in finance to determine shareholders' reaction to all kind of unexpected news (see Sprecher and Pertl 1983, Brown and Warner 1985, MacKinlay 1997, Kothari and Warner 2006)[16]. Numerous event studies have been devoted to the impact of the announcement of shares distributions, earnings, dividends, mergers and acquisitions, technological accidents, product recalls, massive layoffs, etc[17].

To determine if an event has a significant impact on a firm's stock market return, one needs to test whether that the firm's ARs during the event window (the period closely surrounding the actual event) are significantly different from zero. These ARs are the difference between the actual stock returns to the returns that would have been generated in the absence of this event (i.e. the expected or 'normal' returns), where expectations are based on recent market behaviour of the firm's stock. Thus, investors' reaction to a given information release (i.e. a news item) can be measured by comparing the observed return during a given time period following the event to the expected return in the absence of such an event. If investors react (un)favourably to an event, we may expect (negative) positive significant ARs. While the event study methodology is quite homogeneous, several approaches can be implemented and may vary according to the length of the event windows, the length of the estimations windows, the method to aggregate returns (average abnormal returns, AARs; cumulative average abnormal returns, CAARs; buy-and-hold abnormal returns, BHARs) and the model used to compute the counterfactual returns (constant returns, market model, multi-factor model, etc) (Brown and Warner 1980, 1985). Once the ARs are assessed, several researchers then run multivariate regressions to relate cross-sectional differences in the loss incurred by shareholders (as measured by ARs and the associated market value loss) to the event's or firm's features.

The strength of the event study approach is that it is based on the overall assessment of many investors who quickly process all available information in assessing each firm's market value. All these investors have (pecuniary) incentives to make the best decision. However, a general limitation of studying financial

[16] Most of the literature examine stock prices (probably because the data are easily available—see Capelle-Blancard and Monjon, 2012), but the impact on bond prices might also be relevant. See Zerbib (2019) for an examination of green bonds.

[17] For example, see Ding *et al* (2018) for a review of event studies in operations and supply chain management.

markets that also relates to event studies is the Grossman and Stiglitz (1980) paradox which states that there are few incentives for investors to actually generate information as their efforts will spread out immediately to those who do not invest in information production. However, freely available information does not suffer from this paradox. Moreover, the event study methodology must be used only on financially material and easily determinable events in order to reduce the probability of confounding biases. This relates to the possibility to capture ARs from other, unrelated, events or specific news to firms present in the sample period. This also has ramifications for the use of the methodology; it only makes sense to use it in the case of a short event window around the moment the news arrives at the market (MacKinlay 1997).

We will present several synoptic tables in the next three sections. We provide a breakdown by categories of event (industrial accidents, public disclosures, legal actions, environmental regulations, environmental news, green awards and certifications, and corporate environmental practices), and summarize, for each study: the sample, the nature of the events, and the main results. The results are displayed as AAR, CAAR, BHAR or as the coefficient associated to the event in the multivariable regression.

3.4. How to collect and identify environmental events?

The main sources of information used in event studies are newspaper articles, official publications, company press releases, and information from extra-financial rating agencies or NGOs (see the overview in table 2).

Newspaper articles can be used to assess firms' corporate social performance, but they cover a very diverse set of news. The news can relate to the amount and frequency of pollutant releases, the announcement of collective redundancy plans, the number of legal disputes, lawsuits or fines for non-compliance with environmental rules, etc. Using newspaper articles is interesting to identify which information has a significant impact on firms' stock market value, but it requires an extensive data collection process and the heterogeneity of the information can be problematic. Further, what appears in newspapers is filtered by the editors and journalists, who respond to what is happening and filter on the basis of what they deem interesting and relevant to their audiences. In addition, one should keep in mind that news is a product as well: Media have an interest in attracting audiences as this feeds their business model. As a result, this type of information is likely to be biased.

Several studies focus on the public disclosure by authorities, such as the TRI by US firms (Hamilton 1995, Konar and Cohen 1997, Khanna *et al* 1998). Every year, to ensure public information under the 'Right-to-Know Act', US companies must report their polluting emissions (chemical and toxic products) to the authorities. The advantage of such public disclosure is access to homogeneous and detailed information. However, these data do not cover all pollutants and do not provide information about companies' environmental policies and efforts. In addition, only US firms report this information. Further, several online portals provide accidents databases, which are usually constructed and maintained public institutions. Examples are EMDAT (Centre for Research on the Epidemiology of Disasters), INRS (French national research institute for safety), MARS (Major Accident Reporting System), or ZEMA (Zentrale Melde und Auswertestelle für Störfälle und Störungen in verfahrenstechnischen Anlagen).

Compared to these information sources, the information and data provided by the firms themselves are neither regular, objective nor uniform, but are nevertheless a widely used source of information. More and more companies report about their social or environmental performance in their annual reports. Such information has taken on a strategic dimension (Aerts *et al*, 2008, Lyon and Maxwell 2011). For several years, the amount of information disseminated by companies has exceeded what is required by law. Financial communication has become essential for companies (and public administrations). The objective of companies for doing so is twofold. First, it serves to convey a positive image of the issuer to the financial community and beyond. Secondly, it makes it possible to better manage crises (announcements of results lower than expected, threat of takeover, technological accidents, etc). For the firm, the decision to disclose or not to disclose certain (non-mandatory) information can be formalized simply through a cost-benefit arbitrage model, the main benefit being the reduction of costs associated with information asymmetries and agency conflicts, being conflicts between owners and managers (see Healy and Palepu 2001). The latter are due to the subjective nature of the announcements made by the companies. A major concern of course that this allows the companies to mark their own homework, which carries the risk of greenwashing.

In addition, to assess companies' policies in terms of social and environmental responsibility, one can also use information generated by third-party organizations such as NGOs or CSR rating agencies. The former usually have a non-financial agenda and aim to highlight the importance of particular societal interests. Most NGOs focus on specific issues and generally are very transparent about the information the produce. However, this information usually is not very systematic and not available at a regular basis. This contrasts with the commercial CSR rating agencies. Next to the conventional rating agencies (Moody's, Standard and Poor's), CSR rating agencies have emerged and they are specialized in producing

Table 2. Environmental event by disclosure medium: advantages (+) and drawbacks (−).

Source	Availability	Richness	Parsimony	Reliability	Time delay	Examples
Newspapers	+	−	−	−	+	Wall Street Journal, Financial Times.
Official publications	+	−	+	+	−	US TRI, Canada National Pollutant Release Inventory, MARS, China's Green Watch Program.
Firms press releases	−	+	−	−	−	Annual reports, Bloomberg, Reuters, Europresse, Compustat.
NGOs	+	+	−	−	−	Amnesty International, Carbon Tracker, Friends of the Earth, Human Rights Watch, Transparency International, Oxfam
CSR rating agencies	+	−	+	−	−	Asset4, Impak, MSCI, Refinitiv, Sustainalyitics, Vigeo EIRIS.

an assessment of the (relative) commitment of companies to improve their environmental and social performance. Their information aims at being synthetic and homogeneous between different companies and industries. The other side of the coin is the processing of 'primary' information, which is not always transparent (Berg *et al* 2019). In addition, the focus of these agencies is on processes and not on performance. This results from the lack of standardized and verifiable environmental accounting standards and metrics. As they rely to a large extent on unvalidated and unaudited firm information, the same problems as discussed in the previous paragraph prevail in the case of ratings.

From the perspective of the user of the information, in particular the shareholder, we think five properties are highly relevant. These are availability (is the publication easily accessible?), richness (is the information detailed?), parsimony (is the information easy to gather and process?), reliability (is the source objective and reliable?) and time delay (is the information known immediately?). Table 2 suggests that none of the information sources is superior to the others in all respects. Hence, it depends on the purpose of the use of information which sources are most appropriate.

Regardless of the topic, the number of events considered in each event study gradually increased over time. This is to be expected as more incidents are reported with the course of time. This is due to the improvement of monitoring technology and changes in reporting requirements in the past decades. As a result, environmental incidents are easier to be detected and reported. Figure 3 shows the number of events (in logs) for each study used in our analysis by event type, ranked by chronological order (namely by the year of publication of the articles). The rise in the number of events in figure 3 might only reflect the increase in events reported by the studies; not the actual development in the number of environmental accidents that took place since 1980.

3.5. How much?

The aim of event studies in general is to provide a quantitative assessment of the penalty or reward associated to a particular type of event. In contrast, the aim of this paper is to give an overview and reflection about the topics studied in this event study literature and not to provide a conventional meta-analysis. Nevertheless, we have collected all the estimates of those studies to provide insights regarding the empirical findings in this literature. In this regard, it is important to acknowledge that the studies rely on highly different events, samples, countries, periods, methodological choices, and are difficult to compare. Figure 4 presents for each study, detailed in the sections hereafter, the average CAAR, along with the median as well as with the minimum and maximum estimates. It is based on all the CAARs we have collected for the meta-analysis, by event type.

Figure 4 shows a strong dispersion of the estimates, in particular for the studies with the largest impact (in absolute value). On average, the short-term drop in market value consecutive to eco-harmful events is almost 2%, whereas the 'reward' for eco-friendly events is 0.2%. We also included the median results. With eco-harmful events, the median of the stock market responses is −0.6%. With eco-friendly events, the median response is 0%. As we aim at

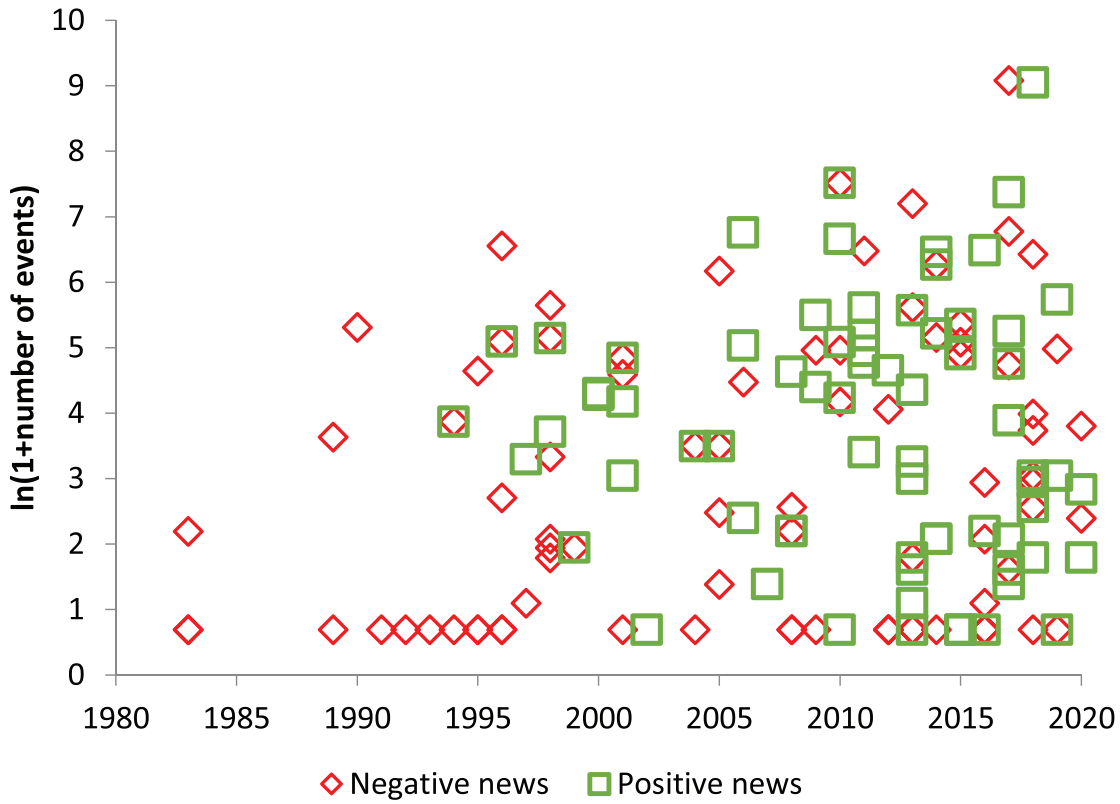

Figure 3. Number of events per study. This figure depicts the number of events included in the studies in the sample (reported as logs). It differentiates between news about negative (eco-harmful) and positive (eco-friendly) events.

a synthesis of the literature in the past four decades, we will not dig deeper into the studies that are used to compile this Figure. We put together a database that can be used for such research purposes as well as for education. We feel that including a full-fledged meta-analysis in this review would take too much space and would damage the flow of our analysis. Instead, in sections 4–6, we will analyse the three main streams identified in the literature regarding the interaction between shareholders and the natural environment, namely high-profile industrial accidents (section 4), policy events (section 5), and the impact of CSR events on shareholder value (section 6).

4. Industrial accidents with environmental concerns

In this section, we reflect on several studies about high-profile industrial accidents with environmental concern. These events result from an accident, negligence or incompetence, or from any combination of these factors and do not have a natural cause. They generally either directly or indirectly resulted in a substantial number of deaths and/or injuries, as well as significant material and environmental damage, and the consequences were both immediate and delayed. In particular, aligned with the chronological order, we address the TMI nuclear meltdown, the Chernobyl nuclear disaster, the Bhopal chemical explosion, the Exxon-Valdez oil spill, the BP Deepwater Horizon spill, and the Fukushima Daiichi nuclear disaster[18]. In several cases, the market value of the firm involved in the accident experienced a significant drop. This relates to an increase in expected costs and risks (table 3). However, as there is mean reversion in investment returns (Mukherji 2011), it is not clear whether such a drop always persists and/or if it is sufficient to provide effective incentives in term of safety.

[18] Previous studies on the effect of bad safety records on equity returns especially focus on civil airplane crashes. Borenstein and Zimmerman (1988) find that equity value losses are related to the number of fatalities and serious injuries, but not to the expected drop in sales. Mitchell and Maloney (1989) find that equity value losses are statistically significant only when crashes are due to pilot errors, by contrast with defects in construction. Broder and Morall (1991) show that stock market reactions vary by which agency has regulatory jurisdiction over the accident and where ex-ante inspection is lax or nonexistent, investor reaction is stronger. Bosch *et al* (1998b) show that the airline industry as a whole incurs losses, while direct competitors of firms responsible for crashes may even benefit from an equity value premium following accidents, see also Walker *et al* (2005) for a study with a sample including September 11, 2001. In addition, several studies examine the impact of natural (or, at least, not directly causes by a specific firm) environmental disasters: earthquakes (Shelor *et al* 1990, Scholtens and Voorhorst 2013), tropical storms (Fink *et al* 2010), various natural catastrophes (Worthington and Valadkhani 2014, Seetharam 2017). Baginski *et al* (1991) focus on the MGM Grand Fire. Jacobs and Singhal (2017) investigate the impact of the collapse of the Rana Plaza building.

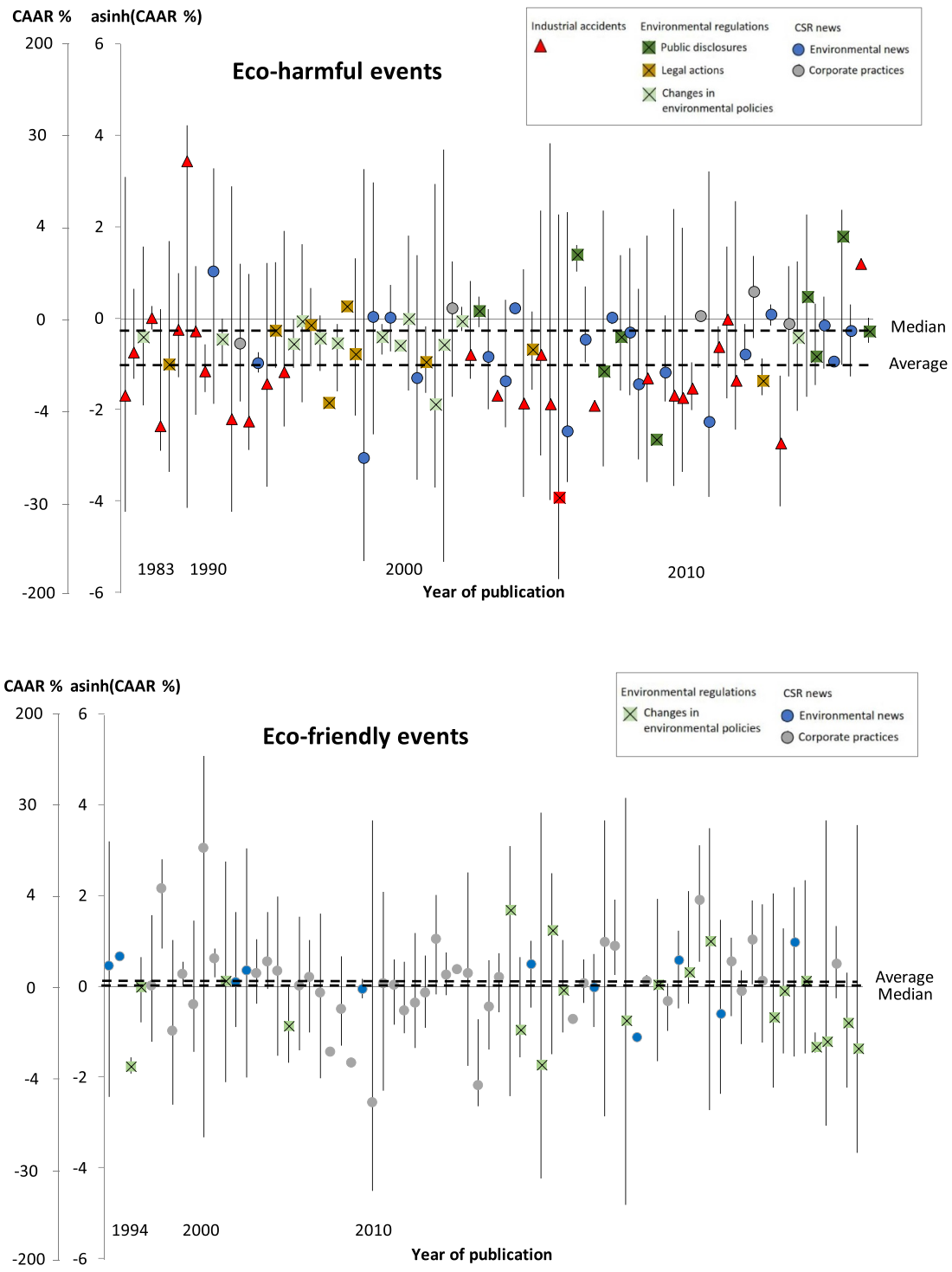

Figure 4. The market reaction to eco-harmful and eco-friendly events. The figure presents the CAAR on the *y*-axis. To allow for a comprehensive assessment of the findings in the literature, we also transformed to an inverse hyperbolic sine (a.k.a. area hyperbolic sine). Hence the *y*-axis is depicted as CAAR and as ASINH(CAAR). The figure shows the average as well as the median CAAR (in %), along with the minimum and the maximum estimates (the *y*-axis is cut off to avoid extreme value for the sake of readability). The studies are presented by year of publication.

4.1. High profile events

4.1.1. TMI

On March 28, 1979, the Unit 2 nuclear power plant (a pressurized water reactor manufactured by Babcock & Wilcox) on the TMI Nuclear Generating Station in Pennsylvania suffered a partial core meltdown. It was caused by a combination of personnel error, design deficiencies, and component failures. Even though it led to no deaths or injuries to plant workers or members of the nearby community,

Table 3. The stock market reaction to industrial accidents with environmental concerns.

Authors	Accident	Sample[a]	Main results (in %)[b]
High profile events (single)			
Bowen *et al* (1983)	Three Mile Island, 1979	US (1; 83)	$AR_{[3]} = -0.764^{***}$; Large nuclear: $AR_{[3]} = -1.612^{***}$
Hill and Schneeweis (1983)		US (1; 64)	General Public Utility: $CAAR_{[0;20]} = -10.9^{**}$; Nuclear: $CAAR_{[0;20]} = -6.1^{**}$
Blacconiere and Patten (1994)	Bhopal, 1984	India (1; 47)	Chemicals: $CAAR_{[-2;2]} = -1.28^{**}$
Kalra *et al* (1995)		India (1; NA)	Union Carbide: $CAAR_{[-1;3]} = -25.7^{***}$; Hazardous chemicals: $CAAR_{[-1;3]} = -1.9^{*}$; Non hazardous chemicals: $CAAR_{[-1;3]} = -1.2^{*}$
Salinger (1992)		India (1; 1)	$CAAR_{[0;20]} = -31.5^{***}$
Fields and Janjigian (1989)	Chernobyl, 1986	Ukraine (1; 89)	(All) power plants: $CAAR_{[-10;3]} = -5.60^{***}$; Nuclear plants: $CAAR_{[-10;3]} = -6.40^{***}$
Kalra *et al* (1993)		Ukraine (1; 69)	Conventional: $CAAR_{[-1;0]} = -1.2^{*}$; Mixed: $CAAR_{[-1;0]} = -2.7^{***}$; Nuclear: $CAAR_{[-1;0]} = -1.6^{**}$
Herbst *et al* (1996)	Exxon-Valdez, 1989	US (1; 13)	Exxon: $CAAR_{[0;9]} = -6.33^{**}$; $CAAR_{[0;15]} = -8.89^{**}$
Mansur *et al* (1991)		US (1; 14)	All firms: $AR_{[0]} = 0.02$; Exxon: $AR_{[0]} = -0.89$
White (1996)		US (1; 1)	Exxon: $CAAR_{[0;30]} = -12.44^{***}$; Green companies: $CAAR_{[0;90]} = 11.2^{***}$
Heflin and Wallace (2017)	Deep Water Horizon, 2010	US (1; 162)	$CAAR_{[0;7]} = -1.76^{*}$; US off-shore: $CAAR_{[0;7]} = -5.44^{***}$
Koda (2016)		US (1; 27)	Natural gas: $CAAR_{[0;5]} = -0.73^{**}$; Utilities and Power: $CAAR_{[0;10]} = 0.93^{***}$
Sabet *et al* (2012)		US (1; 214)	BP: $CAAR_{[0;5]} = -2.62^{**}$; Subcontractors: $CAAR_{[0;5]} = -2.29^{**}$
Betzer *et al* (2013)	Fukushima, 2011	Japan (1; 49)	Nuclear: $CAAR_{[0;2]} = -3.27^{***}$; Renewable energy: $CAAR_{[0;2]} = 11.07^{***}$
Ferstl *et al* (2012)		Japan (1; 46)	Nuclear: FRA/GER/JAP/USA: $CAAR_{[0;4]} = -6.3^{*}/-6.4^{*}/-9.9^{***}/-3.2$; Alternative energy: FRA/GER/JAP/USA: $CAAR_{[0;4]} = 13.4^{**}/39.6^{***}/3.2/-0.5$
Kawashima and Takeda (2012)		Japan (1; 11)	$CAAR_{[0;2]} = -15.294^{***}$
Lopatta and Kaspereit (2014)		Japan (1; 52)	World: $CAAR_{[0;6]} = -2.81^{***}$
Others (single)			
Magness (2009)	Placer Dome, 1996	Philippines (1; 37)	Contagion: $AR_{[1]} = -2.58^{**}$
Capelle-Blancard and Laguna (2008)	Buncefield, 2005	UK (1; 3)	$CAAR_{[0;3]} = -1.03^{***}$
Sample of accidents			
Rothwell (1989)	Nuclear 1978–1985	US (37; 17)	Failed nuclear reactor: $AAR_{[2]} = -0.24^{*}$; $AAR_{[4]} = 0.24^{**}$
Laplante and Lanoie (1994)	Various 1982–1991	N. America (12; 12)	$AAR_{[3]} = -0.46$
Klassen and McLaughlin (1996)	Various 1985–1991	US (22; 16)	$CAAR_{[-1;1]} = -0.815^{*}$

(Continued.)

Table 3. (Continued.)

Authors	Accident	Sample[a]	Main results (in %)[b]
Grand and D'Elia (2005)	Oil spills 1995–2001	Argentina (13; 3)	$CAAR_{[-5;3]} = -2.6883^{**}$
Capelle-Blancard and Laguna (2010)	Petro-chemicals 1990–2005	World (64; 38)	$CAAR_{[0;3]} = -1.17^{***}$; Serious accidents: $CAAR_{[0;3]} = -4.53^{***}$
Carpentier and Suret (2015)	Various 1959–2010	World (161; 161)	$BHAR_{[0;240]} = 3.9277$
Feria-Domínguez *et al* (2016)	Oil spills 2005–2011	US (7; 5)	$CAAR_{[-20;20]} = -3.666^{***}$
Katsikides *et al* (2016)	Oil spills 1989, 2010	US (2; 2)	BP: $AAR_{[30]} = -1.09^{**}$; $AAR_{[45]} = -1.31^{**}$; Exxon: $AAR_{[15]} = -0.67^{**}$; $AAR_{[30]} = -0.37^{**}$
Makino (2016)	Chemicals 2005–2012	Japan (18; 18)	$CAAR_{[0;3]} = -2.68^{***}$; Serious accidents: $CAAR_{[0;3]} = -5.22***$; Minor accidents: $CAAR_{[0;3]} = 0.857$
Fracarolli Nunes (2018)	Various 1989–2015	World (20; 307)	Exxon: $CAR_{[0;5]} = -5.73^{***}$; Samarco Tailings Dam: Costamare: $CAR_{[1;1]} = -7.51\%^{**}$; BHP Biliton: $CAR_{[1;1]} = -7.69\%^{**}$
Kowalewski and Śpiewanowski (2020)	Mining 1995–2016	World (44; 6)	Companies involved: $CAAR_{[0;1]} = 1.51^{*}$; Impact on competitors: $CAAR_{[0;1]} = -0.35^{**}$; Greenfields projects: $CAAR_{[0;1]} = -0.84^{***}$

[a] Sample: Country; date (No. events; No. firms).
[b] $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, 1% level.

the accident at TMI permanently changed the nuclear industry[19].

Bowen *et al* (1983) examine the market value of 83 electric utility companies (General Public Utilities, the owner of TMI facility is excluded) following this accident. The sample is partitioned into several groups. They consider successively utilities with plants build by Babcock & Wilcox, i.e. contractors for the TMI facility (11 cases), firms with where nuclear facilities generated more than 20% of their overall capacity (21 cases), firms with less than 5% of their capacity from oil, no dependence on gas and a nuclear capacity above 10% of overall capacity (14 cases), and a control group of non-nuclear, non-oil and non-gas firms (14 cases). They show that firms with nuclear power plants and utilities planning to build these experienced a drop in equity returns following the TMI accident. The impact on firms with plants build by Babcock & Wilcox or with nuclear capacity above 20% of total capacity of the utility was nearly identical, while the control group appeared to be almost unaffected. Rothwell (1989) examined 37 nuclear reactor failures over the period 1978–85. He finds that the daily return for the owner of a failed reactor dropped by 0.24% after two trading days but increased by 0.24% four trading days later, both compared with a portfolio of nuclear utilities. In addition, Bowen *et al* (1983) provide evidence of a positive shift in the systematic risk and the total risk for 21 nuclear-intensive firms after the TMI accident. However, given that the control group also exhibited an increase, they do not attribute the magnitude of the shift to the accident only. Hill and Schneeweis (1983) confirm the negative impact of the TMI accident. Nuclear utilities (with at least 10% installed nuclear capacity) and non-nuclear utilities experienced a significant decline in their equity returns of −6.1% (during the first month of the event) and −5.4% (six months after the event) respectively following the TMI accident, with an effect significantly greater for the former sample of firms[20].

[19] See, for more details, Backgrounder on the Three Mile Island Accident, US Nuclear Regulatory Commission, 2018: www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html.

[20] In addition, Barrett *et al* (1986) study the impact on the risk premium attached to 76 electric utilities bonds. They show that the average bond risk premium increased after the TMI accident. The impact was larger for firms with nuclear capacity, but it did not relate to the extent of a firm's commitment to nuclear power. Pettway (1981), Fraser and Kolari (1983), Zimmerman (1983) and Chen (1984) report increases in systematic risk, as measured by the beta, while Brooks and D'Souza (1982) provide evidence of a positive shift in total risk for nuclear firms after the TMI accident. Spudeck and Moyer (1989) examine the determinant of the systematic risk for a sample of 62 electric utilities. Their results suggest that some of the market reaction heretofore ascribed to the accident resulted instead from regulatory activity occurring before the accident, which is consistent with Bowen *et al* (1983).

4.1.2. Bhopal

On 3 December 1984, the Union Carbide plant in Bhopal, India, leaked 27 tons of methyl isocyanate, a highly poisonous gas. About 4000 people were killed and another 200 000 were injured. Bhopal is frequently considered as the world's worst chemical disaster[21]. According to Salinger (1992), the primary financial claim regarding Union Carbide was made by the government of India on the behalf of the victims for $3 billion; the lawsuit was settled in February 1987 for $470 million[22]. Consequently, the market value of Union Carbide fell, from $3.5 to $2.5 billion; a decrease of 28%. During the first month, the AR was −31.5%, but a year after the disaster, the cumulative AR had become insignificant and in March 1986 the CAR was +31% after a failed takeover bid and a restructuring and recapitalization of the firm.

Blacconiere and Patten (1994) examined the stock returns of 47 firms in the chemical industry following this disaster. For Union Carbide, the drop in market value went on for more than one month and the chemical industry as a whole was pulled down during ten days after the disaster (−2.4%). Firms with more extensive environmental disclosure prior to the accident experienced a somewhat lower negative loss of their market value (0.6% and −5.34%, respectively). Blacconiere and Patten (1994) suggest that investors interpreted extensive disclosure as a good signal, giving rise to the possibility for firms to disclose good news and suppress bad news. Kalra *et al* (1995) confirm this result for Union Carbide, and find stronger contagion effects to firms producing hazardous chemicals which are more similar to Union Carbide (−1.9%) rather than other non-hazardous chemical firms (−1.2%). Nonetheless, they notice that those companies' returns have rebounded fast and surpassed their pre-crisis levels 18–19 days after the event.

On the 20th anniversary of the Bhopal disaster, a new event caused some turmoil for shareholders. In February 2001, the US based company Dow Chemical had acquired the shares of Union Carbide, which became a fully owned subsidiary. On December 3, 2004, two US artist-activists (the Yes Men) succeeded in being invited by the BBC pretending to be Dow Chemical representatives[23]. They announced that Dow Chemical would accept full responsibility for the Bhopal disaster, and would agree to clean up the site and compensate the victims for an amount of $12 billion. This hoax resulted in a 4% drop in Dow's share price, wiping $2 billion off the market value of the company; the shares rebounded after the BBC issued a disclaimer stating that Dow had not taken this responsibility.

4.1.3. Chernobyl

On April 26, 1986, one of the reactors of the Chernobyl station, located in what is now Ukraine, suffered a catastrophic steam explosion that resulted in a fire, a series of additional explosions, and a nuclear meltdown. The surrounding geographic area was contaminated, and several hundred thousand people were evacuated. Two hundred people were hospitalized immediately, of whom 31 died. Further, the nuclear meltdown produced a radioactive cloud which spread all over Europe. The accident raised concerns about the safety of the nuclear power industry, even in developed countries[24].

Fields and Janjigian (1989) investigate the effect of this accident on 89 US public electric utility stock prices and find that shareholders suffered significant negative ARs. Moreover, utilities using nuclear power experienced greater losses than those without (respectively −6.4% and −4.17% up to three days after the event). These results are highly similar to those reported for the TMI accident, but there is no evidence of a shift in either the systematic risk, the total risk, or the market risk. Kalra *et al* (1993) consider 69 public power utilities listed on the NYSE or the AMEX. Their sample is split into three groups: nuclear capacity of 20% of total capacity or more, nuclear capacity of less than 20% and no-nuclear. In particular, they document a small and transitory effect for the first and the last groups. Indeed, 30 trading days after the Chernobyl meltdown, the cumulative average AR was +0.9% for the non-nuclear and −1.3% for the nuclear firms. The impact was most pronounced for the firms with nuclear capacity between 1% and 20%. This surprising result may be explained by the fact that those firms were in the process of building new nuclear capacity[25].

4.1.4. Exxon Valdez

On March 24, 1989 the Exxon corporation tanker Valdez ran into a submerged reef, spilling some 250 000 barrels' of crude oil into the sea. The Exxon Valdez oil spill was one of the largest environmental disasters ever to occur at sea at that moment, seriously ravaging plants and wildlife[26]. According to Jones *et al* (1994), this oil spill cost Exxon over $4.2 billion in clean-up, liabilities, and penalties[27].

[21] Broughton, E. The Bhopal disaster and its aftermath: A review. Environ Health 4, 6 (2005): https://doi.org/10.1186/1476-069X-4-6.

[22] Amnesty International, Clouds of injustice: Bhopal disaster 20 years.

[23] https://yeslab.org/tags/bhopal.

[24] See Chernobyl, 20 years later, International Atomic Energy Agency, 2005: www-pub.iaea.org/MTCD/Publications/PDF/Pub1312_web.pdf.

[25] See also Pruitt *et al* (1987) for the impact on commodity futures prices.

[26] State of Alaska's Exxon Valdez Oil Spill Trustee.

[27] See Exxon Valdez changed the oil industry forever, National geographic, 2019: www.nationalgeographic.com/environment/2019/03/oil-spills-30-years-after-exxon-valdez/.

Mansur *et al* (1991) study the market response to six events associated with the Exxon Valdez oil spill for 14 major oil firms listed on the NYSE. The only event that caused significant ARs is the announcement (ten days after the disaster, on April 10) that Exxon and Alyeska Pipeline might face substantial punitive damage claims, which were not covered by insurers (−1.69%). In particular, the market did not significantly respond to the disaster, when Alaska initiated a criminal inquiry (on March 30th), or when oil spill response capabilities at the time of the accident were deemed to have been inadequate (on April 7th). Mansur *et al* (1991) suggest that investors were able to discriminate among oil companies based on their exposure to the Trans-Alaska Pipeline since the more exposed firms experienced greater losses than firms less exposed. However, their results were not statistically significant.

Likewise, Herbst *et al* (1996) show that for the five consecutive trading days after the Valdez accident, there were no significant ARs for Exxon. Actually, the decrease in stock price was progressive (see also Katsikides *et al* 2016). Only after ten trading days (two weeks), the cumulative AR was significantly negative for Exxon (−6.33%). Herbst *et al* (1996) do not provide evidence of any intra-industry effect since none of the five largest petroleum companies experienced any loss. According to Herbst *et al* (1996), the market properly assessed the probability that Exxon would have to pay the full cost of clean-ups plus punitive damages, since the stock price decrease was in line with the present value of these total damages. Moreover, there was no significant change in the volatility of Exxon's market value, compared to the overall stock market.

White (1996) confirms that only a limited market impact was to be observed for the first 20 trading days after the oil spill and reports that the stock price decrease was progressive with a significant negative cumulative ARs even after 120 days. White (1996) reports negative but not significant effect for Alyeska consortium or Exxon competitors. In addition, he documents that companies from other sectors rated independently by the council on economic priorities (CEP) as having good environmental performance experienced a positive impact on their market value (11.2% up to 90 days after the event).

4.1.5. Deepwater Horizon

On April 20, 2010, the Deepwater Horizon rig operated by the oil company BP exploded, spilling out nearly five million barrels of oil into the Gulf of Mexico and killing 11 workers. This accident is one of the worst oil spills in history, with long lasting and dramatic consequences both for the environment and for the local fisheries and tourism industries in Louisiana and Florida[28].

In the aftermath of the explosion, BP incurred an AR drop of approximately −6% over the first week. Actually, the stock market response to the catastrophe was not immediate. The largest drop in market capitalisation was observed after April 28 when (following unsuccessful attempts to secure the source of the leak) authorities declared that the oil spill was of national significance and President Obama made a clear statement that BP would be 'ultimately responsible for funding the cost of response and clean-up operations'[29]. Sabet *et al* (2012) show that the main market-mover was the Gulf oil exploration moratorium on deep water drilling that resulted from the concern about the explosion (see also Katsikides *et al* 2016). In the first few months after the disaster, BP lost half its stock market value, which represents tens of billions dollars. In addition, the accident and the subsequent regulatory efforts impacted not only BP, but also its subcontractors and BP's competitors (Koda 2016). However, Heflin and Wallace (2017) show that among the firms drilling in US waters, those with greater environmental disclosure suffered less[30].

4.1.6. Fukushima

On March 11, 2011, a magnitude 9.0 Richter earthquake unleashed a sever tsunami in Japan. It disabled the power supply and the cooling of the Fukushima Daiichi nuclear power plant, operated by TEPCO, a Japanese utility. Three core reactors melted in three days and were stabilized in the following two weeks thanks to recycled water. Although no deaths have been reported for radiation sickness from the nuclear incident, the natural catastrophe led to a toll of about 19 000 human casualties[31].

Kawashima and Takeda (2012) studied 11 Japanese electric companies impacted by this event. Their main results show that up to two days after the events TEPCO stock price dropped by 45.3%, while the average sample drop was of 15.3%[32]. In addition, their

[28] See Deepwater Horizon—BP Gulf of Mexico Oil Spill, US Environmental Protection Agency: www.epa.gov/enforcement/deepwater-horizon-bp-gulf-mexico-oil-spill and Smith *et al* (2011).

[29] Event studies usually focus on stock prices, but the impact of Deepwater Horizon on BP bonds, derivatives and credit default swap was qualitatively similar (Fodor and Stowe, 2010).

[30] Feria-Domínguez *et al* (2016) have considered seven oil spills including the Deepwater Horizon accident between 2005 and 2011. Their results show an average market decrease of 3.7% until 20 days after the accidents. As expected, the Deepwater Horizon accident has had higher effects on stock returns than the average oil spill events.

[31] The Fukushima Nuclear Accident Independent Investigation Commission Report: https://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/report/.

[32] After 30 days, for Tepco the CAR is equal to −125%.

findings indicate that firms which have been affected directly by the earthquake and plants that have relied more on nuclear power faced significant negative ARs (−37.03% and −9.99% respectively up to two days after the event). However, they do not find any evidence of the market sanctioning firms having a similar nuclear reactor as the Fukushima Daiichi plant. They establish an increase in systematic risk and total risk as the market beta and the variances increased following the event. Overall, these findings indicate that shareholders were concerned about the future cost of energy, in particular nuclear power, which could significantly increase due to new safety policies.

Ferstl *et al* (2012) consider stock returns in France, Germany and the US from nuclear and alternative energy firms. Their results show that nuclear stocks in Japan underwent a significant and prolonged market penalty (−15.3% up to 24 days after the event), while in Germany and France, similar companies experienced the same drop (−6.3% and −6.4% respectively up to four days after the event), but one that faded away more quickly. However, they do not find any significant stock price impact for US firms. Moreover, they find alternative energy companies benefited from the event in terms of positive returns (mainly in Europe) but this effect did not last. Ferstl *et al* (2012) point out that shareholders might expected a change toward alternative energies for Germany and France. Nonetheless, the effect was stronger in Germany compared to France (39.6% and 13.4% respectively up to four days after the event). The German government announced a phasing out of all nuclear energy generation three days after the Japanese disaster. Confirming these findings, Betzer *et al* (2013) examine the spillover effect of the Fukushima event in Europe. They find that the abrupt decision of the German government to stop nuclear energy production was the main factor behind the shareholders reactions; not the dramatic Fukushima Daiichi event. No German stock reacted significantly during this first tragic event while European stocks have not reacted to any of the two events. However, they results indicate that German renewable energy firms have strongly benefited from their policy announcement change on the short run while nuclear and conventional stocks were significantly penalized (11.07% and −3.27% respectively on event day). In addition, Betzer *et al* (2013) highlight that even if those initial market reactions were strong, both industries' stocks reached a plateau for 20 days. Finally, Lopatta and Kaspereit (2014) consider a worldwide sample of 52 utilities relying to various degree on nuclear power. Their results show that firms with a higher share of nuclear power in their total capacity have been impacted more strongly by the event (−9.2% up to six days after the event while all stocks dropped by 2.81%). They also note that all utilities with nuclear capacity were affected.

4.1.7. Others

In 1996, a Canadian industry, Placer Dome, with mining operations in the Philippines, suffered a massive failure of the Makulapnit Dam, which dumped four million tons of sewage into the Boac River. Magness (2009) analyse the contagion effects of the Placer Dome event on the Canadian mining industry. She observes a significant drop of 2.6% in share prices for the Canadian mining industry one day after the event. However, she finds that firms having a more environmentally committed management have been affected to a lesser extent, while financial disclosures have negatively affected the firm's market value. Kowalewski and Śandewski (2020) have also considered the mining industry and find that financial markets react more strongly to the natural rather than human-made disasters occurring in mines.

The British Buncefield depot caught fire on December 11, 2005, and this raged for three days after several explosions. Although it caused no human casualties, the event has affected around 400 businesses nearby and released a non-toxic black smoke across the area. At the source of the accident, four major oil companies (Total, Texaco, BP and Shell), owner of the Buncefield depot, were considered responsible. Capelle-Blancard and Laguna (2008) note that on the day of the explosion, the four owners suffered on average only a slight financial loss of −0.6% despite the seriousness of the event.

4.2. Sample of accidents

In contrast with the previous single-event studies[33], Capelle-Blancard and Laguna (2010) examine the stock market reaction to separate accidents in chemical plants and refineries worldwide between 1990 and 2005. Their sample includes 64 major events (a quarter of them resulted in a toxic release, and half of them caused at least one death or serious injury), but not as high-profile as those mentioned previously in this section. They establish that firms' market capitalization decreases on average with 1.3% the two days following the disaster, and they show that the loss is related to the number of casualties and to pollution. Similarly, Makino (2016) examines chemical accidents (18) that occurred in Japan between 2005 and 2012 and finds that the financial markets have reacted more strongly to serious accidents.

Carpentier and Suret (2015) examine the stock market reaction to 161 industrial accidents (both environmental and non-environmental), reported on the front page of *The New York Times* from 1959 to 2010. They show that the decline in firm value is mostly related to government interventions and

[33] The first event studies based on several accidents were carried out by Laplante and Lanoie (1994) and Klassen and McLaughin (1996), but in tandem with other positive environmental events (e.g. green awards). These papers are discussed in the next section.

rather low for accidents with environmental concerns compared to airplane crashes. In addition, they show that the CAARs following environmental accidents do not differ from zero after one year.

The recent literature also examines the impact of specific accidents, such as oil spills (Grand and D'Elia 2005, Feria-Domínguez *et al* 2016, Katsikides *et al* 2016) or mining tragedy (Kowalewski, Śpiewanowski, 2020). Overall, the market reaction appears to be limited, and these market incentives are highly unlikely to encourage managers to change fundamentally their environmental safety policy or to consider divestment by financial investors.

5. Environmental regulation

In this section, we reflect on the studies that investigate the stock market response to environmental regulation. Over the past four decades, the principles of environmental protection policies have evolved from legal command-and-control regulation (the 'first wave'), to market-based instruments (the 'second wave') and to disclosure strategies (the 'third wave') (Tietenberg 1998, Kotchen 2013). We first discuss studies about the impact of public disclosure, then how stock markets react to other public information regarding legal actions in relation to environmental regulation, and lastly studies that focus on environmental policy change, especially the launch of emission trading schemes.

5.1. Public disclosures

Disclosure strategies involve public and private attempts to improve information about pollution. The idea is to stimulate market dynamics, in order to induce firms to self-regulate and adopt environmentally friendly strategies (Tietenberg 1998, Khanna 2001). The growing popularity of these strategies among domestic and international regulators, which comes at a low cost for regulators, raises the question of whether information disclosure is effective in generating pressures from shareholders on firms to improve their environmental performance. Disclosure may have much less systematic effects on firm valuation than accidents. First, there can be a positive effect because the firm is becoming more transparent. This reduces the risks of the firm as such from the perspective of the shareholder. There also can be a negative market response when the information being disclosed suggests additional risks might be incurred or costs can be expected.

An example of such disclosure policy is the TRI, which has been promoted in the US by the Emergency Planning and Community 'Right to Know Act' of 1986, is the most important case of environmental policy based on public disclosure. In a seminal article, Hamilton (1995) studies the stock market response to the first public announcement of the TRI in 1989 for 436 firms. The sample is composed up to 75% of manufacturing firms (chemicals, paper, primary metals, petroleum and textiles). All firms were listed at the NYSE or AMEX. Hamilton finds that the stock market value on average dropped by $4.1 million the first day (−0.284%) of firms reporting TRI releases (see table 4).

Since the study of Hamilton (1995), many papers have been written and continue to appear dealing with this topic. The upper panel of table 4 reports some of these studies. For example, Konar and Cohen (1997), using a sample of 130 firms, show that investors respond to information published by the media on the TRI database, rather than to the TRI itself. They also find that firms that experienced the largest stock price decline subsequently reduced their emissions more than their industry peers did. Khanna *et al* (1998) extend Hamilton's analysis over several years (1989–1994) for a sample of 91 chemical firms. They find that firms whose toxic release rates increased between 1991 and 1994 suffered significant negative ARs (ranging from 0.23% to −0.71%). Arora (2001) investigate the market response to the TRI in 1997 for 645 firms. Arora (2001) first estimates with a logistic regression the probability of engaging in pollution prevention activity. Then, firms are classified according to the difference between actual and predicted performance. Firms that fail to meet expectations experienced a drop in their stock market value, while firms that exceed their expected level of prevention activity are not rewarded (Arora 2001). Bui (2005) is skeptical about the relevance of stock market appreciation regarding the TRI (see also Ananathanarayanan (1998) and Cram and Koehler (2001) for methodological issues). She studies a sample of 106 petrochemical firms over the period 1989–1998 and finds that the observed fall in toxic releases due to the TRI has been overestimated. She controls for the fact that all reporting firms face a common event window: the TRI events are identical for each company in each year. The assumption of zero covariance across ARs is therefore almost surely violated. Bui (2005) concludes that the negative ARs around TRI reporting dates for petroleum companies are insignificant. She reports the results for two types of companies: Companies are classified as reporting 'bad news' ('good news') if their TRI releases are larger (lower or equal) in the current year than in the previous year. Then, she finds there is no evidence that companies reporting bad news had statistically significant negative ARs during the event window, or had returns that were statistically significantly different from firms reporting good news. Bui (2005) also compares ARs of firms reporting the TRI, with those of non-reporting firms, and find no evidence of significant ARs differences

Table 4. The stock market reaction to public disclosures with environmental concerns.

Authors	Disclosure	Sample [a]	Main results (in %) [b]
Hamilton (1995)	TRI	US; 1989 (1; 436)	$CAAR_{[0;5]} = -1.2^{***}$; Firms with media coverage: $CAAR_{[0;5]} = -0.93^{**}$; with superfund: $CAAR_{[0;5]} = -0.96^{***}$
Konar and Cohen (1997)	TRI	US; 1989–92 (2; 130)	Media covered TRI: $CAAR_{[0;5]} = -0.743^{***}$
Ananathanarayanan (1998)	TRI	US; 1989–95 (7; 165)	$CAAR_{[0;1]} = -1.905^{**}$
Khanna *et al* (1998)	TRI	US; 1989–94 (6; 91)	1991: $CAAR_{[0;1]} = -0.35^{**}$; 1992: $CAAR_{[0;1]} = -0.31^{*}$; 1993: $CAAR_{[0;1]} = -0.71^{**}$; 1994: $CAAR_{[0;1]} = -0.233^{**}$
Arora (2001)	TRI	US; 1997 (1; 637)	4th quartile: $CAAR_{[-1;0]} = -0.52^{**}$; 3rd quartile: $CAAR_{[-1;0]} = -0.87^{*}$
Freedman and Patten (2004)	TRI	US; 1989 (1; 112)	Highest TRI air release: $CAAR_{[-1;1]} = -0.5$; 10 K report: $CAAR_{[-1;1]} = 0.64$
Bui (2005)	TRI	US; 1989–98 (11; 106)	TRI reporting 10 year avg: $CAAR_{[-2;0]} = -0.207^{*}$; Non-TRI reporting 10 year avg: $CAAR_{[-2;0]} = -0.325^{*}$
Shane and Spicer (1983)	CEP	US; 1970–77 (8; 72)	(All) Environmental reports: $AR_{[-2]} = -3.282^{***}$
Lanoie *et al* (1998)	ME-BC	Canada; 1990 (5; 19)	Plants out of compliance: $AR_{[0]} = 1.486^{**}$; First appearance: $AR_{[0]} = 1.1096^{*}$
Gupta and Goldar (2005)	GRP	India; 1999–02 (3; 50)	Pulp & Paper: $CAAR_{[0;10]} = -0.1912^{**}$; Automotive: $CAAR_{[0;10]} = 0.0869^{**}$
Dasgupta *et al* (2006a)	ME-SK	Korea; 1993–00 (87; 57)	Beverage: $CAR_{[-3;2]} = -0.186^{*}$; Fiber: $CAR_{[-3;3]} = -0.14^{*}$
Cañón-de-francia *et al* (2008)	EPER	Spain; 2004 (1; 64)	Listed firms: $CAAR_{[-1;1]} = -0.16$; Non-listed firms: $CAAR_{[-1;1]} = 0.05$
Zhou and Yin (2018)	Various	China; 2015–16 (53; 99)	1st appearance: $CAAR_{[0;5]} = -1.6^{**}$; 2nd appearance: $CAAR_{[0;5]} = -2.44^{**}$; 5+ appearances: CAAR = 0.45

[a] Sample: Country; date (No. events; No. firms).
[b] $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, 1% level.

between them[34]. Freedman and Patten (2004), based on a sample of 112 firms, show that environmental disclosure reduces the impact of the TRI announcements, limiting the scope of environmental disclosure under a largely voluntary regime.

Actually, the first event study regarding environmental public disclosure did not consider the well-researched TRI. Instead, Shane and Spicer (1983) consider the release of eight major studies conducted by the US CEP on firm's environmental performances in four industries (Oil, Power, Paper and Steel) over the period 1970–1975 (see bottom panel of table 4). A total of 72 firms are considered. Information is from *The Wall Street Journal* and *The New York Times*. Shane and Spicer (1983) show that firms experience large abnormal negative returns during two days prior to the newspaper reports on the release of the CEP studies. Firms revealed to have low pollution-control performance rankings have significantly more negative ARs than companies with high rankings (high

[34] There also is a broad literature that relates firms' long-term financial performance with environmental performance. For example, Konar and Cohen (2001) show that poor environmental performance (as measured by TRI level of emissions in 1988, and the number of environmental lawsuits against the firm in 1989) has a significant effect on the intangible-asset value and Tobin's q of publicly traded firms that belong to the S&P 500, after controlling for market share, R&D expenditures, advertising expenses, etc Cormier and Magnan (2007) investigates the impact of voluntarily disclosed information of environmental reporting. They control for the endogeneity between a firm's decision to disclose information, its exposure to media and its stock market value. Disclosure by German firms of environmental information has a positive effect on investors' appreciation of the relationship between its reported earnings and value. It shows French and Canadian firms are not affected. Further, for all three countries, firm size and media exposure are strongly related to environmental reporting.

pollution control firms have on the event day 2.08% higher returns than low pollution control firms).

Other studies in this line of research, not relying on TRI data, are Lanoie *et al* (1998) who base their study on a list of polluters published twice a year by the Ministry of the Environment of British Columbia (ME-BC) in Canada over the period 1990–1992. The sample consists of 19 publicly listed Canadian firms. The firms are put into two categories: firms not complying with an environmental standard or permit and firms with environmental performance near, or going well beyond the regulatory threshold. It shows that firms do not incur statistically ARs. However, firms that appear in the list of polluters more than once incur higher losses than firms appearing only once. Further, Gupta and Goldar (2005) examine the Green Rating Project by a leading environmental NGO in India and funded by the United Nations Development Programme through the central Ministry of Environment and Forests. They examine three industries, pulp and paper, automobile and chloralkali firms, and find that the announcement of weak environmental performance leads to large negative ARs up to ten days (−0.12%). Dasgupta *et al* (2006a) examine the value impact of public disclosure of environmental performance with regulated facilities in South Korea (SK). Since the mid-1980s, the ME-SK has published a list of facilities in violation with existing Korean environmental laws and regulations (emission standard, equipment failure, etc). They find that the average reduction in market value (−9.7%[35]) is found to be higher than the estimated changes in market value for similar events in Canada and the US, and of a similar magnitude as observed changes in other developing countries (Argentina, Chile, Mexico, and Philippines). Dasgupta *et al* (2006b) also show that the larger the extent of coverage by newspapers, the larger the reduction in market value. In addition, Cañón-de-francia *et al* (2008) consider the first publication of the European Pollutant Emission Register (EPER) and its impact on the market value of 64 Spanish firms between 2003 and 2004. They show a negative impact for EPER listed firms, and a positive impact for those which might have been considered as potential polluters but which do not exceed the legal thresholds and consequently not listed in the EPER.

5.2. Legal actions

Lawsuits and judicial actions following environmental violations date back to the 1970s (Grad and Rockett 1970) and enforcement is part of the strategic plan of most of the environmental public agencies[36]. The eventual fines have obviously a negative impact on firm value. However, it depends on several factors, such as type of opponent, firm characteristics (Bhagat *et al* 1998), the reputational damage (Alexander 1999) and in case fines are less than expected, stock returns could be positive. We provide an overview of this literature in table 5.

Muoghalu *et al* (1990) examine 128 initial lawsuits and 74 case settlements involving a fine related to the Resource Conservation and Recovery Act and the Superfund Acts in the US over the period 1977–1986 (See also Little *et al* 1995). The source of information mainly is *The Wall Street Journal*. They find abnormal losses at the time of announcements of lawsuits (an average loss of $33.3 million in market value, −1.23%), but no significant ARs at the time of settlement. They also find that losses due to lawsuits filings are much weaker for the petrochemical industry than for other industries. Closely related is the study of Laplante and Lanoie (1994), who investigate the impact on firms' market value of 9 lawsuits and 13 suit settlements announcement in Canada. To identify the events of interest, they use Canadian print media (mostly *The Financial Post* and *The Globe & Mail*). In contrast with Muoghalu *et al* (1990), they find that the stock value declines only the day of suit settlements. Laplante and Lanoie (1994) conclude that weak regulatory enforcement and the lax response of the Canadian legislative authorities compared with the US ones may explain these divergent results.

Badrinath and Bolster (1996) examine the stock market response to legal actions of the US Environmental Protection Agency (EPA) over the period 1977–1991. Their sample consists of 704 actions (385 violations on the filing date and 319 cases on the settlement date) regarding firms publicly listed on the NYSE, the AMEX, and the NASDAQ. Badrinath and Bolster (1996) find a 0.43% loss in violator firm value during the week of settlement and establish that the market penalty is unrelated to fine size. Further, they show it is more pronounced for violations under the Clean Air Act, for repeat violators, and for more recent EPA actions. Bosch *et al* (1998a) show that firms may benefit by cooperating with the EPA, since compliant strategies reduce wealth losses.

Karpoff *et al* (2005) study the impact on stock market excess return in relation to 478 environmental violations by US publicly traded companies over the period 1980–2000 (see also Karpoff *et al* 1998). The sample is obtained from a search in 'The Wall Street Journal Index'. In contrast to Badrinath and Bolster (1996), they find that companies violating environmental laws incur equity value losses of a similar magnitude as the amount of legal penalties (fines and clean-up costs) eventually imposed on them. Hence, it seems that US stock markets do not impose a reputation penalty on firms for being responsible for harmful effects. Karpoff *et al* (2005) argue that the violations may produce ill will, but do not affect the

[35] It should be noted that this strong decrease in market value might be due to some extreme events, as one event in their sample caused a CAR higher than 100%.

[36] See www.epa.gov/enforcement/basic-information-enforcement.

Table 5. The stock market reaction to legal actions with environmental concerns.

Authors	Sample [a]	Main results (in %) [b]
Muoghalu *et al* (1990)	US; 1977–86 (202; 202)	Lawsuit filing:$CAAR_{[-1;0]} = -1.228^{***}$
Mansur *et al* (1991)	US (1; 14)	Claim against Exxon and the Alyeska Pipeline: $AR_{[0]} = -1.69^{**}$
Laplante and Lanoie (1994)	N. America; 1982–91 (11; 4)	Canadian firms: Lawsuit filing: $AAR_{[0]} = -0.14$; Lawsuit settlement: $AAR_{[0]} = -2^{*}$
Little *et al* (1995)	US; 1977–86 (103; 58)	Disclosing suites in the financial statements: $CAAR_{[-1;0]} = -0.98^{**}$; Not disclosing suit: $CAAR_{[-1;0]} = -1.27^{***}$
Badrinath and Bolster (1996)	US; 1972–91 (704; 167)	Lawsuit settlement: $CAAR_{[0;5]} = -0.428^{***}$
Bhagat *et al* (1998)	US; 1981–83 (27; 27)	Lawsuit filing: $CAAR_{[-1;0]} = -3.08^{***}$
Bosch *et al* (1998a)	US; 1970–90 (171; 77)	Firms targeted by the EPA: $CAAR_{[1;10]} = -1.2^{*}$, Firms losing against the EPA: $CAAR_{[-1;0]} = -1.04^{***}$
Karpoff *et al* (1998)	US; 1980–91 (283; 283)	Lawsuits allegations: $CAAR_{[-1;0]} = -1.58^{**}$; Charges filed: $CAAR_{[-1;0]} = -1.92^{***}$
Alexander (1999)	US; 1984–90 (6; 6)	$CAAR_{[-1;0]} = 1.45$
Dasgupta *et al* (2001)	S. America; 1990–94 (126; 48)	Government actions vs other positive events: $CAAR_{[-5;1]} = 15.055^{**}$; Complaints vs other negative events: $AAR_{[-1]} = -9.143^{**}$
Lorraine *et al* (2004)	UK; 1993–00 (23;15)	Fines: $AAR_{[7]} = -0.79^{**}$
Grand and D'Elia (2005)	Argentina; 1995–01 (32; 12)	Citizen complaints: $AAR_{[3]} = -1.1634^{**}$
Karpoff *et al* (2005)	US; 1980–00 (478; 478)	$CAAR_{[-1;0]} = -1^{***}$; Allegations: $CAAR_{[-1;0]} = -1.69^{***}$; Charges filed: $CAAR_{[-1;0]} = -1.58^{***}$
Wei *et al* (2011)	US; 1980–01 (652; 400)	$CAAR_{[-1;0]} = -0.425^{***}$
Xu *et al* (2016)	China; 2007–11 (173; 173)	Fines: $CAAR_{[-10;10]} = -3.6^{**}$
Haslem *et al* (2017)	US; 1995–06 (877; 877)	$CAAR_{[-1;1]} = 0.615^{***}$; Win for the defendant: $CAAR_{[-1;1]} = -0.524^{***}$; Loss for the defendant: $CAAR_{[-1;1]} = -0.946^{***}$
Wang *et al* (2019a)	China; 2008–15 (145; 102)	Fines: $Coeff_{[0;1]} = -1.78^{***}$

[a] Sample: Country; date (No. events; No. firms).
[b] $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, 1% level.

quality of the firms' final products nor break implicit labor or supply contracts.

More recently, Haslem *et al* (2017), relying on 83 260 lawsuits filed in the US (including 877 environmental litigation), suggest that the reputational loss due to corporate misconduct is lower than previously expected and that the loss in market value can be mainly attributed to the media coverage, the expectation of subsequent litigation, and the defendant's willingness to settle. Philipich (2018) examine the impact for the coal-burning industry in the US of the EPA Clean Power Plant introduced in 2015 and the legal efforts to challenge it. He reports a negative market reaction to the issuance of the final version of the Clean Power Plan (but not for the draft version) and a positive on following a Supreme Court ruling which forced the EPA to alleviate some rules.

5.3. Policy (change)

In table 6, we provide an overview of studies that investigate the stock market response to (changes in) environmental policies. In this regard, the early studies primarily covered specific laws. For example, Blacconiere and Northcut (1997) consider the impact of the establishment of the Superfund Amendments and Reauthorization Act of 1986 on 72 chemical firms. Next to the disclosure of mismanagement, the main purpose of this amendment was to toughen up the Comprehensive Environmental Response, Compensation, and Liability Act of 1980. It included a minimum clean-up requirement and specified that most clean-up agreements with polluters would have to be entered in federal courts. Blacconiere and Northcut (1997) show that shareholders reacted negatively to the implementation of this act. However, they responded much less pronounced in the case of firms communicating more on their environmental initiatives in their 10 K reports.

Diltz (2002) examines how electric firms' shareholders react to 20 different stages in the transition of the 1990 Clean Air Act Amendments. This program of amendments sought to reduce toxic air emissions

Table 6. The stock market reaction to changes in environmental policies.

Authors	Policies	Sample [a]	Main results (in %) [b]
Blacconiere, Blacconiere and Northcut (1997)	SARA	US; 1985–86 (26; 72)	$CAAR_{[0;5]} = -2.295$; Legislative actions: $CAAR_{[0;5]} = -3.328^{**}$
Diltz (2002)	Clean Air Act	US; 1990 (1; 97)	Pre-Announcement: $CAAR_{[-20;-1]} = 3.35^{***}$; Announcement: $CAAR_{[0;108]} = 4.58^{*}$
Cañón-de-francia *et al* (2007)	IPPC	Spain; 2002 (3; 58)	$CAAR_{[0;3]} = -1.29^{**}$
Johnston *et al* (2008)	S02	US; 1995–06 (12; 19)	Purchasing utilities: $CAAR_{[0;1]} = 0.49^{**}$; Control Utilities: $CAAR_{[0;1]} = -0.02$
Ramiah *et al* (2013)	CPRS & renewable energy	Australia; 2005–11 (19; 1770)	Alternative energy: $CAAR_{[-10;5]} = -31.34\%^{***}$
Ramiah *et al* (2015)	Political news	World; 1997–11 (133; na)	Obama's election: Positive reaction: $AR_{[0]} = 4.29^{*}$; Negative reaction: $AR_{[0]} = -5.32$
Tamechika and Okuda (2017)	Eco-points Programme	Japan; 2009–10 (3; 13)	$CAAR_{[-1;1]} = 2.53^{***}$
Philipich (2018)	Clean Air Act	US; 2014–16 (5; 42)	Final version: $AR_{[1]} = -1.85^{**}$
Zhao *et al* (2018)	Various	China; 2007–15 (20; 52)	Legislative control: $CAAR_{[-4;4]} = -2.2^{***}$; Administrative control: $CAAR_{[-10;10]} = 1.8^{**}$; Market-based regulation: $CAAR_{[-6;6]} = -4.4^{***}$; Env. disclosure: $CAAR_{[-6;6]} = 5.3^{***}$
Tian *et al* (2019)	Environmental laws	China; 2016 (1; 270)	Politically connected: $CAR_{[-5;4]} = -1.26$; Non-politically connected: $CAR_{[-5;4]} = -3.51$; Mean difference:-2.24^{***}
Pham *et al* (2020)	ETS & others	France; 2005–10 (16; 797)	Chemical: $CAAR_{[-2;2]} = -3.26^{***}$; Construction & materials: $CAAR_{[-2;2]} = 1.09^{**}$; Ind. Transp.: $CAAR_{[-2;2]} = 1.97^{**}$
Sam and Zhang (2020)	Environmental laws	China; 2015 (5; 2050)	Inspection: Non-polluting: $CAAR_{[0;3]} = 0.2^{**}$; Polluting: $CAAR_{[0;3]} = -0.7^{***}$; Plan Approved: Non-Polluting: $CAAR_{[0;3]} = -0.3^{**}$; Polluting: $CAAR_{[0;3]} = -0.14^{***}$
Bushnell *et al* (2013)	GHG	Europe; 2006 (1; 552)	ETS: All industries: $CAAR_{[0;2]} = -0.5^{*}$; Crude petroleum extraction: $CAAR_{[0;2]} = -3^{*}$
Chapple *et al* (2013)	GHG	Australia; 2006–09 (5; 58)	Task group to design ETS: $AR_{[0]} = -1.8^{**}$; Delay to implement the ETS: $AR_{[0]} = 2.1^{**}$
Jong *et al* (2014)	GHG	Europe; 2006 (1; 393)	$CAR_{[-1;2]} = -0.75^{***}$
Kong *et al* (2014)	GHG	China; 2011 (640; 640)	Carbon ETS: All firms: $CAAR_{[-10;10]} = -2.1$; Green firms: $CAAR_{[-10;10]} = 6.0$
Luo and Tang (2014)	GHG	Australia; 2011 (7; 336)	Carbon tax: $AR_{[4]} = -0.6^{***}$
Brouwers *et al* (2016)	GHG	Europe; 2006–13 (8; 368)	2006: $CAAR_{[0;3]} = -2.49^{***}$; 2009: $CAAR_{[0;3]} = 1.97^{**}$
Jiang and Luo (2018)	Climate	China; 2009–11 (1; 1847)	Delayed carbon legislation: $CAAR_{[-2;2]} = 0.84^{***}$

(Continued.)

Table 6. (Continued.)

Authors	Policies	Sample [a]	Main results (in %) [b]
Schütze *et al* (2018)	Climate	World; 2009–17 (12; 369)	Green firms: $CAAR_{[-1;3]} = 1.52^{*}$ (COP18)/-1.08^{*} (COP20)/-1.04^{*} (2016 US election); Brown firms: $CAAR_{[-1;3]} = -0.97^{*}$ (COP21)/-0.47^{*} (2016 US election)
Pham *et al* (2019)	Climate	Ger.; 2014–16 (20; 17 sectors)	COP21: Basic Resources: $AR_{[0]} = -7.91^{***}$; Retail: $AR_{[0]} = 1.49$; Media: $AR_{[0]} = 1.44^{**}$; Technology: $AR_{[0]} = 1.84^{**}$
Guo *et al* (2020)	Climate	China; 2014–17 (10; 609)	(All) Milestone policies: $CAAR_{[-3;3]} = -0.544^{***}$

[a] Sample: Country; date (No. events; No. firms).
[b] $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, 1% level.

and acid rain caused by the massive use of coal. This regulation also was the corner stone of the US SO_2 market. In this regard, Diltz (2002) studies the impact of the Phase I of the US SO_2 market on 38 power plants covered by these regulations and 59 other plants not subject to it. On the announcement day, he finds slightly significant different share price returns for Phase I and non-Phase I firms. Therefore, his results suggest that both groups are perceived similarly by investors. Diltz (2002) concludes that the monthly returns variation results from US interest rates changes and from investor concerns about deregulation of the electricity sector. Johnston *et al* (2008) also consider the US SO_2 market and find that shareholders assign a positive price to a firm's bank of SO2 emission allowances.

Cañón-de-francia *et al* (2007) consider the 2002 Integrated Pollution Prevention and Control Act (IPPC) implementation in Spain. The IPPC transposes a European directive of 1996, which consists of standardizing measures between EU member states regarding pollutant emissions and the evaluation of companies' environmental performance. They found that investors reacted negatively to the law (−1.29%), but firms investing more in research and development (R&D) were less affected. This might results from the fact that R&D investment enhances firm capacity to adapt to new regulation.

Next to specific environmental policies, the event study literature also started to consider a wider variety of announcements like speeches made by politics regarding the environment or international climate policies. As to the former, Ramiah *et al* (2015) consider the election on November 4th, 2008 of the president Barack Obama who has centred his political campaign on energy policy, climate change. Ramiah *et al* (2015) find that the biggest polluters suffered negative ARs. Similarly, Schütze *et al* (2018) consider Donald Trump's speech regarding the US withdraw from the Paris Agreements (−0.9% and −0.27% respectively for green and brown firms up to two days after the event)[37]. Focusing on international policies, Schütze *et al* (2018) study the environmental decisions by the socalled Conference of the Parties (COP)s from 2009 to 2016. They find that the Cancun and Doha summits benefited environmentally friendly businesses, while brownfield firms were not impacted. The Paris summit penalized polluting firms, but did not result in significant ARs for green businesses. They interpret their findings as a change in market behaviour: the financial markets seem to have switched from rewarding green firms to penalizing brown ones and they seem to have started to view fossil fuel industries as more financially risky. Jiang and Luo (2018) focus on China's non-ratification of the Copenhagen Climate Summit from 2009 to 2011. They find that delayed legislation on carbon emissions has increased the share price of the state-owned firms. Relatedly, Johnston *et al* (2008) consider the emission allowances of SO_2 rights and analyse both the asset and option value. They show that stock markets positively value firms having an excess in allowances. The main reason is because these rights can be sold or inventoried for future use. However, they do not provide strong evidence regarding the option value of the emission permits. Johnston *et al* (2008) find positive returns for firms purchasing rights, but these were not statistically different from non-purchasing firms (i.e. control group). Therefore, they do not know if the market really priced the real option value of the emission allowances.

Inspired by the US experiences, the EU attempted to tackle greenhouse gas (GHG) emissions with a similar market emission system implemented in January 2005, but with much less success. The EU's Emissions Trading System (ETS) has been motivated by the Kyoto Protocol. It encompasses 27 countries and has

[37] Brans and Scholtens (2020) study the market response to tweets by president Trump where he mentions firms. It shows that only in the case of clear negative sentiment in these tweets, there is a (negative) effect on the value of the firm mentioned.

been implemented in four phases; it excluded several industries and was quite lenient in granting emission permits[38]. For the first phase, Bushnell *et al* (2013) show that carbon intensive firms were the most penalized, while less regulated industries have benefited from this downturn (see also Jong *et al* 2014). Jong *et al* (2014) arrive at different results. Firstly, they discover a significant share price increase for lower carbon intensive firms and the ones holding more permits. Secondly, they do not find a significant market reaction to ETS trade activities or from the pass-through of carbon leakage.

They argue this can be due to carbon leakage, which occurs when firms reallocate their activity into countries where the restrictions on carbon emissions are weaker (Jong *et al* 2014). Brouwers *et al* (2016) analysed the impact of the verified versus allocated yearly GHG emissions under the ETS from 2005 to 2013 (i.e. the first two phases). They obtain significant results only for the first publications of each phase. Their results are mainly valid for carbon-intensive industries that are less able to pass on carbon costs on their final goods. Similarly, Pham *et al* (2019) consider German firms, whereas Pham *et al* (2020) consider French firms.

China introduced seven ETS-like pilot projects in provincial regions in October 2011. Kong *et al* (2014) use a sample of 640 firms and show that the announcement of this Chinese carbon emission rights trading scheme benefited 'environmental firms'. Environmental firms able to sell their unused rights have obtained positive ARs. Additionally, environmental firms putting more efforts into environmental protection are more recompense by investors, mostly if they are located in the pilot region. Guo *et al* (2020) consider the announcement of ten environmental policies in China between 2014 and 2017, and find that heavily polluting firms are negatively impacted (see also Huang *et al* 2017).

For the Australian ETS, Luo and Tang (2014) examine how firms reacted to seven key carbon legislative events permitting the setting up of the market in 2011 (see also Chapple *et al* 2013). They find higher negative markets reaction for material and financial sectors, and only significant ARs for firms' direct carbon exposure (covered by the tax) and not to indirect emissions (not covered by the tax)[39].

To wrap up, three major aspects of this regulatory literature can be noted. First, it aims at analysing the markets' reaction to announcements that frame the entire regulatory process. Indeed, those event studies cover: upstream, day-to-day and downstream regulatory tools. Upstream, they analyse the implementation or change of policies. Closer to firms' daily activity, they study various regulatory tools that aim to motivate companies to adopt more responsible practices, such as public disclosure or ETS mechanisms. Downstream, they consider repressive legal measures in the event of non-compliance. Therefore, this literature analyses all the longitudinal aspects of the regulatory process. Another important aspect of this evolution is the gradual shift from a national (public disclosure, legal actions and certain policies) to an international perspective (COP and ETS) of environmental issues. It can be seen that studies on emissions of polluting or toxic products with localized effects (TRI) have gradually given way to studies on GHG emissions that need to be tackle proposing global solutions. Finally, in the light of this literature, stock market reactions appear to be relatively consistent since public disclosure, legal sanctions and announcements of policy changes mostly induce negative ARs. Nevertheless, most of these effects are small, meaning that they do not seem to result in sufficient financial incentives for firms to improve their environmental performance. This does not mean that it is necessary to fundamentally improve those tools since they already do have wealth effects. However, in our opinion, regulators should hold on to this toolbox and significantly impose stricter standards and sanctions at a faster pace.

6. CSR

This section reviews the event studies about firms' social responsibility, in particular environmental corporate news and corporate environmental practices. With the course of time, academics have started to consider an increasingly wider set of environmental events. Moreover, it shows that the papers have

[38] From 2005–2007, the first phase was a 'learning by doing' phase enabling regulators, governments and firms to adapt themselves and to estimate a carbon price for phase II. It only covered CO_2 emissions of power generators and energy-intensive industries, most of the allowances were given for free and financial penalties were given for not complying. From 2008 to 2012, phase II imposed lower caps in allowances (6.5% lower compared to 2005), reducing the level of free allocation (to around 90%), increasing non-compliance fines (from 40€ in 2005–100€ per tonne), authorising firms to buy international credits, increasing the number of sectors covered by including airplane, and accounting for NO_2. From 2013 to 2020, phase III strengthened the system by targeting a 20% reduction of the GHG emissions. It introduced a single EU-wide cap, the auctioning of the allowances, the harmonization of member states allocations rules, and the increase in the number of states subject to the ETS. Finaly, from 2021 to 2030, phase IV aims to cut emission by 43% of 2005 levels for 2030. It mainly consists in reducing allowances to 2.2% as of 2021 and strengthening the Market Stability Reserve.

[39] Also focusing on the Australian market, Ramiah *et al* (2013) examine the introduction of 19 prior bills between 2005 and 2011 regarding the reduction of carbon pollution (including related to ETS) and renewable energy policies. They find strong market reaction in particular once the Australian government decided not to commit to the Copenhagen Accord objectives. They record a 31% decrease in cumulative abnormal returns for the alternative energy sector.

become less and less interested with the impact of 'events' strictly speaking (such as accidents, oil spills, lawsuits, new regulations), but more and more by the impact of 'announcements', sometimes without a specific tangible outcome. The pioneering papers (Laplante and Lanoie 1994, Klassen and McLaughlin 1996) include a broad set of both negative and positive environmental news. These studies were followed by a large number of papers focusing on corporate disclosures, with—unsurprisingly—a positive tone. Lastly, the most recent approaches take advantage of the abundance of data available to conduct more detailed studies on the type of news (or ads) that can affect stock prices.

6.1. Environmental news

The studies discussed in the previous two sections primarily focus on one specific type of events. However, several studies also consider the impact on shareholder wealth on various environmental events, often less dramatic, and using large sample of both negative and positive events. Table 7 provides and encompassing overview of the main features of studies addressing the stock market response to various environmental news regarding corporations.

As far as we are aware of, Laplante and Lanoie (1994) were the first to conduct a study on both negative and positive environmental events. They study the impact of 47 events published in two Canadian newspapers from 1982 to 1991. They consider a various set of eco-harmful events (accidents and legal actions—see also tables 3 and 5), but also eco-friendly investments. Overall, they found significantly negative ARs for firms on the announcement of both suit settlements and on investment date.

In the same spirit, Klassen and McLaughlin (1996) assess firms' corporate environmental performance by using green awards, and several environmental crisis. They consider companies listed on the NYSE or the AMEX over the period 1985–1991 and examine both positive and negative events. For a sample of 22 negative events (oil spill, gas leak, explosion and other incidental pollution—see also table 3), they find statistically significant ARs of −0.8%. For their sample of 140 positive events (announcement of an environmental award), they find statistically significant ARs of 0.82%, that is an average increase of over US$80 million per event. They interpret this smaller reaction, in absolute value, as 'scepticism' from shareholders toward the firm's true commitment to environmental projects. Nonetheless, this finding demonstrates that financial markets may positively value strong environmental commitments.

Rao (1996) uses a sample of 14 firms, which were the subject of an article in *The Wall Street Journal* over the period 1989–1993 that denounced unethical corporate conduct towards the environment. The results suggest that the stock market responded very much since average AR reached −5.3% on the day of announcement[40].

Dasgupta *et al* (2001) collected environmental news from newspapers in Argentina (La Nacion), Chile (El Mercurio), Mexico (Excelsior) and the Philippines (The Manila Bulletin). They show that stock markets do react negatively[41] to citizens' complaints targeted at specific firms (see also tables 5 and 8), and positively to the announcement of rewards and recognition of superior environmental performance. Lorraine *et al* (2004) study the impact of 23 fines for environmental pollution and nine various positive environmental news from 1993 to 2000 to assess eco-friendly corporate performance extracted from both UK public agencies and newspapers. Their sample size limits their findings but overall, they find a significantly negative market reaction to fine settlements until one week after the event release. Regarding positive news, they obtained a small but significantly positive market reaction. Hsu and Wang (2013) constructed two textual indicators to observe how markets react to news related to GHG emissions of 1345 firms from 1989 to 2008. Their first indicator corresponds to the total number of positive and negative terms in newspapers. The second indicator is the total number of negative terms minus the positive ones divided by the total number of positive and negative words. Hence, they show that shareholders react favourably to negative media reports about companies' exposure to climate risk. They conclude that shareholders view climate change investments as an expensive cost. However, this reaction is weaker for firms that pollute the most and for the ones, which have poor environmental performance.

Jones and Rubin (2001) study a broad set of environmental events. Their sample is composed of 98 negative environmental events reported in *The Wall Street Journal* between 1970 and 1992 in which electric power companies or oil firms with listed stocks were involved. The events selected by Jones and Rubin (2001) did have to meet two criteria. First, the event must have had a negative environmental impact as the result of the actions of a producing division of the firm. Second, the event must not have affected the quality of the firm's physical product. They selected events that produce ill will, but do not affect the quality of the firms' final products nor break implicit labour or supply contracts. Overall, they find

[40] Xu *et al* (2012, 2016), Huang *et al* (2017), Lo *et al* (2018) and Wang *et al* (2019a) examine broad incidents in China while Lundgren and Olsson (2009, 2010), consider 142 environmental incidents events worldwide. They still report negative impact on shareholder wealth.

[41] In this study, one event (Grupo Bimbo in 1992) caused a CAR higher than 100%.

Table 7. The stock market reaction to CSR news with environmental concerns.

Authors	Source	Sample [a]	Main results (in %) [b]
Laplante and Lanoie (1994)	Newspapers 1982–1991	N. America (47; 47)	Canadian firms: Accidents: $AAR_{[3]} = -0.46$; Lawsuit settlement: $AAR_{[0]} = -2^{*}$; Green investment: $AAR_{[0]} = -1.09^{*}$
Klassen and McLaughlin (1996)	Various 1985–1991	US (22; 16)	Accidents: $CAAR_{[-1;1]} = -0.815^{*}$; Green awards: $CAAR_{[-1;1]} = 0.628^{***}$
Rao (1996)	Various 1989–1993	US (14; 14)	Eco-harmful: $CAAR_{[0;20]} = -5.29^{**}$
Dasgupta *et al* (2001)	Newspapers 1990–1994	S. America (126; 48)	Gov. actions vs other positive: $CAAR_{[-5;1]} = 15.055^{**}$; Complaints vs other negative: $AAR_{[-1]} = -9.143^{**}$; Green awards: $AAR_{[;1]} = 14.086^{**}$; Green investment: $CAAR_{[-5;1]} = -1.082$
Jones and Rubin (2001)	Newspapers 1970–1992	US (98; 57)	Accidents & legal actions: $AAR_{[0]} = 0.3907^{**}$
Lorraine *et al* (2004)	Various 1993–2000	UK (32; 24)	Eco-friendly: $AAR_{[7]} = -0.09$; Fines: $AAR_{[7]} = -0.79^{**}$
Grand and D'Elia (2005)	Various 1995–2001	Argentina (32; 12)	Eco-harmful: Citizen complaints: $AAR_{[3]} = -1.1634^{**}$; Oil companies: $CAAR_{[-5;3]} = -2.6883^{**}$; Eco-friendly: Green investment: Announcement: $AAR_{[2]} = 2.5148^{**}$; Inauguration: $AAR_{[-3]} = 1.9533^{*}$; Certification: $AAR_{[0]} = -1.3188$
Lundgren and Olsson (2009, 2010)	GES Investment Services 2003–2006	World (142; 74)	Eco-harmful: World: $CAAR_{[-20;20]} = -1.3^{*}$; Europe: $CAAR_{[-20;20]} = -3.6^{***}$; $CAAR_{[-40;40]} = -5.38^{**}$
Xu *et al* (2012)	Public authority & media 2010	China (57; 57)	Potential environmental risk: $CAAR_{[-30;30]} = -0.2$; Exhausted gaz: $CAAR_{[-30;30]} = 5.1^{*}$; Waste water discharge: $CAAR_{[-30;30]} = -10.9$; River pollution: $CAAR_{[-30;30]} = -156^{*}$;
Flammer (2013)	KLD 1980–2009	US (273; 273)	Eco-friendly: $CAAR_{[-1;0]} = 0.84^{***}$; Eco-harmful: $CAAR_{[-1;0]} = -0.65^{***}$
Hsu and Wang (2013)	Newspapers 1989–2008	US (1345; 1345)	Eco-harmful: $CAAR_{[-1;0]} = 0.01^{**}$; Environmental industries: $CAAR_{[-1;0]} = -0.12^{*}$; Non environmental industries: $CAAR_{[-1;0]} = 0.11^{**}$
Deák and Karali (2014)	Newspapers 2007–2010	US (526; 23)	Eco-harmful: $coeff_{[-3;3]} = 1.042$ Eco-friendly: $coeff_{[-3;3]} = -0.446$
Krueger (2015)	KLD 2001–2007	World (212; <745)	Eco-harmful: $CAAR_{[-10;10]} = -3.03^{**}$; Eco-friendly: $CAAR_{[-10;10]} = -1.37^{*}$
Fracarolli Nunes and Lee Park (2016)	Newspapers 2015	Germany (1; 7)	Volkswagen Dieselgate. Automaker #4: $CAAR_{[-2;2]} = -20.451^{***}$; Automaker #6: $CAAR_{[-2;2]} = -3.478^{***}$
Huang *et al* (2017)	Public authorities, Wind 2002–2014	China (113; 113)	Eco-harmful: $CAAR_{[-1;1]} = -0.903^{**}$
Xu *et al* (2016)	Public authorities & media 2007–2011	China (173; 173)	Eco-harmful: $CAAR_{[-10;10]} = -4.4^{*}$
Li and Wu (2017)	GTA-CSRR 2008–2016	China (1595; 419)	Eco-friendly: 2011/2012/2013/2014/2015/2016: $CAAR_{[-1;1]} = -0.46^{***}/-1.32^{***}/-1.31^{***}/-0.9^{***}/-0.88^{***}/0.86^{**}/0.53^{**}$
Lo and Kwan (2017)	Hang Sen Sustainability 2010–2012	Hong-Kong (48; 17)	Eco-friendly: $Coeff_{[-1;0]} = 1.502^{**}$

(Continued.)

Table 7. (Continued.)

Authors	Source	Sample [a]	Main results (in %) [b]
Sarumpaet and Hendrawaty (2017)	Newspapers 2014–2015	Indonesia (36; 36)	Eco-harmful: $AR_{[0]} = -1.405$
Lo *et al* (2018)	Public authorities 2006–2013	China (618; 294)	Eco-harmful: $CAAR_{[-1;0]} = -0.41^{***}$
Wood *et al* (2018)	Public authorities, EPA 1984–2016	World, (41; 41)	Auto-manufacturers: Eco-harmful: $AR_{[0]} = -1.01^{**}$
Capelle-Blancard and Petit (2019)	Covalence EthicalQuote 2002–2010	World (8829; 100)	Eco-harmful vs Eco-friendly: $Coeff_{[-1;1]} = 0.001$
Wang *et al* (2019a)	Newspapers 2008–2015	China (145; 102)	Eco-harmful: $CAAR_{[-1;1]} = -1.15^{***}$; Water: $Coeff_{[0;1]} = -2.76^{***}$; Air: $Coeff_{[0;1]} = -1.56^{*}$

[a] Sample: Country; date (No. events; No. firms).
[b] $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, 1% level.

that the capital market response was not statistically significant.

Some papers also examine the case of environmental frauds, in particular in the automotive industry. In September 2015, the EPA revealed that Volkswagen fraudulently modified its diesel engines in order to comply with emission regulation. This environmental fraud resulted in the recall of 600 000 vehicles in the United States, and lawsuits against the company. Fracarolli Nunes and Lee Park (2016) examine 33 US auto-manufacturers after the scandal and report strong negative spillovers. Wood *et al* (2018) consider a broad range of 41 auto-manufacturers failures between 1984 and 2016. They report an average loss of 1% and an increased suspicion after the Dieselgate event. They claim that the stock market's response should encourage companies to adopt more ethical behaviour, at least as part of their macro-marketing strategy. However, it is not clear whether the penalty is severe enough.

More recent studies with various CSR events rely on much larger sample sizes: hundreds or even thousands (environmental and non-environmental) events which allow for the examination of their influence on (almost) day-to-day basis[42]. Flammer (2013) has a sample of 117 eco-friendly events and 156 eco-harmful events extracted from *The Wall Street Journal* over the period 1980–2009. She finds that announcements of eco-harmful corporate behaviour lead to negative ARs (−0.65%), and that eco-friendly corporate initiatives generate positive ARs (0.84%). Her results suggest that companies have been increasingly penalized for irresponsible behaviour towards the environment over time, and that shareholders of firms with stronger environmental performance react less negatively to the announcement of eco-harmful behaviour. Krueger (2015) examines 2116 negative and positive ESG events concerning 745 different firms between 2001 and 2007. The data are extracted from the KLD database. The results confirm that negative news is followed by a stock price decrease, while the impact of good events is positive only in cases of poor stakeholder relations. In the content analysis, they show that investors react more strongly to ESG news containing more economic and legal information. Capelle-Blancard and Petit (2019) investigate the stock market's reaction to about 33 000 ESG news flashes from 2002 to 2010 provided by Covalence-EthicalQuote, which targets 100 multinational companies. The interesting feature of this paper is that their extensive database allows examining the impact of day-to-day environmental news. They find that firms coping with negative ESG events experience a low but statistically significant drop in their market value, namely −0.1%. In contrast, companies coping with positive events do not experience any significant change in their market value. In addition, it seems that stock market penalties do not vary significantly over time. Their results also indicate that existing firm reputation mitigates the losses and that market participants only react to information disclosed by the media and not to firm's own press releases. Finally, they establish that losses are larger when there is a cultural proximity between shareholders and the event, and when the content of the environmental news has a quantitative, an economic or a legal dimension.

[42] Other examples of studies which examine the impacts of CSR events, with a focus on environment, are Deák and Karali (2014), who consider 526 positive and negative events about 23 US firms in the food industry; Li and Wu (2017), who consider 1595 positive events in China; Dorfleitner *et al* (2018), who consider 8539 events in North America.

6.2. Corporate practices

While most of the debate focuses on the damage that companies cause to the environment, some companies can be proactive and aim to limit their negative impacts and reduce their ecological footprint.

Table 8. The stock market reaction to green awards, rankings, ratings and certifications.

Authors	Event	Sample [a]	Main results (in %) [b]
Klassen and McLaughlin (1996)	Green awards (Various)	US; 1985–91 (162; 112)	$CAAR_{[-1;1]} = 0.628^{***}$
Yamashita *et al* (1999)	Green ranking (Fortune magazine)	US; 1986–93 (6; 75)	Rank II vs Rank IV: $AR_{[0]} = 8.18^{***}$; Rank II vs Rank IV: $AR_{[0]} = 7.16^{**}$; Rank III vs Rank IV: $AR_{[0]} = 6.23^{**}$
Dasgupta *et al* (2001)	Green awards (government explicit recognition)	S. America; 1990–94 (126; 48)	$AAR_{[1]} = 14.086^{**}$
Takeda and Tomozawa (2008)	Green ranking (Nikkei Environmental Management Ranking)	Japan; 1998–05 (8; 646)	1998–2001: $CAAR_{[-1;1]} = -0.6^{***}$; 2002–2005: $CAAR_{[-1;1]} = 0.7^{***}$
Yamaguchi (2008)	Green ranking (Nikkei Environmental Management Ranking)	Japan; 1998–06 (8; 69)	$CAAR_{[-1,1]} = -0.1$ (1998); -1.2^{***} (1999); 0.4 (2000); 0.8^{**} (2001); -0.3 (2002); 0.7 (2003); 1.2^{***} (2004); 0.2 (2005)
Anderson-Weir (2010)	Green ranking (Newsweek Green Rankings)	US; 2009 (1; 394)	$CAAR_{[-3;3]} = -2.62^{***}$
Cellier and Chollet (2012)	Green rating (Vigeo)	Europe; 2004–09 (1838; 739)	Best 30%: $coeff_{[-2;2]} = -0.05$ Worst 30%: $coeff_{[-2;2]} = 0.263^{*}$
Jacobs *et al* (2010)	Green awards (Various)	World; 2004–06 (780; 340)	Federal awards: $CAAR_{[-1;0]} = -0.03$; Non-government awards: $CAAR_{[-1;0]} = -0.26^{*}$
Lyon *et al* (2013)	Green awards (Green Company Awards)	China; 2008–11 (77; 48)	$CAAR_{[-4;4]} = -1.3^{**}$
Deák and Karali (2014)	Green awards & rankings (Various)	US; 2007–10 (526; 23)	$coeff_{[-3;3]} = -0.446$
Cordeiro and Tewari (2015)	Green ranking (Newsweek Green Rankings)	US; 2009 (1; 500)	Overall Green Rank: $Coeff_{[1;3]} = 0.264^{***}$
Murguia and Lence (2015)	Green ranking (Newsweek Green Rankings)	World; 2010 (1; 100)	Green Score: $Coeff_{[0;1]} = 1.379^{***}$
Yadav *et al* (2016)	Green ranking (Newsweek Green Rankings)	US; 2012 (1; 416)	$SCAR_{[-1;1]} = 0.2042^{***}$; Score-up: $SCAR_{[-1;1]} = 0.2336^{***}$; Score-down: $SCAR_{[-1;1]} = -0.0243$
McMillan *et al* (2017)	Green ranking (Newsweek Green Rankings)	US; 2009–12 (4; 500)	Top Service: $CAAR_{[0;10]} = -0.64^{**}$; Bottom Service: $CAAR_{[0;10]} = -0.04$; Top Manufacturing: $CAAR_{[0;7]} = -0.47^{**}$; Bottom Manufacturing: $CAAR_{[0;6]} = 0.38^{**}$
Dorfleitner *et al* (2018)	Green rating (Reuters)	N. America; 2002–14 (8539; 1278)	$Coeff_{[740;960]} = 4.38^{***}$
Schütze *et al* (2018)	Green ranking (Clean 200)	World; 2009–17 (12; 369)	Emerging countries: $AAR_{[-1]} = -0.86^{*}$; Developed countries: $CAAR_{[-1;3]} = 1.16^{*}$;
Chen (2001)	Green certification (ISO 14001)	Taiwan; 1991–99 (20; 20)	$SCAR_{[-7;7]} = 0.86^{*}$
Grand and D'Elia (2005)	Green certification (ISO 14001)	Argentina; 1995–01 (32; 12)	$AAR_{[0]} = -1.3188$
Montalván and Chang (2006)	Green certification (ISO 14001)	S. America; 1987–04 (10; 10)	$CAAR_{[-1;1]} = 1.267^{***}$
Cañón-de-Francia and Garcés-Ayerbe (2009)	Green certification (ISO 14001)	Spain; 1996–02 (80; 32)	$CAAR_{[-1;1]} = -0.6^{***}$; First: $CAAR_{[-1;1]} = -1.71^{***}$
Jacobs *et al* (2010)	Green certification (ISO 14001)	World; 2004–06 (780; 340)	$CAAR_{[-1;0]} = 0.35\%$
Bouslah *et al* (2010)	Green certification (Forest & ISO 14001)	N. America; 1998–05 (160; 42)	$CAAR_{[-1;1]} = 0.47^{*}$; $CAAR_{[0;720]} = -16.14^{***}$

(Continued.)

Table 8. (Continued.)

Authors	Event	Sample [a]	Main results (in %) [b]
Paulraj and De Jong (2011)	Green certification (ISO 14001)	US; 1996–08 (140; 280)	$AR_{[1]} = -0.46^{***}$
Foster and Guitierrez (2013)	Green certification (Clean Industry Certificate)	Mexico; 2003–07 (25; 5)	$AR_{[0]} = 0.8^{*}$
Zhang *et al* (2017)	Green certification (CDM)	China; 2005–13 (115; 91)	$CAAR_{[-1;1]} = 3.44^{***}$
Lam *et al* (2016)	Awards, rankings and certifications	China; 2005–14 (656; 169)	$Coeff_{[0]} = 0.51$
Wang *et al* (2019b)	Third party assessments	US; 2005–14 (308; 308)	$CAAR_{[0;1]} = 0.22$

[a] Sample: Country; date (No. events; No. firms).
[b] $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, 1% level.

However, this raises several questions: Are they sincere? What really motivates them? Do they have a real impact? There is a growing literature interested in this corporate environmentalism, CSR strategic behaviours and greenwashing (Delmas and Burbano 2011, Lyon and Maxwell 2011). Part of this literature uses event studies to examine how shareholders react to these actions: Are they positively valued by investors (for example, because they might increase firm reputation) or are they seen as an unnecessary cost? We report the key features of such studies in table 8. In this regard, Jacobs *et al* (2010) distinguish two kinds of such voluntary corporate disclosures, depending on whether the news is published by the firms themselves, or by a third-party. First, Environmental Awards and Certifications (EACs) are '*announcements about recognition granted by third-parties specifically for environmental performance*'. EACs consist of two sub-categories: green awards and certifications (e.g. ISO 14001). Second, Jacobs *et al* (2010) define Corporate Environmental Initiatives (CEIs) as '*announcements about self-reported corporate efforts to avoid, mitigate, or offset the environmental impacts of the firm's products, services or processes*'. This includes the announcement of green investment, integrating voluntary environmental programs (VEP), and green philanthropy. We complement this classification by including rankings and ratings. These are both delivered by third parties and permit to adopt an assessment of the firms' perceived 'greenness'. However, rankings (often) classify best performers while ratings are more inclusive. Nonetheless, they both slightly depart from green certifications since they do not request firms to follow a series of norms to keep being accredited. Please be aware that we also include self-reported green/environmental annual statements in the CEIs. We report the key features of studies after environmental awards, rankings, ratings and certifications in table 8. Those about reporting, voluntary programs, and investment initiatives are shown in table 9.

6.2.1. Awards, rankings and ratings[43]

Klassen and McLaughlin (1996) and Dasgupta *et al* (2006b) were the first to consider green awards delivered to firms with good environmental performances. Dasgupta *et al* (2001) refer to this through the terminology of 'explicit government recognition'. They find they associate with positive wealth effects. In the same vein, rankings are classifications of top environmental performers made by third parties. In this regard, Yamashita *et al* (1999) focus on firms' environmental conscientiousness scores published in *Fortune* magazine in 1993. The article reported '10 Leaders', '10 Most Improved' and '10 Laggards' according to their environmental performance from 130 of the US's largest manufacturing companies. It shows that firms did not experience any statistically significant ARs, albeit that the signs are those expected: 'The Leaders' and 'The Most Improved' companies experienced positive ARs while the 'The Laggards' had ARs on the event day.

Takeda and Tomozawa (2008) analyze the stock price reaction during 1998–2005 of the annually published environmental management ranking of the *Nikkei* newspaper. They find negative ARs from 1999 to 2000 and positive ones after 2003. To explain this market reversal, they consider that the ratification of the Kyoto protocol and the establishment of the Ministry of the Environment have been strong signals, which are thought to have incentivized this market sentiment reversal. However, using the same database but controlling with a GARCH model for the heteroskedasticity of the residuals, Yamaguchi (2008) shows

[43] Relatedly, several papers examine the impact on firm's market value of being include in (or exclude from) socially responsible (SR) indices. However, since most of these SR indices are based on ESG criteria, and do not focus on green indices, we did not consider these studies in our sample. See, for instance, Capelle-Blancard and Couderc (2009), Gladysek and Chipeta (2011), Robinson *et al* (2011), Oberndorfer *et al* (2013).

Table 9. The stock market reaction to green reports, VEP, green investments and CEI.

Authors	Event	Sample [a]	Main results (in %) [b]
Laplante and Lanoie (1994)	Green investment	N. America; 1982–91 (13; 13)	$AAR_{[0]} = -1.09^{*}$
Hall and Rieck (1998)	Green investment	US; 1982–95 (40; 40)	Recycling: $AR_{[0]} = 0.29$, Eco-friendly products: $AR_{[0]} = 1.7^{**}$
Gilley *et al* (2000)	Green investment	US; 1983–96 (71; 71)	Product-driven: $CAAR_{[-1;0]} = 0.56$; Process-driven: $CAAR_{[-1;0]} = -0.45^{*}$
Knowles-Mathur and Mathur (2000)	Green investment	US; 1989–95 (73; 73)	$CAAR_{[-10;10]} = -2.46^{***}$
Dasgupta *et al* (2001)	Green investment	S. America; 1990–94 (126; 48)	$CAAR_{[-5;1]} = -1.082$
Halme and Niskanen (2001)	Green investment	Finland; 1970–96 (64; 10)	$CAAR_{[-10;1]} = -1.99^{***}$
Grand and D'Elia (2005)	Green investment	Argentina; 1995–01 (32; 12)	Announcement: $AAR_{[2]} = 2.5148^{**}$; Inauguration: $AAR_{[-3]} = 1.9533^{*}$
Nagayama and Takeda (2006)	Green investment	Japan; 1996–04 (862; 271)	Environmental R&D: $CAAR_{[-1;2]} = 0.859^{***}$; Environmental accounting: $CAAR_{[-1;2]} = -0.437^{**}$
Callado-Muñoz and Utrero-González (2008)	Green investment	Spain; 2003–05 (102; 102)	Green philanthropy, sponsoring and R&D: Consumer Goods & Services: $CAAR_{[-7;7]} = 3.90^{***}$; Petrol: $CAAR_{[-7;7]} = -1.91^{***}$; Financial: 0.62; Industries/construction: $CAAR_{[-7;7]} = -2.74^{***}$
Jacobs *et al* (2010)	Green investment	World; 2004–06 (780; 340)	Environmental strategies: $CAAR_{[-1;0]} = 0.63^{***}$; Eco-friendly products: $CAAR_{[-1;0]} = 0.01$
Bose and Pal (2012)	Green investment	World; 1997–09 (104; 48)	Manufacturing firms: $CAAR_{[-1;1]} = 0.32^{*}$; High R&D firms: $CAAR_{[-1;1]} = 0.48^{*}$
Ba *et al* (2013)	Green investment	World; 1996–09 (261; 14)	Green vehicle: $CAAR_{[-1;1]} = 0.45^{**}$
Wassmer *et al* (2014)	Green investment	US; 2002–08 (183; 71)	$CAAR_{[-3;3]} = 0.63^{***}$
Lam *et al* (2016)	Green investment	China; 2005–14 (656; 169)	$CAAR_{[0;1]} = -0.28^{**}$
Sadovnikova and Pujari (2017)	Green investment	US; 2005–07 (190; 59)	Green marketing: $CAAR_{[-3;2]} = 0.75^{***}$; Green technology: $CAAR_{[-2;1]} = -0.39^{**}$
Byrd and Cooperman (2018)	Green investment	N. America; 2011–20 (18; 27)	Carbon capture/sequestration: Positive events: $CAAR_{[-1;1]} = 1.2^{**}$; Setbacks: $CAAR_{[-1;1]} = -0.12$
Robinson *et al* (2018)	Green investment	China; 2010–15 (NA; 10)	China Mobile Ltd: $AR_{[0]} = -1.569$; Taiwan Semiconductor: $AR_{[0]} = 0.322$
Yusoff *et al* (2006)	Green report	Malaysia; 2003 (152; 152)	Reporting: $CAAR_{[0;252]} = 0.2073$; Non reporting: $CAAR_{[0;252]} = -0.0537$
Nossa *et al* (2009)	Green report	Brazil; 1999–06 (244; 100)	$AR_{[0]} = -2$
Reddy and Gordon (2010)	Green report	Australia/N.Z.; 2003–09 (68; 68)	Australia: $CAAR_{[-1;1]} = -3.068^{***}$; New-Zealand: $CAAR_{[-1;1]} = -3.284^{***}$
Jacobs *et al* (2010)	VEP (Climate Leaders;	World; 2004–06 (780; 340)	VEP: $CAAR_{[-1;0]} = -0.95^{***}$
Fisher-Vanden and Thorburn (2011)	VEP (Ceres, Climate Leaders)	World; 1993–08 (117; 117)	Climate Leaders (2006–08): $CAAR_{[0;1]} = -0.67^{***}$; Ceres: $CAAR_{[0;1]} = 0.11$
Keele and Dehart (2011)	VEP (Climate Leaders)	US; 2002–08 (29; 29)	$CAAR_{[1;2]} = -1.23^{***}$
Kim and Lyon (2011)	VEP (CDP)	World; 2003–06 (4; 224)	GHG industries: first CDP disclosure: $CAR_{[-2;2]} = -2.8^{**}$; third CDP disclosure: $CAR_{[0;1]} = 1.05^{**}$

(Continued.)

Table 9. (Continued.)

Authors	Event	Sample [a]	Main results (in %) [b]
Yu (2012)	VEP (NEPT)	World; 2000–07 (179; 13)	Participating firms: All sample: $CAAR_{[-1;8]} = 1.34^{**}$; First event: $CAAR_{[-1;13]} = 3.71^{**}$
Lee *et al* (2015)	VEP (CDP)	Korea; 2008–09 (2; 143)	CDP Participants: $CAAR_{[-5;5]} = -6.8^{***}$; Non Participants: $CAAR_{[-5;5]} -4.1$
Dam and Petkova (2014)	VEP (CDP)	World; 2005–11 (7; 66)	$CAAR_{[-10;10]} = -3.24^{**}$
Griffin *et al* (2017)	VEP (CDP)	US; 2006–12 (7; 3460)	Disclosed GHG emissions to the CDP: $Coeff_{[-1;1]} = -1.48^{***}$
Wang *et al* (2019b)	Various CEI	US; 2005–14 (308; 308)	$CAAR_{[0;1]} = 0.73^{**}$

[a] Sample: Country; date (No. events; No. firms).
[b] $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, 1% level.

that the market reacts positively for the top ranked firms, while it penalizes the lowest ranked ones.

The *Newsweek*'s 'Green Score', which publish several rankings evaluating US or the world largest companies' green performance from 1 to 100 (best performer), is also extensively used. In 2010, the Green Score consisted of a weighted sum of three subscores: 'Environmental Impact Score', 'Green Policies Score' (GPS,) and 'Reputation Survey Score' (RSS) with a weight of 45%, 45% and 10% respectively[44]. Murguia and Lence (2015) find an increase in the market value for the world's 100 highest rated firms. This improvement is especially pronounced for the top 50 firms, non-US companies, and the firms from less polluting sectors. By considering the 2009 Newsweek green ranking of the largest 500 US firms, Cordeiro and Tewari (2015) find a positive market reaction to the raw and within-industry rankings (see also Anderson-Weir 2010). Yadav *et al* (2016) obtain similar results with the 2012 rankings. McMillan *et al* (2017) also obtained significant and positive market reactions for service industries and negative returns for manufacturing companies.

Finally, green ratings are wide-ranging third party assessment of firms' perceived 'greenness'. Cellier and Chollet (2010) and Dorfleitner *et al* (2018) examine the impact of the publication of those ratings on firms returns. They take a 'best-in-class' approach by comparing the financial performance of the best and worst eco-friendly firms. Their finding show that the worst environmental performers have higher returns.

[44] The EIS examines historical environmental performance such as GHG or SO_2 emissions or water use. The GPS is an index provided by MSCI to assess the firms' managerial performance on five major issues: climate-change policies and performance, pollution policies and performance, product impact, environmental stewardship, and management of environmental issues. Finally, the RSS is an opinion survey of CSR professionals, academics and other experts.

6.2.2. Certification

Several types of environmental certification aim at improving 'green' management practices. They usually support the implementation of green supply chain. The International Standardization Organisation (ISO) has been the most commonly covered certification. Actually, the literature studies particular ISO certification regarding the '14000' category because this evaluates firms' green management policies and procedures. The results regarding ISO 14001 certification are ambivalent: Some show negative ARs (Cañón-de-Francia *et al*, 2009, Paulraj and De Jong 2011), and others point at positive ARs (Chen 2001, Montalván *et al* 2006, Jacobs *et al* 2010).

Furthermore, Bouslah *et al* (2010) cover three types of forest certifications and the ISO 14001 certification announcements in the US and Canada. For the short run, they find insignificant market reactions for forest certifications. However, for the long run (for which event studies are not very suitable though), they arrive at a negative impact. Their results also show that financial markets seem to react differently according to the issuer of the certification. In particular, shareholders seem to penalise certifications delivered by private entities, while they do not significantly respond in case NGOs are involved in the certification process. Zhang *et al* (2017) use the announcement of the clean development mechanism projects (CDM) certifications in China. The CDM is a project under the Kyoto Protocol, which allows signatory developed countries to purchase certified emission reductions from developing ones. To do so, high-income countries can buy the certificates on financial markets or invest in projects aiming at reducing developing countries' GHG emissions. Zhang

et al (2017) find that financial markets assess CDM certification announcements positively, but this effect tends to decrease over time.

6.2.3. Environmental reports

Environmental reports refer to the publication by the firms themselves of environmental information in their financial reports. In particular, several scholars have scanned companies' 10-K, 10-Q or sustainability reports for their influence on stock market returns. For example, Yusoff *et al* (2006) use this methodology on 152 Malaysian firms and find that the disclosure in 2003 of environmental reports did not significantly enhanced the companies' share prices. However, he finds that profit and size of the firms are relevant motives for firms to disclose environmental reports. Likewise, Nossa *et al* (2009) analyse the balance sheets of 100 largest companies quoted on the Sao Paulo Stock Exchange from 1999 to 2006 to construct a social and environmental indicator. They did not find any significant market reaction. Reddy and Gordon (2010) study the publication of sustainability or environmental reports from firms in Australia and New Zealand from 2003 to 2009. They find a positive and significant market reaction to sustainability reports being published. However, they do not find any specific market reaction in case the companies publish environmental reports. Wang *et al* (2019b) examine several types of announcements and reports relative to firms' environmental projects. They find a weak but positive share price increase when a third party actually recognize the greenness of the firms. Nonetheless, financial markets do not react to announcements of any action or reports published by the firms (Wang *et al* 2019b). They also shows that more socially responsible and transparent firms regarding their CSR and environmental projects have higher returns. Nonetheless, the results also suggest that once confounding news is accounted for, the market reaction is firstly induced by the firm's financial performance, and then by its environmental efficiency. Further, Wang *et al* (2019b) find that financial markets put a higher weight on forward-looking announcements, even though this kind of action does not always translate into concrete projects.

6.2.4. VEP

VEPs, which are programs followed discretionary by companies to go beyond compliance, in order to exhibit their commitment to environmental issues. For example, the US EPA has launched the national environmental performance track (NEPT) Program in 2000. The goal of this program is to improve and assess firm's environmental performance through a series of indicators relative to climate change, clean water and land preservation. It also incentivizes firms to publish annually their progress to achieve their objectives. Yu (2012) analyses how shareholders interpret firms' announcements when signing up to the NEPT program and finds a significant and positive market reaction. He notes that companies that have invested heavily in human capital have been the main beneficiaries of these announcements. Once part of the program, these investments allow attracting highly qualified people capable of increasing the company's productivity, which can be beneficial for the company's image.

Keele and DeHart (2011) conduct a highly similar study regarding another institution launched in 2002, namely the US EPA Climate Leaders program. This program is to help firms keep track of and manage their GHG emissions. Using the announcement of the partnership between the companies and the program, they find insignificant results on the announcement day in the short run and significantly negative returns with a wider event window of two or three days. Fisher-Vanden and Thorburn (2011) study the market reaction to the integration and to subsequent announcements related to these programs. They consider the Climate Leader and the Ceres program. Ceres is a project created in 1989, which follows general principles regarding ecological awareness and accounting. In this regard, Fisher-Vanden and Thorburn (2011) find significant negative returns for both joining the Climate leader program and announcing their objective to reduce their GHG emissions. Regarding the Ceres program, they obtain insignificant ARs. Overall, Fisher-Vanden and Thorburn (2011) establish that trying to tackle environmental issues and climate change through environmental programs will not be effective in the US, because GHG emission reduction are considered to conflict with profit maximization[45].

VEP studies are also used to consider GHG emissions reduction, for example along the carbon disclosure project (CDP). Inspired by the Kyoto Protocol of 1997, GHG emissions, in particular CO_2, have been targeted for their effect on climate change. In this regard, the CDP has been launched in 2002, in response to the request of a consortium of 300 institutional investors, who asked the world's 500 largest companies to voluntarily disclose their GHG emissions and their objectives to reduce these. However, such a program is not mandatory and its impact is likely to be limited. Kim and Lyon (2011) find no effect on stock market value associated to the participation in the CDP, until Russia's ratification of the Kyoto Protocol, which caused the Protocol to go into effect. Dam and Petkova (2014) consider the participation of firms in the environmental supply chain sustainability programs of the CDP and find a low but

[45] Scholtens and Dam (2007) study the effect of banks signing up to the Equator Principles. This VEP stipulates social and environmental requirements regarding international project finance. They establish that banks who sign up are not penalized by their investors.

significant market penalty. Griffin *et al* (2017) consider a sample of nearly 2000 SEC 8 K filings that refer to GHG emissions and do not find any difference in the market response for CDP disclosers compared to CDP non-disclosers, which suggest that disclosure to the CDP makes no difference to the way shareholders assess the impact of GHG emissions on firm value. Lee *et al* (2013) show that markets sanction Korean companies that disclose their carbon emissions through the CDP. Foster and Gutierrez (2013) claim that mandatory environmental standards and voluntary certification programs are less substitutes than complements. To support their argument, they consider four Mexican firms for which a Clean Industry Certificate was granted between 2003 and 2007. They find a positive reaction of the stock market to the news about the certificate being granted.

6.2.5. Green investment

Without being part of any VEP or having committed to a specific program based on a certification, firms can also discretionarily decide to invest in green projects. In this regard, Gilley *et al* (2000) distinguish process- and product-driven environmental initiatives. Process-based initiatives are an attempt at greening the production process; they include recycling, waste management, and improved production design and delivery system practices. As a result, they limit supply chain costs, improve input management and business organization, reduce the use of hazardous materials, and decrease the likelihood of accidents. Since these investments are internal and are not widely communicated, they have less effect on reputation. Product-driven initiatives occur when firms improve or create goods and services that explicitly account for environmental externalities. These improvements are less significant due to less environmental impact than process-based innovations and can be used for greenwashing (Bénabou and Tirole 2010). For example, Hall and Rieck (1998) test the market reaction of donations, social policy, recycling (so process-driven initiatives), and environmentally-friendly products. They find that shareholders value both positively environmentally-friendly activities and recycling. A positive impact is also found by Nagayama and Takeda (2006) for environmental R&D, by Bose and Pal (2012) for green supply chain management initiatives, by Ba *et al* (2013) for green vehicle innovations, by Byrd and Cooperman (2018) for carbon capture and sequestration technology breakthroughs and by Wassmer *et al* (2014) for various CEIs. Gilley *et al* (2000) find no market reaction to green process-driven investments, but a significant increase of the share price for product-driven initiatives. In contrast, Knowles-Mathur and Mathur (2000) find no significant market reaction to green products, recycling, or appointments of environmental policy managers, and find that green promotion drive downward share prices. Mixed results are also found by Callado-Muñoz and Utrero-González (2008) for the Spanish market. Halme and Niskanen (2001) examine green investments by the Finnish forest industry from 1970 to 1996 and report an instantaneous negative impact, but followed by a price recovery. Unlike previous findings based on developed countries, Lam *et al* (2016) find that in China, shareholders react negatively to CEI announcements.

7. Conclusion

Our study reviews four decades of academic research after the response of shareholders to environmental accidents, policies, and responsibility. This is motivated by the debate about whether to regard the financial market as a friend or a foe in the struggle against environmental degradation (Tietenberg 1990, Acemoglu, 2019). Our review shows that academic research does not occur in isolation but speaks to and with society and reflects upon and engages with the transformations it undergoes.

For this 40 year period, we detected three different streams in the literature (finance, regulation, CSR), that derive inspiration from each other and result in a better understanding as to how financial markets respond to environmental performance of firms and industries. The first stream reflects on the occurrence of several dramatic industrial accidents. It relies on the finance literature driven by the EMH and provides a first estimate of the losses incurred by shareholders. The second stream, motivated by the potential magnitude of these losses, sees environmental economists taking over this topic. They propose using market forces to incentivize firms to protect the environment. This literature suggests that the traditional 'command-and-control' instruments should be complemented by market-based incentives when public disclosure is warranted. Hence, it is up to the shareholders to sanction firms, instead of public authorities. The law and economics literature shows in some cases market penalties may be even higher than fines. The third stream starts in the new millennium. Here, the topic becomes more business-oriented and the concept of market efficiency gives room to that of CSR. Further, the tone of the debate becomes more positive. In addition, the focus expands to a multitude of environmental corporate practices. Novel big data techniques support this line of research. Thus, in the 40 year period reviewed, the perspective changes from financial markets to policy, and from policy to business, as such reflecting broader societal processes.

Our literature review provides a structured setting. It is not only a narrative, but also provides analysis and additional materials, which we hope will be useful to the scientific community for further research, strategy and policy. In this regard, the references collected here are available in the form of an

online open access bibliographic database[46]. We aim to update this database. This material is designed to be used as a source and point of departure for other synthesis studies, such as meta- or bibliometric analysis, and intended to help especially young researchers progress and improve their research design and to contribute to the academic literature and societal debate.

In this review, we observe that with many environmental events, there is a response from stock market participants and that the value of the firm is affected. In particular, this is the case with eco-harmful events. Here, we find that the AARs are −2.0% in the event window. However, the median of these returns is −0.6%. For eco-friendly events, the response is even more modest. They yield on AARs of +0.2%, but the median is 0%.

The event study methodology is well-suited to establish the short-term response of the participants, but not very useful to assess the long-term impact. However, whether the response from the stock market participants is adequate to bring about change is much more difficult to assess. This is because environmental accidents are economic externalities, which by definition are hard to price. Further, applying the methodology assumes that all financial market participants have thorough understanding of the ramifications of these occurrences. This is hard to believe given the huge complexity of ecosystems, both on a local and global scale. We establish that there is a significant response, but it is small from an economic point of view. We cannot even be sure whether the direction of the market response is accurate due to the lack of appropriate metrics. The latter relates to the incongruence between management sciences and natural sciences regarding the use of denominators; the former keeps to monetary units, whereas the latter requires a smorgasbord of metrics and indicators. In the literature studied here, it is monetary units that signal the appreciation of market participants. We feel this a very poor proxy for the actual impact on the natural habitats of plants and wildlife, on ecosystems, and on health, wellbeing and livelihoods of people affected by a case such as the Brumadinho dam disaster. With the development of the study of ecosystem services and willingness-to-pay instruments, the literature tries to put a price tag on these items. This is highly useful, but we feel that using monetary values alone is not helpful to address the degradation of ecosystems as it presumes the existence of trade-offs. Monetizing and making trade-offs is the hallmark of economics and management, but we do not think it useful to transpose this tool to the natural environment and to social relations. This concern is supported by our analysis, which shows that there is no convincing evidence that financial markets can be entrusted with the responsibility of disciplining companies for their environmental performance. This results from the fact that there is insufficient theory and data as to the effects of externalities in relation to firm and industry performance and the role of financial markets and institutions in this regard. Therefore, we think multidisciplinary, and preferably interdisciplinary, research and theory is required to progress and to allow for addressing and internalizing the economic externalities.

In the beginning of our review, we questioned the place and role of financial markets in the framing of environmental policies. Our analysis does not provide support for the notion that financial markets can be put central in this regard. The often very limited market response to environmental and social harm suggests that financial market participants are not adequately equipped to gauge the impact of market externalities. Therefore, it does not seem wise to entrust them with the responsibility of disciplining companies' environmental performance. We hope and expect our review will stimulate the research about the effects of economic externalities. In particular, we encourage researchers to include non-financial performance in the analysis and to investigate the long-term effects of such externalities. Furthermore, we think it is important to relate this research to the context of the problems analysed and to acknowledge that research interests as well as methodologies used are subject to broader societal challenges.

To wrap up, it shows that we end with more questions than we started with. We establish that the financial market reaction may complement regulation but that it cannot be seen as an appropriate substitute. It shows that financial markets find it hard to translate environmental concerns to financial consequences. As a result, the market disciplining approach to environmental protection is limited, let alone that it is a force to the good. Therefore, we advocate a critical look at the societal value of CSR practices and the role of financial markets.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

Acknowledgments

The authors thank Marie-Aude Laguna and three anonymous referees for their remarks and fruitful discussions.

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[46] Bibliographic database: https://adriendesroziers.com/data-and-databases/.

References

#Alexander C R 1999 On the nature of the reputational penalty for corporate crime: evidence *J. Law Econ.* **42** 489–526

#Ananathanarayanan A 1998 Is there a green link? A panel data value event study of the relationship between capital markets and toxic releases *Working Paper* (Rutgers University)

#Anderson-Weir C H 2010 How does the stock market react to corporate environmental news? *Underg. Econ. Rev.* **6** 9

#Arora S 2001 Voluntary abatement and market value: an event study approach *Discussion Paper* 00-30 (Stanford Institute for Economic Policy Research)

#Ba S, Lisic L L, Liu Q and Stallaert J 2013 Stock market reaction to green vehicle innovation *Prod. Oper. Manage.* **22** 976–90

#Badrinath S G and Bolster P J 1996 The role of market forces in EPA Enforcement Activity *J. Regulatory Econ.* **10** 165–81

#Betzer A, Doumet M and Rinne U 2013 How policy changes affect shareholder wealth: the case of the Fukushima Dai-ichi nuclear disaster *Appl. Econ. Lett.* **20** 799–803

#Bhagat S, Bizjak J and Coles J L 1998 The shareholder wealth implications of corporate lawsuits *Financial Manage.* **27** 5–27

#Blacconiere W G and Northcut W D 1997 Environmental information and market reactions to environmental legislation *J. Account. Auditing Finance* **12** 149–78

#Blacconiere W G and Patten D M 1994 Environmental disclosures, regulatory costs, and changes in firm value *J. Account. Econ.* **18** 357–77

#Bosch J C, Eckard E W and Lee I 1998a EPA enforcement, firm response strategies, and stockholder wealth: an empirical examination *Manage. Decis. Econ.* **19** 167–77

#Bose I and Pal R 2012 Do green supply chain management initiatives impact stock prices of firms? *Decis. Support Syst.* **52** 624–34

#Bouslah K, M'Zali B, Turcotte M F and Kooli M 2010 The impact of forest certification on firm financial performance in Canada and the US *J. Bus. Ethics* **96** 551–72

#Bowen R M, Castanias R P and Daley L A 1983 Intra-industry effects of the accident at Three Mile Island *J. Financ. Quant. Anal.* **18** 87–111

#Brouwers R, Schoubben F, Van Hulle C and Van Uytbergen S 2016 The initial impact of EU ETS verification events on stock prices *Energy Policy* **94** 138–49

#Bui L 2005 Public disclosure of private information as a tool for regulating environmental emissions: firm-level responses by petroleum refineries to the toxics release inventory *Working Paper* (Brandeis University)

#Bushnell J B, Chong H and Mansur E T 2013 Profiting from regulation: evidence from the European carbon market *Am. Econ. J. Econ. Policy* **5** 78–106

#Byrd J and Cooperman E S 2018 Investors and stranded asset risk: evidence from shareholder responses to carbon capture and sequestration (CCS) events *J. Sustain. Finance Invest.* **8** 185–202

#Callado-Muñoz F and Utrero-González N 2008 Do investors react to environmental friendly news? An analysis for Spanish capital market *Corp. Ownersh. Control* **5** 315–21

#Cañón-de-francia J and Garcés-Ayerbe C 2009 ISO 14001 environmental certification: a sign valued by the market? *Environ. Resource Econ.* **44** 245–62

#Cañón-de-francia J, Garcés-Ayerbe C and Ramírez-Alesón M 2007 Are more innovative firms less vulnerable to new environmental regulation? *Environ. Resource Econ.* **36** 295–311

#Cañón-de-francia J, Garcés-Ayerbe C and Ramírez-Alesón M 2008 Analysis of the effectiveness of the first European Pollutant Emission Register (EPER) *Ecol. Econ.* **67** 83–92

#Capelle-Blancard G and Laguna M A 2008 The buncefield oil depot explosion: where there's smoke, there's (stock market) fire? *Appl. Financ. Econ. Lett.* **4** 103–7

#Capelle-Blancard G and Laguna M A 2010 How does the stock market respond to chemical disasters? *J. Environ. Econ. Manage.* **59** 192–205

#Capelle-Blancard G and Petit A 2019 Every little helps? ESG news and stock market reaction *J. Bus. Ethics* **157** 543–65

#Carpentier C and Suret J M 2015 Stock market and deterrence effect: a mid-run analysis of major environmental and non-environmental accidents *J. Environ. Econ. Manage.* **71** 1–18

#Cellier A and Chollet P 2012 The impact of corporate social responsibility on stock prices: an event study of vigeo rating announcement *Working paper*

#Chapple L, Clarkson P M and Gold D L 2013 The cost of carbon: capital market effects of the proposed emission trading scheme (ETS) *Abacus* **49** 1–33

#Chen J H 2001 ISO certification and abnormal return of stock price: the study of the Taiwan stock market *Rev. Pacific Basin Financial Markets Policies* **4** 109–26

#Cordeiro J J and Tewari M 2015 Firm characteristics, industry context, and investor reactions to environmental CSR: a stakeholder theory approach *J. Bus. Ethics* **130** 833–49

#Dam L and Petkova B N 2014 The impact of environmental supply chain sustainability programs on shareholder wealth *Int. J. Oper. Prod. Manage.* **34** 586–609

#Dasgupta S, Hong H J, Laplante B and Mamingi N 2006a Disclosure of environmental violations and the stock market in the Republic of Korea *Ecol. Econ.* **58** 759–77

#Dasgupta S, Hong H J, Laplante B and Mamingi N 2006b Firms' environmental performance: does news matter? *Policy Research Working Paper* no. WPS 3888

#Dasgupta S, Laplante B and Mamingi N 2001 Pollution and capital markets in developing countries *J. Environ. Econ. Manage.* **42** 310–35

#Deák Z and Karali B 2014 Stock market reactions to environmental news in the food industry *J. Agric. And Appl. Econ.* **46** 209–25

#Diltz J D 2002 US equity markets and environmental policy. The case of electric utility investor behavior during the passage of the Clean Air Act Amendments of 1990 *Environ. Resource Econ.* **23** 379–401

#Dorfleitner G, Utz S and Wimmer M 2018 Patience pays off–corporate social responsibility and long-term stock returns *J. Sustain. Finance Invest.* **8** 132–57

#Feria-Domínguez J, Jiménez-Rodríguez E and Merino I 2016 Financial perceptions on oil spill disasters: isolating corporate reputational risk *Sustainability* **8** 1090

#Ferstl R, Utz S and Wimmer M 2012 The effect of the Japan 2011 disaster on nuclear and alternative energy stocks worldwide: an event study *Bus. Res.* **5** 25–41

#Fields A and Janjigian V 1989 The effect of Chernobyl on electric-utility stock prices *J. Bus. Res.* **l8** 81–88

#Fisher-Vanden K and Thorburn K S 2011 Voluntary corporate environmental initiatives and shareholder wealth *J. Environ. Econ. Manage.* **62** 430–45

#Flammer C 2013 Corporate social responsibility and shareholder reaction: the environmental awareness of investors *Acad. Manage. J.* **56** 758–81

#Foster A D and Gutierrez E 2013 The informational role of voluntary certification: evidence from the Mexican clean industry program *Am. Econ. Rev.* **103** 303–8

#Fracarolli Nunes M 2018 Supply chain contamination: an exploratory approach on the collateral effects of negative corporate events *Eur. Manage. J.* **36** 573–87

#Fracarolli Nunes M and Lee Park C 2016 Caught red-handed: the cost of the Volkswagen Dieselgate *J. Glob. Responsibility* **7** 288–302

#Freedman M and Patten D M 2004 Evidence on the pernicious effect of financial report environmental disclosure *Account. Forum* **28** 27–41

#Gilley K M, Worrell D L, Davidson III W N and El-Jelly A 2000 Corporate environmental initiatives and anticipated firm performance: the differential effects of processdriven versus product-driven greening initiatives *J. Manage.* **26** 1199–216

#Grand M C and D'Elia V V 2005 Environmental news and stock markets performance: further evidence for argentina *Working Paper* (Universidad del CEMA)

#Griffin P A, Lont D H and Sun E Y 2017 The relevance to investors of greenhouse gas emission disclosures *Contemp. Account. Res.* **34** 1265–97
#Guo M, Kuai Y and Liu X 2020 Stock market response to environmental policies: evidence from heavily polluting firms in China *Econ. Model.* **86** 306–16
#Gupta S and Goldar B 2005 Do stock markets penalize environment-unfriendly behaviour? Evidence from India *Ecol. Econ.* **52** 81–95
#Hall P L and Rieck R 1998 The effect of positive corporate social actions on shareholder wealth *J. Financ. Strateg. Decisions* **11** 83–89
#Halme M and Niskanen J 2001 Does corporate environmental protection increase or decrease shareholder value? The case of environmental investments *Bus. Strategy Environ.* **10** 200–14
#Hamilton J T 1995 Pollution as news: media and stock market reactions to the toxic release inventory data *J. Environ. Econ. Manage.* **28** 98–103
#Haslem B, Hutton I and Smith A H 2017 How much do corporate defendants really lose? A new verdict on the reputation loss induced by corporate litigation *Financial Manage.* **46** 323–58
#Heflin F and Wallace D 2017 The BP oil spill: shareholder wealth effects and environmental disclosures *J. Bus. Finance Account.* **44** 337–74
#Herbst A F, Marshall J F and Wingender J 1996 An analysis of the stock market's response to the Exxon Valdez disaster *Glob. Finance J.* **7** 101–14
#Hill J and Schneeweis T 1983 The effect of Three Mile Island on electric utility stock prices: a note *J. Finance* **38** 1285–92
#Hsu A W H and Wang T 2013 Does the market value corporate response to climate change? *Omega* **41** 195–206
#Huang H, Wu D and Gaya J 2017 Chinese shareholders' reaction to the disclosure of environmental violations: a CSR perspective *Int. J. Corp. Soc. Responsibility* **2** 12
#Jacobs B W, Singhal V R and Subramanian R 2010 An empirical investigation of environmental performance and the market value of the firm *J. Oper. Manage.* **28** 430–41
#Jiang Y and Luo L 2018 Market reactions to environmental policies: evidence from China *Corp. Soc. Responsib. Environ. Manage.* **25** 889–903
#Johnston D M, Sefcik S E and Soderstrom N E 2008 The value relevance of greenhouse gas emissions allowances: an exploratory study in the related US SO_2 market *Eur. Account. Rev.* **17** 747–64
#Jones K and Rubin P H 2001 Effects of harmful environmental events on reputations of firms *Advances in Financial Economics* vol **6**, ed M Hirschey, K John and A Makhija (Bingley: Emerald) pp 161–82
#Jong T, Couwenberg O and Woerdman E 2014 Does EU emissions trading bite? An event study *Energy Policy* **69** 510–9
#Kalra R, Hendersonc G V and Raines G A 1993 Effects of the Chernobyl nuclear accident on utility share prices *Q. J. Bus. Econ.* **32** 52–78
#Kalra R, Hendersonc G V and Raines G A 1995 Contagion Effects in the Chemical Industry following the Bhopal disaster *J. Financ. Strateg. Decisions* **8** 1–11
#Karpoff J M, Lott J R and Rankine G 1998 Environmental violations, legal penalties, and reputation costs *John M. Olin Law Economics Working Paper No.* 71 p 22
#Karpoff J M, Lott, Jr. J R and Wehrly E W 2005 The reputational penalties for environmental violations: empirical evidence *J. Law Econ.* **48** 653–75
#Katsikides S, Markoulis S and Papaminas M 2016 Corporate social responsibility and stock market performance: an event study approach *Int. J. Eng. Adv. Technol.* **6** 1–8
#Kawashima S and Takeda F 2012 The effect of the Fukushima nuclear accident on stock prices of electric power utilities in Japan *Energy Econ.* **34** 2029–38
#Keele D M and DeHart S 2011 Partners of USEPA climate leaders: an event study on stock performance *Bus. Strategy Environ.* **20** 485–97
#Khanna M, Quimio W R H and Bojilova D 1998 Toxic release information: a policy tool for environmental protection *J. Environ. Econ. Manage.* **36** 243–66
#Kim E H and Lyon T 2011 When does institutional investor activism increase shareholder value? The carbon disclosure project *BE J. Econ. Anal. Policy* **11** 311–26
#Klassen R D and McLaughlin C P 1996 The impact of environmental management on firm performance *Manage. Sci.* **42** 1199–214
#Knowles-Mathur L K and Mathur I 2000 An analysis of the wealth effects of green marketing strategies *J. Bus. Res.* **50** 193–200
#Koda Y 2016 Do peers get punished: stock market effect of BP oil spill on peers *J. Environ. Resource Econ. Colby* **3** 9
#Konar S and Cohen M A 1997 Information as regulation: the effect of community right to know laws on toxic emissions *J. Environ. Econ. Manage.* **32** 109–24
#Kong D, Liu S and Dai Y 2014 Environmental policy, company environment protection, and stock market performance: evidence from China *Corp. Soc. Responsib. Environ. Manage.* **21** 100–12
#Kowalewski O and Śpiewanowski P 2020 Stock market response to potash mine disasters *J. Commodity Markets* **20** 100124
#Krueger P 2015 Corporate goodness and shareholder wealth *J. Financ. Econ.* **115** 304–29
#Lam H K, Yeung A C, Cheng T C E and Humphreys P K 2016 Corporate environmental initiatives in the Chinese context: performance implications and contextual factors *Int. J. Prod. Econ.* **180** 48–56
#Lanoie P, Laplante B and Roy M 1998 Can capital markets create incentives for pollution control? *Ecol. Econ.* **26** 31–41
#Laplante B and Lanoie P 1994 The market response to environmental incidents in Canada: a theoretical and empirical analysis *South Econ. J.* **60** 657–72
#Lee S Y, Park Y S and Klassen R D 2015 Market responses to firms' voluntary climate change information disclosure and carbon communication *Corp. Soc. Responsib. Environ. Manage.* **22** 1–12
#Li B and Wu K 2017 The price of environmental sustainability: empirical evidence from stock market performance in China *Sustainability* **9** 1452
#Little P, Muoghalu M I and Robison H D 1995 Hazardous waste lawsuits, financial disclosure, and investors' interests *J. Account. Auditing Finance* **10** 383–98
#Lo C K, Tang C S, Zhou Y, Yeung A C and Fan D 2018 Environmental incidents and the market value of firms: an empirical investigation in the Chinese context *Manuf. Service Oper. Manage.* **20** 422–39
#Lo K Y and Kwan C L 2017 The effect of environmental, social, governance and sustainability initiatives on stock value: examining market response to initiatives undertaken by listed companies *Corp. Soc. Responsib. Environ. Manage.* **24** 606–19
#Lopatta K and Kaspereit T 2014 The cross-section of returns, benchmark model parameters, and idiosyncratic volatility of nuclear energy firms after Fukushima Daiichi *Energy Econ.* **41** 125–36
#Lorraine N H J, Collison D J and Power D M 2004 An analysis of the stock market impact of environmental performance information *Account. Forum* **28** 7–26
#Lundgren T and Olsson R 2009 How bad is bad news? Assessing the effects of environmental incidents on firm value *Am. J. Finance Account.* **1** 376–92
#Lundgren T and Olsson R 2010 Environmental incidents and firm value: international evidence using a multi-factor event study framework *Appl. Financ. Econ.* **20** 1293–307
#Luo L and Tang Q 2014 Carbon tax, corporate carbon profile and financial return *Pacific Account. Rev.* **26** 353–73

#Lyon T, Lu Y, Shi X and Yin Q 2013 How do investors respond to green company awards in China? *Ecol. Econ.* **94** 1–8
#Magness V 2009 Environmental disclosure in the mining industry: a signaling paradox? *Adv. Environ. Account. Manage.* **4** 55–81
#Makino R 2016 Stock market responses to chemical accidents in Japan: an event study *J. Loss Prev. Process Ind.* **44** 453–8
#Mansur I, Cochran S J and Phillips J E 1991 The relationship between the equity return levels of oil companies and unanticipated events: the case of the Exxon Valdez incident *Logist. Transp. Rev.* **38** 241–55
#McMillan A, Dunne T C, Aaron J R and Cline B N 2017 Environmental management's impact on market value: rewards and punishments *Corp. Reput. Rev.* **20** 105–22
#Montalván S M and Chang J T 2006 Is there a market payoff for being green at the lima stock exchange? *Sustainability Accounting and Reporting* ed S Schaltegger, M Bennet and R Burrit (London: Springer) pp 251–80
#Muoghalu M, Robison H D and Glascock J L 1990 Hazardous waste lawsuits, stockholder returns, and deterrence *South Econ. J.* **7** 357–70
#Murguia J M and Lence S H 2015 Investors' reaction to environmental performance: a global perspective of the Newsweek's 'Green Rankings' *Environ. Resource Econ.* **60** 583–605
#Nagayama S and Takeda F *2006* An empirical study on the impact of environmentally friendly news on stock prices in Japan *Asia-Pacific Economic Association 2006 Meeting*
#Nossa V, Cezar J F, Da Silva Júnior A, Baptista É C S and Nossa S N 2009 The relationship between abnormal returns and social and environmental responsibility: an empirical study of companies traded on the bovespa from 1999 to 2006 *Brazilian Bus. Rev.* **6** 117–31
#Paulraj A and De Jong P 2011 The effect of ISO 14001 certification announcements on stock performance *Int. J. Oper. Prod. Manage.* **31** 765–88
#Pham H N A, Nguyen V, Ramiah V, Saleem K and Moosa N 2019 The effects of the Paris climate agreement on stock markets: evidence from the German stock market *Appl. Econ.* **51** 6068–75
#Pham H N A, Ramiah V and Moosa I 2020 The effects of environmental regulation on the stock market: the French experience *Account Finance* **60** 3279–304
#Philipich K 2018 The impact of EPA regulation and US supreme court oversight on the shareholders of US utilities utilizing coal *Evolving Energy Realities: Adapting to What's Next, 36th USAEE/IAEE North American Conf. (23-26 September 2018)* (International Association for Energy Economics)
#Ramiah V, Martin B and Moosa I 2013 How does the stock market react to the announcement of green policies? *J. Banking Finance* **37** 1747–58
#Ramiah V, Pichelli J and Moosa I 2015 Environmental regulation, the Obama effect and the stock market: some empirical results *Appl. Econ.* **47** 725–38
#Rao S M 1996 The effect of published reports of environmental pollution on stock prices *J. Financ. Strategic Decis.* **9** 25–32
#Reddy K and Gordon L 2010 The effect of sustainability reporting on financial performance: an empirical study using listed companies *J. Asia Entrepreneurship Sustain.* **6** 19–42
#Robinson J, Glean A and Moore W 2018 How does news impact on the stock prices of green firms in emerging markets? *Res. Int. Bus. Finance* **45** 446–53
#Sabet S A H, Cam M A and Heaney R 2012 Share market reaction to the BP oil spill and the US government moratorium on exploration *Aust. J. Manage.* **37** 61–76
#Sadovnikova A and Pujari A 2017 The effect of green partnerships on firm value *J. Acad. Marketing Sci.* **45** 251–67
#Salinger M 1992 Value event studies *Rev. Econ. Stat.* **74** 671–7
#Sam A and Zhang X 2020 Firm size, political connections, and the value relevance of environmental enforcement in China *Working paper*
#Sarumpaet S and Hendrawaty E 2017 Market reactions to corporate unethical behaviors: a study from Indonesia *Working paper*
#Schütze F, Aleksovski D and Mozetic I 2018 Stock market reactions to international climate negotiations *Working paper*
#Shane P and Spicer B 1983 Market response to environmental information produced outside the firm *Account. Rev.* **58** 521–38
#Takeda F and Tomozawa T 2008 A change in market responses to the environmental management ranking in Japan *Ecol. Econ.* **67** 465–72
#Tamechika H and Okuda S Y 2017 Stock price responses to the eco-points programme for electrical household appliances: evidence from Japan *Appl. Econ.* **49** 5856–64
#Tian M, Xu G and Zhang L 2019 Does environmental inspection led by central government undermine Chinese heavy-polluting firms' stock value? The buffer role of political connection *J. Clean. Prod.* **236** 117695
#Wang C, Zhang H, Lu L, Wang X and Song Z 2019a Pollution and corporate valuation: evidence from China *Appl. Econ.* **51** 3516–30
#Wang Y, Delgado M S, Khanna N and Bogan V L 2019b Good news for environmental self-regulation? Finding the right link *J. Environ. Econ. Manage.* **94** 217–35
#Wassmer U, Cueto D C and Switzer L N 2014 The effect of corporate environmental initiatives on firm value: evidence from fortune 500 firms *M@n@gement* **17** 1–19
#Wei Z, Xie F and Posthuma R A 2011 Does it pay to pollute? Shareholder wealth consequences of corporate environmental lawsuits *Int. Rev. Law Econ.* **31** 212–8
#White M A 1996 *Investor Response to the Exxon Valdez Oil Spill* (Charlottesville, VA: McIntire School of Commerce, University of Virginia)
#Wood L C, Wang J X, Duong L N, Reiners T and Smith R 2018 Stock market reactions to auto manufacturers' environmental failures *J. Macromarketing* **38** 364–82
#Xu X D, Zeng S X and Tam C M 2012 Stock market's reaction to disclosure of environmental violations: evidence from China *J. Bus. Ethics* **107** 227–37
#Xu X D, Zeng S X, Zou H L and Shi J J 2016 The impact of corporate environmental violation on shareholders' wealth: a perspective taken from media coverage *Bus. Strategy Environ.* **25** 73–91
#Yadav P L, Han S H and Rho J J 2016 Impact of environmental performance on firm value for sustainable investment: evidence from large US firms *Bus. Strategy Environ.* **25** 402–20
#Yamaguchi K 2008 Reexamination of stock price reaction to environmental performance: a GARCH application *Ecol. Econ.* **68** 345–52
#Yamashita M, Sen S and Roberts M C 1999 The rewards for environmental conscientiousness in the US capital markets *J. Financ. Strateg. Decisions* **12** 73–82
#Yu F 2012 Participation of firms in voluntary environmental protection programs: an analysis of corporate social responsibility and capital market performance *Contemp. Econ. Policy* **30** 13–28
#Yusoff R, Rahman S and Wan Mohamed W N 2006 The economic consequences of voluntary environmental reporting on shareholder wealth *Soc. Manage. Res. J.* **3** 1–23
#Zhang B, Lai K H, Wang B and Wang Z 2017 Shareholder value effects of corporate carbon trading: empirical evidence from market reaction towards clean development mechanism in China *Energy Policy* **110** 410–21
#Zhao X, Fan Y, Fang M and Hua Z 2018 Do environmental regulations undermine energy firm performance? An empirical analysis from China's stock market *Energy Res. Soc. Sci.* **40** 220–31
#Zhou H and Yin H 2018 Stock market reactions to environmental disclosures: new evidence from China *Appl. Econ. Lett.* **25** 910–3

Acemoglou D 2019 Are the climate kids right? *Project Syndicate* **5** (https://www.project-syndicate.org/commentary/climate-change-economic-growth-by-daron-acemoglu-2019-11)
Aerts W, Cormier D and Magnan M 2008 Corporate environmental disclosure, financial markets and the media: an international perspective *Ecol. Econ.* **64** 643–59
Aldy J E, Auffhammer M, Cropper M L, Fraas A G and Morgenstern R 2020 Looking back at fifty years of the Clean Air Act *NBER Working Paper* No. 26687
Baginski S P, Corbett R B and Ortega W R 1991 Catastrophic events and retroactive liability insurance: the case of the MGM grand fire *J. Risk Insurance* **58** 247–60
Barrett W B, Heuson A J and Kolb R W 1986 The effect of Three Mile Island on utility bond risk premia: a note *J. Finance* **41** 255–61
Bebbington J, Schneider T, Stevenson L and Fox A 2020 Fossil fuel reserves and resources reporting and unburnable carbon: investigating conflicting accounts *Crit. Perspect. Account.* **66** 102083
Bénabou R and Tirole J 2010 Individual and corporate social responsibility *Economica* **77** 1–19
Berg F, Kölbel J and Rigobon R 2019 Aggregate confusion: the divergence of ESG ratings *MIT Sloan Research Paper No.* 5822-19
Bergquist A-K, Söderholm K, Kinneryd H, Lindmark M and Söderholm P 2013 Command-and-control revisited: environmental compliance and technological change in Swedish industry 1970–1990 *Ecol. Econ.* **85** 6–19
Biais B, Mariotti T, Rochet J and Villeneuve S 2010 Large risks, limited liability, and dynamic moral hazard *Econometrica* **78** 73–118
Borenstein S and Zimmerman M B 1988 Market incentives for safe commercial airline operation *Am. Econ. Rev.* **78** 913–35
Bosch J C, Eckard E W and Singal V 1998b The competitive impact of air crashes: stock market evidence *J. Law Econ.* **41** 503–19
Brans H and Scholtens B 2020 Under his thumb. The effect of President Donald Trump's Twitter messages on the US stock market *PLoS One* **15** 0229931
Broder I E and Morall III J F 1991 Incentives to provide safety: regulatory authority and capital market reactions *J. Regulatory Econ.* **3** 309–22
Brooks L D and D'Souza R E 1982 Electric utility returns and risk in the light of Three Mile Island *Public Util. Fortnightly November* **11** 26–32
Brown S J and Warner J B 1980 Measuring security price performance *J. Fnanc. Econ.* **8** 205–58
Brown S J and Warner J B 1985 Using daily stock returns: the case of event studies *J. Financ. Econ.* **14** 3–31
Capelle-Blancard G and Couderc N 2009 The impact of socially responsible investing: evidence from stock index redefinitions *J. Invest.* **18** 76–86
Capelle-Blancard G and Monjon S 2012 Trends in the literature on socially responsible investment: looking for the keys under the lamppost *Bus. Ethics* **21** 239–50
Carpentier C and Suret J 2021 On the Rationality of Institutional Investors: The Case of Major Industrial Accidents *J. Behav. Finance* **22** 289–305
Chen C R 1984 The structural stability of the market model after the Three Mile Island accident *J. Econ. Bus.* **36** 133–40
Cormier D and Magnan M 2007 The revisited contribution of environmental reporting to investors' valuation of a firm's earnings: an international perspective *Ecol. Econ.* **62** 613–26
Cram D and Koehler D 2001 *Pollution as News: Controlling for Contemporaneous Correlation of Returns in Event Studies of Toxic Release Inventory Reporting* (Harvard School of Public Health Working paper)
Cropper M L and Oates W E 1992 Environmental economics: a survey *J. Econ. Lit.* **30** 675–740
Delmas M A and Burbano V C 2011 The drivers of greenwashing *Calif. Manage. Rev.* **54** 64–87
Ding L, Lam H, Cheng T C E and Zhou H 2018 A review of short-term event studies in operations and supply chain management *Int. J. Prod. Econ.* **200** 329–42
Fama E, Fisher L, Jensen M and Roll R 1969 The adjustment of stock prices to new information *Int. Econ. Rev.* **10** 1–21
Fink J D, Fink K E and Russell A 2010 When and how do tropical storms affect markets? The case of refined petroleum *Energy Econ.* **32** 1283–90
Fraser D R and Kolari J W 1983 Effects of Three Mile Island on nuclear and non- nuclear dependent utilities *J. Midwest Finance Assoc.* **12** 1285–92
Freeman R E and Liedtka J 1991 Corporate social responsibility: a critical approach *Bus. Horiz.* **34** 92–99
Friedman M 1970 The social responsibility of business is to enhance its profits *New York Times* (Chicago, IL: University of Chicago Press) pp 173–78
Gladysek O and Chipeta C 2011 The impact of socially responsible investment index constituent announcements on firm price: evidence from the JSE *South African J. Econ. Manage. Sci.* **15** 429–39
Grad F and Rockett L 1970 Environmental litigation—where the action is? *Nat. Resour. J.* **10** 742–62
Grossman S J and Stiglitz J E 1980 On the impossibility of informationally efficient markets *Am. Econ. Rev.* **70** 393–408
Hart O and Zingales L 2017 Companies should maximize shareholder welfare not market value *J. Law Finance Account.* **2** 247–74
Heal G 2008 *When Principles Pay: Corporate Social Responsibility and the Bottom Line* (New York: Columbia University)
Healy P M and Palepu K G 2001 Information asymmetry, corporate disclosure, and the capital markets: A review of the empirical disclosure literature *J. Account. Econ.* **31** 405–40
Jacobs B W and Singhal V R 2017 The effect of the Rana Plaza disaster on shareholder wealth of retailers: implications for sourcing strategies and supply chain governance *J. Oper. Manage.* **49-51** 52–66
Jones J D, Jones C L and Phillips-Patrick F 1994 Estimating the costs of the Exxon-Valdez oil spill *Res. Law Econ.* **16** 109–49
Khanna M 2001 Non-mandatory approaches to environmental protection *J. Econ. Surv.* **15** 291–324
Kinderman D 2012 'Free us up so we can be responsible!' the co-evolution of corporate social responsibility and neo-liberalism in the UK, 1977–2010 *Soc. Econ. Rev.* **10** 29–57
Konar S and Cohen M A 2001 Does the Market Value Environmental Performance? *Rev Econ Stat.* **83** 281–89
Kotchen M 2013 Voluntary- and information-based approaches to environmental management: a public economics perspective *Rev. Environ. Econ. Policy* **7** 276–95
Kotchen M and Moon J J 2012 Corporate social responsibility for irresponsibility *The BE J. Econ. Anal. Policy Contributions* **12**
Kothari S and Warner J 2006 Econometrics of event studies *Handbook of Empirical Corporate Finance* ed E Eckbo (Amsterdam: Elsevier) 3–36
Lyon T and Maxwell J 2011 Greenwash: corporate environmental disclosure under threat of audit *J. Econ. Manage. Strategy* **20** 3–41
MacKinlay A C 1997 Event studies in economics and finance *J. Econ. Lit.* **35** 13–39
Malkiel B G and Fama E F 1970 Efficient capital markets. A review of theory and empirical work *J. Finance* **25** 383–417
Mayers D and Smith C W 1982 On the corporate demand for insurance *Foundations of Insurance Economics* (*Huebner International Series on Risk, Insurance and Economic Security*) ed G Dionne and S E Harrington (Berlin: Springer) p 14
Mitchell M and Maloney M 1989 Crisis in the cockpit? The role of market forces in promoting air travel safety *J. Law Econ.* **32** 329–55

Mukherji S 2011 Are stock returns still mean-reverting *Rev. Financial Econ.* **20** 22–27
Oberndorfer U, Schmidt P, Wagner M and Ziegler A 2013 Does the stock market value the inclusion in a sustainability stock index? An event study analysis for German firms *J. Environ. Econ. Manage.* **66** 497–509
Pettway R H 1981 The effects of the Three Mile island accident upon risk perceptions of investors in public utility shares *Working Paper* (Public Utility Research Center, University of Florida) p 23
Pruitt S W, Tawarangkoon W and Wei J K C 1987 Chernobyl, commodity, and chaos: an examination of the reaction of commodity futures prices to evolving information *J. Futures Markets* **7** 556–69
Robinson M, Kleffner A and Bertels S 2011 Signaling sustainability leadership: empirical evidence of the value of DJSI membership *J. Bus. Ethics* **101** 493–505
Rothwell G S 1989 Stock market reaction to nuclear reactor failures *Contemp. Econ. Policy* **3** 96–106
Roulet T J and Touboul S 2015 The Intentions with which the road is paved: attitudes to liberalism as determinants of greenwashing *J. Bus. Ethics* **128** 305–20
Schmalensee R and Stavins R N 2019 Policy evolution under the Clean Air Act *J. Econ. Perspect.* **33** 27–50
Scholtens B and Dam L 2007 Banking on the equator. are banks that adopted the equator principles different from non-adopters? *World Dev.* **35** 1307–28
Scholtens B and Voorhorst Y 2013 The impact of earthquake on the domestic stock market *Earthq. Spectra* **29** 325–37
Seetharam I 2017 Environmental disasters and stock market performance *Working paper* (Stanford University)
Shavell S 2007 Liability for accidents *Handbook Law Econ.* **1** 139–82
Shelor R M, Anderson D C and Cross M L 1990 The impact of the California earthquake on real estate firms' stock value *J. Real Estate Res.* **5** 335–40
Smith C W and Stulz R M 1985 The Determinants of Firms' Hedging Policies *J. Financial Quant. Anal.* **20** 391–405
Smith L C, Smith M and Ashcroft P 2011 Analysis of environmental and economic damages from British Petroleum's Deepwater Horizon oil spill *Albany Law Rev.* **74** 563–85
Sprecher C R and Pertl M A 1983 Large losses, risk management and stock prices *J. Risk Insurance* **50** 107–17
Spudeck R E and Moyer C 1989 A note on the stock market's reaction to the accident at Three Mile Island *J. Econ. Bus.* **41** 235–41
Stavins R N 1989 Harnessing market forces to protect the environment *Overcoming Indifference: Ten Key Challenges in Today's Changing World* ed K Schwab (New York: New York University Press)
Stiglitz J 2019 The end of neoliberalism and the rebirth of history *Project Syndicate* **4** (https://economics.utoronto.ca/gindart/2019-11-04%20-%20The%20end%20of%20neoliberalism%20and%20the%20rebirth%20of%20history.pdf)
The symbol # indicates academic papers which examine the impact of environmental events on firm's stock market value, using the event study methodology. These papers are presented in the Online Appendix.
Tietenberg T H 1990 Economic instruments for environmental regulation *Oxford Rev. Econ. Policy* **6** 17–33
Tietenberg T H 1998 Disclosure strategies for pollution control *Environ. Resource Econ.* **11** 587–602
Tietenberg T H and Lewis L 2018 *Environmental and Natural Resource Economics* 11th edn (New York: Routledge)
Tirole J 2006 *The Theory of Corporate Finance* (Princeton, NJ: Princeton University)
Walker T, Thiengtham D J and Lin M Y 2005 On the performance of airlines and airplane manufacturers following aviation disasters *Can. J. Administrative Sci.* **22** 21–34
Worthington A and Valadkhani A 2004 Measuring the impact of natural disasters on capital markets: an empirical application using intervention analysis *Appl. Econ.* **36** 2177–86
Zerbib O D 2019 The effect of pro-environmental preferences on bond prices: evidence from green bonds *J. Banking Finance* **98** 39–60
Zimmerman M B 1983 The valuation of nuclear power in the post-Three Mile Island era *Energy J.* **4** 15–29
Zingales L 2015 Presidential address: does finance benefit society? *J. Finance* **70** 1327–63