The impact of a spill or pollution accident on firm environmental activity: An empirical investigation

Abstract: Spill and pollution (SP) accidents cause significant damage to the natural environment. They also result in financial costs and reputational losses for the offending firm. As such, understanding how firms respond to such crises is of significant interest to firm stakeholders, such as investors, customers, regulators, NGOs, employees, and local communities. In this study, we examine whether publicly disclosed SP accidents cause firms to alter their approach to environmental management, as expressed by the adoption of environmental management practices (EMPs). Using a unique panel data from 2002 to 2013, representing over 400 publicly-traded US manufacturing firms, we find that in the absence of a SP accident, firms adopt more EMPs each year. However, when firms experience a SP accident they respond in surprising ways: while sustainability leading firms do not alter their existing approach to EMP adoption, regardless of the severity of the accident, all other firms do. Firms which are not sustainability leaders *escalate* the number of EMPs they adopt after low severity accidents and *de-escalate* the number of EMPs they adopt after high severity accidents. We also find that de-escalation can last for up to three years and firms do not seem to recover from de-escalation in future years. Finally, incurring more accidents or more severe accidents leads to greater de-escalation. Given that the number of EMPs firms adopt determines a firm's environmental performance, de-escalation can have significant negative consequences for both the natural environment and firms themselves.

1. Introduction

Spill and pollution (SP) accidents such as the Bhopal Gas Tragedy, Exxon-Valdez Oil Spill, Chernobyl Disaster and Deepwater Horizon Oil Spill have lasting economic, social and environmental impacts. For example, the Deepwater Horizon Oil Spill (also known as the BP Oil Spill) discharged more than 4.5 million barrels of toxic oil in the Gulf of Mexico, which affected over 8000 species of flora and fauna and caused eleven deaths. It cost BP $18.7 billion, the largest corporate settlement in U.S. history. Similar accidents of varying severity are reported regularly in the public media and generate negative publicity for firms. They also damage share price and market values (Endrikat 2016, Flammer 2013, Karpoff et al. 2008, Klassen and McLaughlin 1996) and may negatively impact a firm's reputation (Flammer 2013). In fact, publicized sustainability accidents wiped $500B off the value of U.S. companies from 2015 – 2019 ("ESG Controversies" 2019). As profit seeking entities, firms are expected to address SP accidents by presenting an appropriate set of actions to firm stakeholders which reduce the possibility of similar events occurring in the future. These actions include examining the firm's existing approach to environmental management, as expressed through the adoption of environmental management practices (EMPs), and subsequently adjusting that approach in current or future years. In choosing an approach, firms must wrestle with competing priorities. On one hand, they may need to maintain or increase annual investments in EMP adoption to address deficiencies in their existing environmental management system. On the other hand, they may need to pay for unplanned fines and clean-up costs associated with the accident. Doing both may be challenging, if not impossible. The ultimate choice they make has significant ramifications for the natural environment and firm.

EMPs are the techniques, policies, and procedures a firm uses to monitor and control the impact of its operations on the natural environment (Montabon et al. 2007). The adopted EMPs form the backbone of a firm's environmental management system (EMS), which in-turn regulates a firm's environmental performance (Khanna and Anton 2002). In the absence of a SP accident, our data shows that firms steadily adopt more EMPs each year. However, it is not clear whether or how firms adjust their approach to EMP adoption following a SP accident. Escalating the existing annual increases in EMP adoption in response to an accident would make logical sense because it might strengthen a firm's EMS (Anton et al. 2004), improving its ability to prevent a future accident. It might also increase legitimacy with key stakeholders at a time when a firm's reputation may be at risk (Bansal and Clelland 2004). However, escalation would require investment of scarce labor and financial resources at a time when incremental resources may already be needed to address fallout from the accident (fines, clean-up costs, reputation management costs). For example, Mosaic Fertilizer incurred $2B in remediation and clean-up costs, fines, and penalties for improper waste management related to their phosphate mining and production operations in Florida and Louisiana (Valentine 2015). Similarly, Tyson Foods agreed to pay almost $4M in fines and penalties related to violations of the Clean Air Act at several of its production facilities (U.S. EPA 2013a).

Alternately, firms may respond to a SP accident by de-escalating annual increases in adoption. De-escalation could be the preferred option because managers prefer conservative options in times of crisis (Staw et al. 1981). It could also be the preferred option because managers may cannibalize EMP adoption budgets to cover costs associated with the accident. De-escalation would conserve valuable resources while the firm analyzes root cause and addresses weaknesses with their current environmental strategy (Schroeder et al. 2008). As a final option, firms may respond to a SP accident by continuing with their existing pattern of annual increases in EMP adoption. They would choose this approach because they are confident the current approach maximizes environmental performance or minimizes the risk of a future accident (Judge et al. 1998, Schulz-Hardt et al. 2009). Of the three options, escalation would be the preferred response by regulators and environmental stakeholders because the number of EMPs a firm adopts is directly related to environmental performance (Anton et al. 2004, Hartmann and Vachon 2018, Klassen and Whybark 1999, Potoski and Prakash 2005, Toffel 2005). Conversely, de-escalation would be of concern because it results in firms adopting fewer EMPs in the current year, and possibly future years, than they would have adopted in the absence of an accident, with potentially significant negative ramifications for environmental performance.

The primary objective of this study is to investigate the conditions under which firms choose among the varied options in response to a publicly-disclosed SP accident. We examine the following questions: First, does a SP accident cause a firm to change their existing approach to EMP adoption? Second, do underlying characteristics of the accident, such as the cumulative frequency or severity, impact this relationship? Third, do firm characteristics, such as their approach to sustainability, moderate the firm's response to an accident? Finally, if firms do alter their approach to EMP adoption following a SP accident, how long does the effect last? Using a unique panel data from 2002 to 2013 representing over 400 publicly-traded US manufacturing firms and rigorous econometric methods, we find that in the absence of a SP accident firms in all industry-sectors steadily adopt more EMPs each year. However, following an accident, firms behave in surprising ways. Sustainability leading firms (i.e., those with an exemplary sustainability record) do not alter their approach to EMP adoption, i.e., they stay on course, irrespective of the number of accidents incurred or the severity of the accidents. In contrast, the response from all other firms is contingent on the severity of the accident. They *escalate* the number of EMPs they adopt following low severity accidents and *de-escalate* the number of EMPs they adopt following more severe accidents. Because relatively few firms are considered to be sustainability leaders and the vast majority of SP accidents are higher severity, the risk of de-escalation following a SP accident is high. Further, de-escalation can last for up to three years. Since firms do not seem to recover from de-escalation in future years, the decision to de-escalate can have significant negative implications for both short- and long-term firm environmental performance. The findings serve as a cautionary tale for regulators, NGOs, concerned citizens, and environmental stakeholders of all types.

The results are robust to various econometric specifications, alternate measures of key variables, and panel choice, and make significant contributions to theory and practice. For managers, should de-escalating EMP adoption following a SP accident not be a deliberate choice (e.g., a natural reaction to resource constraints), making them aware of the environmental risk associated with de-escalation may be sufficient to spur voluntary action on their part to minimize or avoid it. For policy-makers, we identify a limitation of traditional command-and-control regulatory approaches for managing firm environmental performance. While regulation might motivate firms to resolve the existing accident, it may not motivate them to avoid de-escalation and continue adopting EMPs following an accident. Alternately, we suggest using incentive-based approaches or technical assistance programs (TAPs) to encourage continued EMP adoption following a SP accident. For researchers, we make several contributions. First, we shed light on a commonly held belief that firms escalate the adoption of EMPs in response to an environmental accident, perhaps to strengthen their environmental management system or achieve legitimacy in the eyes of their stakeholders.

Instead, we find that most firms de-escalate the number of EMPs they adopt following an accident and that this behavior persists over time. The results also demonstrate that both the severity of the SP accident and the focal firm's sustainability record strongly influence how firms respond to SP accidents, with potentially significant implications for on-going firm environmental performance. Second, our results indicate that previously unstudied factors play a critical role in influencing firm decisions regarding EMP adoption. This suggests that stakeholder pressure or institutional pressure, the primary theoretical lenses from which EMP adoption has been studied previously (Delmas 2001, Delmas and Toffel 2008, Foster Jr et al. 2000, Hofer et al. 2012, Reuter et al. 2010, Sarkis et al. 2010) are not comprehensive in their ability to explain adoption decisions. Third, we develop a more robust definition of environmental management activity and an expanded set of EMPs which synthesizes a disparate literature on the subject of EMP adoption (Anton et al. 2004, Hofer et al. 2012, Khanna and Anton 2002). Finally, we substantiate the value of using publicly reported data to conduct research on firm environmental activity. Such data serves as a valuable complement to other methods often used to conduct research in this area since it allows for replication studies, has a panel structure which supports the use of advanced econometric methods, and facilitates assessment of a significantly larger set of EMPs, industries, and firms.

2. Theory and Hypotheses

2.1 EMP adoption: Costs, benefits and motives

Environmental management practices encompass a variety of efforts designed to minimize the negative impact of a firm's operations or supply chain on the natural environment. Examples include changes to process, product, and technology, revised managerial policies, environmental training, participation in strategic alliances and partnerships, conducting audits and risk assessment, managing supplier environmental performance, implementing KPIs and scorecards, environmental restoration efforts, and commitments to various emission reduction protocols, among others. The adopted EMPs constitute one dimension of firm-level corporate social responsibility (Klassen and McLaughlin 1996) and directly impact firm environmental performance (Anton et al. 2004, Hartmann and Vachon 2018, Klassen and Whybark 1999, Potoski and Prakash 2005, Toffel 2005).

Adopting EMPs involves a variety of costs and benefits. Costs primarily include labor investments, but may also include capital outlays, depending on the EMP adopted. For example, labor investments will be required to revise managerial policies, conduct environmental training, participate in strategic alliances, conduct audits, manage supplier performance or implement environmental scorecards. However, capital investments will be required to repair environmental damage. Capital outlays would also be required if process changes or the adoption of emission protocols require changes in technology, such as the installation of pollution control equipment. Benefits derived from EMP adoption are also varied. One obvious benefit is reduced air, water and land pollution (Anton et al. 2004, Hartmann and Vachon 2018, Klassen and Whybark 1999, Potoski and Prakash 2005, Toffel 2005). Depending on the EMP, adopters may also realize a financial benefit (King and Lenox 2002, Su et al. 2015). This could result from reduced energy, water, and material consumption, reduced waste generation and associated disposal costs, better performing operational processes (Klassen and Whybark 1999, Sroufe 2003) or increased product revenues derived from an enhanced 'green' reputation (Kumar 2016, Servaes and Tamayo 2013). Financial benefits could also include cost avoidance, such as fines avoided by conducting internal compliance audits or proactively managing supplier environmental performance. A final, less tangible benefit resulting from EMP adoption is improved legitimacy with key stakeholders (Bansal and Clelland 2004). Legitimacy means being seen by key stakeholders as behaving responsibly with respect to accepted norms, values, or beliefs regarding environmental protection, management and compliance (Suchman 1995).

Firms differ in how they value adoption costs and benefits and consequently their motives for adopting EMPs. They may be motivated to adopt because adoption efforts are championed by strong, pro-environmental leaders or occur within firms which have developed strong cultures of ecological responsibility (Bansal and Roth 2000, Lawrence and Morell 1995, Winn 1995). They might also be motivated to show key stakeholders that they are ecologically responsible producers capable of meeting acceptable standards of behavior and performance (Banerjee et al. 2003, Henriques and Sadorsky 1996, Madsen and Ulhøi 2001, Rueda-Manzanares et al. 2008). Finally, firms may believe that adoption improves their competitive position. In support of this motive, an expansive literature suggests that the number of EMPs a firm adopts is positively associated with a firm's operational (Klassen and Whybark 1999, Sroufe 2003) and financial performance (King and Lenox 2002, Su et al. 2015). In summary, firms adopt EMPs to be environmentally responsible, achieve legitimacy or improve competitiveness (Bansal and Roth 2000). However, while a single motive may dominate a firm's macro strategy, different motives may underly individual EMP adoption decisions. Irrespective of the motive to adopt, EMP adoption often involves potentially significant labor and capital commitments with uncertain payoffs.

2.2 Firm response to publicized spill or pollution accidents

Many firms experience spill and pollution (SP) accidents of varying severity and frequency over time. Some of these accidents are disclosed publicly. Research has shown that media reports disclosing firm misdeeds can influence senior leaders' actions, both in terms of firm strategy and resource allocation (Xiong and Bharadwaj 2013). Consider senior leader actions following the negative publicity associated with the Exxon Valdez oil spill, where 11 million gallons of oil were spilled when the supertanker ran aground in Alaska in

1989. In addition to spending $4.3 billion in clean-up, fines, and settlement costs, Exxon Mobil spent significant resources to upgrade its operational management system, including both preventive and reactive environmental management and safety programs(ExxonMobil 2018). Although most SP accidents are considerably smaller in scale and scope, unarguably they can significantly impact subsequent firm actions.

This study focuses on whether firms adjust the quantity of EMPs they adopt in response to a publicized spill or pollution accident, i.e., *escalate* or *de-escalate* the number of EMPs they adopt. This decision is important to study because the number of EMPs a firm adopts determines their environmental performance. EMP adoption has increased steadily over the past many years (see Figure 1). However, it is not clear how that trajectory might change as a consequence of a SP accident. Since most firms adopt more EMPs each year in the absence of an accident, escalation would mean increasing adoption beyond the typical annual increases and de-escalation would mean slowing the annual increases, not necessarily reducing adoption below prior year levels (see Figure 2 for a visual depiction of each possible response option). The choice a firm makes (i.e., *escalate* or *de-escalate*) would likely depend on how they evaluate the trade-off between the costs of the accident, such as fines and clean-up costs, reputational damage (Flammer 2013), and lost legitimacy with key stakeholders, and the costs and benefits of EMP adoption, discussed previously.

Insert Figures 1 and 2 about here

Firms might *escalate* the number of EMPs they adopt in response to an accident for at least two reasons. First, a SP accident could call into question the efficacy of a firm's installed EMP set, and current approach to EMP adoption, to prevent a future accident. If so, the firm may escalate the annual increases in adoption to strengthen its environmental management system (Anton et al. 2004) and reduce the risk of a future accident. However, we expect few firms to escalate for this reason because no specific EMP or combination of EMPs is designed specifically to reduce the probability of a future SP accident (see Table A.1, Appendix A). In fact, a SP accident would likely provide firm decision-makers with evidence of this uncertain relationship. Second, an accident might damage a firm's reputation (Flammer 2013) and the firm may escalate adoption to publicly signal their commitment to environmental management, as a form of reputation management (Bansal and Clelland 2004, Deegan and Rankin 1996). While firms which value legitimacy might pursue this option, it seems they would do so only if they believed escalation could restore a damaged reputation. However, reputation is only developed over extended periods of time (Mahon 2002, Rhee and Haunschild 2006, Roberts and Dowling 2002, Sims 2009) and is difficult to restore in the short term once lost (Sims 2009). Finally, a decision to escalate would require additional labor and financial resources at a time when incremental resources may already be needed to address fallout from the accident (fines, clean-up costs, reputation management costs).

In contrast, broad support exists for a conclusion that most firms will *de-escalate* the number of EMPs they adopt following a SP accident. First, firms prefer conservative options after experiencing accidents, especially if the accident is perceived as a threat (Staw et al. 1981). Since EMP adoption often requires significant resource investments (King and Lenox 2002), de-escalation would conserve the most resources and thus be the most conservative response option. Second, since both EMP adoption and SP accident remediation require scarce firm resources (Karpoff et al. 2005, King and Lenox 2002) and relate to the firm's environmental efforts, they are likely budgeted within a common budget and thus share a fixed set of resources. As such, decision-makers would likely need to cannibalize EMP adoption budgets to secure incremental resources necessary to manage an accident (fines, clean-up costs, reputation management costs), resulting in de-escalation. Third, a SP accident could impact firm profits and firm decision-makers prefer cost reduction when pressed to quickly address profit gaps (Hardcopf et al. 2017). This is explained as an instance of the "current moment bias" (Laibson 1997) in which decision makers over-emphasize immediate and controllable outcomes at the expense of long-term results. Since de-escalation is the most immediate and controllable response, it would be the preferred choice. Fourth, most decision-makers prefer decision options with less outcome uncertainty (Dow and da Costa Werlang 1992) and de-escalation would have the least outcome uncertainly. Fifth, de-escalation could allow firms to conserve valuable resources while they assess root-cause of the accident and develop an appropriate path forward. Such root-cause problem solving is central to quality improvement methods such as lean, TQM, and Six Sigma (Schroeder et al. 2008). Finally, de-escalation might result from firm leaders refocusing efforts back to existing EMPs, rationalizing those revealed as poor, insufficient or inadequate, while adding others. Considering the strong support for de-escalation and the mixed support for escalation, we hypothesize the following relationship between SP accidents and EMP adoption:

> ***Hypothesis 1a (H1a):*** *Spill or pollution accidents are negatively associated with the number of EMPs a firm adopts.*

2.3 The severity of the accident and firm response

Firms vary in the number of spill and pollution accidents they experience. Further, the accidents they face vary significantly in severity. On one end of the spectrum are accidents associated with localized spills or emissions violations that are contained to a specific plant or facility. They occur relatively frequently as compared to more severe accidents and may involve a modest fine. For example, in 2009 Archer Daniels Midland Company's Quincy, IL facility leaked 130 gallons of soybean oil into the Mississippi River (Husar

2010). On the other end of the spectrum are accidents which impact larger geographic areas or more profoundly impact the natural environment (e.g., Exxon-Valdez oil spill, BP oil spill). While these events occur infrequently, they can involve significant fines, clean-up costs, and legal costs. While we posit in H1a that most firms will respond to a SP accident by de-escalating on-going EMP adoption, we find theoretical support for a conclusion that the magnitude of de-escalation will depend on the severity of the accident.

The arguments which resulted in H1(a) assume that the accident is sufficiently severe so as to elicit a firm response. However, low severity accidents may not elicit a response because either they don't capture sufficient decision-maker attention (Ocasio 1997) or are not expected to materially impact the firm. In contrast, severe accidents are likely to elicit a strong response because firm managers perceive them as an existential threat (Staw et al. 1981). Compared to low severity accidents, more severe accidents could be perceived as threats because they result in lower stock prices and market values (Endrikat 2016, Flammer 2013, Karpoff et al. 2005, Klassen and McLaughlin 1996). They also require scarce firm resources for clean-up and fine payment (Karpoff et al. 2005), and may damage a firm's reputation, although the evidence is mixed (Flammer 2013, Jones and Rubin 2001, Karpoff et al. 2005, 2008, Liu and Shankar 2015). Further, severe accidents may suggest unethical leadership behavior to firm stakeholders, which could further negatively impact market valuation (Karpoff et al. 2008) and legitimacy. Firms respond to threats by reducing communication complexity, centralizing power, and prioritizing efficiency efforts, ultimately leading to behavioral rigidity (Staw et al. 1981). This means that firms likely avoid adopting new practices or techniques following more severe accidents and instead focus on conserving valuable resources.

> ***Hypothesis 1b (H1b):*** *The severity of spill or pollution accidents is negatively associated with the number of EMPs a firm adopts.*

2.4 The moderating role of firm sustainability

In H1a and H1b, we posit that firms will de-escalate the number of EMPs they adopt as the number and severity of accidents increase, respectively. However, we believe that these relationships are not universal, but contingent on a firm's sustainability performance. Firms with a strong sustainability performance record (sustainability leaders), such as those which pursue EMP adoption out of a felt ecological responsibility, are typically led by strong pro-environmental leaders which champion adoption efforts and have strong pro-environmental cultures (Bansal and Roth 2000, Lawrence and Morell 1995, Winn 1995). A defining feature of these firms is a concern for social good (Bansal and Roth 2000). This does not imply that they are agnostic to the costs and benefits of EMP adoption or a SP accident, but that their decisions are driven by a corporate ideology of long-term sustainability. Further, because of their pro-environmental attitudes and beliefs, sustainability leaders likely implement more EMPs than other firms. Increased implementation experience should lead to a critical mass of skills, capabilities, and trained resources that are dedicated to sustainability pursuits (Darnall and Edwards Jr 2006). Therefore, high sustainability firms might have a lower marginal cost of implementing additional EMPs. In addition, since sustainability leading firms are motivated to do what is right rather than what is socially acceptable or profitable, they tend to take independent courses of action rather than mimic other firms or blindly respond to external stimuli (Bansal and Roth 2000). In the current context, this means we expect them to ’stay the course’ (avoid de-escalation) following a SP accident. This would happen because de-escalation is contrary to their values, culture and self-identified social contract. Further, since they take a more thoughtful approach toward adoption, they likely believe their current approach maximizes environmental performance and minimizes the risk of a future SP accident (Judge et al. 1998, Schulz-Hardt et al. 2009). Finally, because they have established a critical mass of skills, capabilities, and resources (Darnall and Edwards Jr 2006), any financial and labor savings realized by de-escalating adoption may be too limited to justify this approach.

Additional support for the conclusion that high sustainability firms resist the temptation to de-escalate can be found by examining the behavioral attributes of decision-makers responsible for EMP adoption decisions. Decision-makers in sustainability leading firms will have gained significant experience and expertise in environmental and social sustainability. That experience and expertise should improve decision-maker self-confidence in making sustainability decisions, such as EMP adoption. Research has shown that decision-makers with high self-efficacy and confidence, such as that derived through experience, may stay on course even when presented with negative feedback on that course of action (Judge et al. 1998). Thus, managers in such firms will discount negative information, believing they can overcome potential obstacles presented by the negative feedback (Schulz-Hardt et al. 2009). They may also treat accidents as exceptions which do not accurately represent the capability of the existing EMS, as expressed by the EMPs they have adopted. Finally, they may see SP accidents as rare events that could provide opportunities for learning (Baum and Dahlin 2007, Rerup 2009). In sum, we expect that sustainability leaders will not alter their approach to EMP adoption following an accident, while all other firms will de-escalate the number of EMPs they adopt. Extending this logic to the severity of an accident and incorporating the logic from H1b, we expect that sustainability leaders will not alter their approach to EMP adoption following an accident, regardless of severity, while all other firms will increasingly de-escalate adoption as the severity of the accident increases.

> ***Hypothesis 2a (H2a):*** *The association between SP accidents and the number of EMPs a firm adopts is moderated by a firm’s sustainability record; such that sustainability leading firms will not alter the number of EMPs they adopt in response to SP accidents, while all other firms will de-escalate the number of EMPs they adopt.*

Hypothesis 2b (H2b): *The association between the severity of SP accidents and the number of EMPs a firm adopts is moderated by a firm's sustainability record; such that sustainability leading firms will not alter the number of EMPs they adopt in response to the severity of SP accidents, while all other firms will progressively de-escalate the number of EMPs they adopt as the severity of SP accidents increase.*

3. Data

3.1 Data sources and sample

We investigate EMP adoption in publicly-traded US manufacturing firms using data from two Thomson Reuter's databases, ASSET4 and Worldscope. Annualized data on EMP adoption, SP accidents, other environmental accidents, sustainability performance, and use of a certified EMS is obtained from ASSET4, a database used extensively in related academic research (Cheng et al. 2014, Eccles et al. 2014, Ioannou and Serafeim 2012). Information on firm size and profitability is obtained from Worldscope, a global financial and economic database also used previously in academic research (Hawn and Ioannou 2016). Finally, information on SP accident severity was gathered directly from Thomson Reuters. The study focuses on U.S. firms to eliminate potential heterogeneity in approaches to EMP adoption across countries, as different countries may value environmental issues differently. Moreover, this approach limits the country-level heterogeneity in the legal frameworks surrounding SP accidents. We also include only publicly traded firms because financial information is federally mandated and readily available, and because our theoretical framework more clearly applies to public companies since they are more impacted by accidents (e.g., share price). Finally, we focus on traditional manufacturing industries because firms in these industries are a primary source of environmental pollution (Banerjee et al. 2003) and are more likely to experience spill and pollution accidents. The unit of analysis is firm-year, the data spans 2002 to 2013, and the sample includes 442 firms. Because new firms enter the panel each year, the panel is unbalanced.

3.2 Dependent variable

EMP adoption: This variable captures the magnitude of a firm's environmental management activity each year and is operationalized as the number of EMPs a firm deploys each year. This is equal to the number of EMPs adopted the prior year, minus any drops, plus any new adoptions. Firm involvement with environmental management has been operationalized in a variety of ways by previous researchers. This includes a single, multi-item construct (Christmann 2004, Rueda-Manzanares et al. 2008), several multi-item constructs (Klassen 2001, Sarkis et al. 2010), a count of EMPs (Anton et al. 2004, Hardcopf et al. 2019, Hartmann and Vachon 2018, Khanna and Anton 2002), and a count of EMPs after adjusting for intensity of implementation (Hofer et al. 2012). In this paper, we use 50 environmental management practices which were selected through an exhaustive process to ensure validity and broad domain coverage (see Appendix

A). The 50 management practices constitute the most comprehensive set of EMPs in the literature to-date and encompass the broad spectrum of environmental actions firms undertake to manage their environmental performance (see Appendix A, Table A.1 for details of each EMP).

3.3 Independent variables

Spill or pollution (SP) accident: A SP accident represents "an event published in the media linked to chemical, oil, and fuel spills, as well as accidents related to the overall impacts of the company on the environment"[1]. They include any of the company activities which may directly or indirectly pollute the environment or the surrounding area, be it air, water or soil, or cause pollution. Some examples of spill and pollution accidents include the Exxon-Valdez and Deepwater Horizon Oil Spills, 3M's contamination of drinking water in Minnesota (Minnesota Pollution Control Agency 2018), and Aerovox's PCB contamination of New Bedford Harbor in Massachusetts (U.S. EPA 2013b). To create the variable, Thomson Reuters (TR) collects news articles for each firm from various public and private sources, including company issued press releases, company websites, and media publications. Thomson Reuters' analysts then review each article, remove duplicates, and report the number of SP accidents a firm experienced each year. This variable (*'Count of SP accidents')* is used in the main analysis. However, we create two additional variables as robustness checks. Since some firms may not experience an accident in a single year while others experience several, we create a binary variable, i.e., yes/no (*'SP accident')* to counter the scale effect of experiencing multiple accidents. Additionally, since C*ount of SP accidents* is positively skewed with a long tail, we create an ordinal variable to counter the effect of influential outliers (*'SP accidents_ordinal'),* where 0=no accidents, 1=1 accident, 2=2 accidents, 3=3 accidents, 4=4 or 5 accidents, and 5=6 or more accidents in a single year.

Spill or pollution (SP) accident severity: Spill or pollution accidents generally progress through a series of stages, including the initial spill or pollution event, subsequent legal action, and finally a determination of potential fines and clean-up costs. By providing information on legal action and settlement costs in the news reports publicizing the accidents, the public is made aware of the stage to which an accident has progressed. Since each stage represents progressively more severe consequences for the firm, in terms of financial and reputational costs, this information is used to develop a measure of SP accident severity. Source news reports on each accident were obtained directly from Thomson Reuters. The lead author manually reviewed each report and coded the accident for severity using the following categorization scheme: *'No Spill Event'* = the firm did not experience an accident; *'Spill Event Only'* = the firm experienced a spill or pollution event, but there was no mention of a lawsuit or legal action in the article;

[1] Thomson Reuters 2013 ASSET4 ESG Data Glossary.

'Legal Action Taken' = the article specifically mentions that a lawsuit or legal action was underway; and *'Settlement Details'* = the article not only mentions legal action, but also quantifies the cost of the fine or settlement. In total, 532 news reports were reviewed and coded for severity. Each level of severity is operationalized as an indicator variable in the econometric analysis.

We also develop as robustness checks two alternate, more traditional measures of SP accident severity. The first approach captures severity as the total cost of an accident and is operationalized in three different ways: (1) as a binary measure, i.e., costs were mentioned in the article or not; (2) a continuous measure, i.e., the total cost of fines and cleanup mentioned in the article; and (3) as an ordinal measure, where cost of fines and cleanup was classified into the following 5 categories to account for outliers: 0 = cost not mentioned; 1 = $1 - $10,000; 2 = $10,001 - $100,000; 3 = $100,001 - $1,000,000; 4 = 1,000,000+. The second approach captures severity as the scope of the environmental impact on the surrounding geography and is operationalized as dummy variables where, 0 = no accident, 1 = local impact (e.g., town/city), 2 = regional impact (e.g., state), and 3 = broad impact (e.g., multiple states or international).

3.4 Moderating variables

Firm sustainability record: Inclusion on a sustainability stock index, such as the Dow Jones Sustainability Indices (DJSI) or the FTSE4Good Index, has frequently been used in prior research to proxy a firm's sustainability record (Artiach et al. 2010, Cheung 2011, Chih et al. 2008, 2010, Collison et al. 2008, Consolandi et al. 2009, Curran and Moran 2007, Lourenço et al. 2012, Ziegler and Schröder 2010). Following these studies, we classify firms as 'sustainability leaders' in the years they are selected for inclusion on a sustainability index and 'all other' otherwise. Firms are selected for inclusion based on their sustainability performance, as evaluated by the index or the index's chosen representative. Inclusion on a sustainability index indicates that a firm's environmental, social, and governance (ESG) record is among the very best. For example, the DJSI World Index includes only the top 10% of eligible firms. Data used to measure inclusion on a sustainability index was obtained from ASSET4. Overall, approximately 15% of the firms in our sample are classified as 'sustainability leaders'. Since firms not included on a sustainability index may not be 'low' sustainability, we classify them as 'all others' or not sustainability leaders.

3.5 Control variables

Consistent with prior related research, we include several variables to control for their effect on the number of EMPs a firm adopts.

Other environmental incidents: Although SP accidents account for about 80 percent of all environmental incidents tracked by Thomson Reuters, firms may experience environmental incidents not related to spills and pollution events, such as incidents related to a firm's impact on biodiversity or the impact a firm's products have on the natural environment. Firms may adopt EMPs in response to these ‘other environmental incidents’ and systematically differ in the number of the incidents they experience. We control for this potential source of heterogeneity by including a count of ‘other environmental incidents’ experienced by a firm in period *t-1* (the same period as SP accidents).

Firm size: Larger firms have more capital, labor and technology resources, and firm size has been shown previously to impact the number of EMPs a firm adopts (Christmann 2004, Delmas and Toffel 2008, Hofer et al. 2012). To control for such resource heterogeneity, we use the natural log of corporate sales (Hofer et al. 2012).

Firm profitability: Similar to size, more profitable firms are likely to have the financial stability over time to make investments in EMPs, which have uncertain near-term returns. We use return on assets (ROA) to capture firm profitability (Hardcopf et al. 2019, Zhang et al. 2008).

Certified environmental management system (Certified EMS): An EMS is a framework for improving environmental performance that can be certified by third-party organizations (certification is optional, but typical). Examples include ISO 14000/14001 and the European Union’s Eco-Management and Audit Scheme (EMAS). Basic elements of an EMS include reviewing environmental goals, analyzing environmental impacts, setting environmental objectives and targets, establishing programs to meet objectives and targets, monitoring and measuring progress, and reviewing progress (U.S. EPA 2020). Given that an EMS identifies gaps and suggests ways to improve environmental performance, and EMPs are the specific actions firms take to improve environmental performance, there is likely high correlation between the presence of a certified EMS and the number of EMPs a firm adopts. Since firms with a certified EMS are also less likely to experience a SP event, we control for this potential source of endogeneity by including a control variable coded as 1 if the firm has a certified EMS and 0 otherwise.

Fixed effects: We control for year, industry and firm fixed effects in all analyses by including dummy variables or using fixed effect estimation.

In examining our data, we find that firms in our panel adopt more EMPs each year, from an average of 3.6 EMPs per firm in 2002 to 19.5 EMPs in 2013 (Figure 1). This is not surprising since environmental management has garnered increased attention in recent decades, culminating in the Paris Agreement on climate change[2]. Descriptive statistics and a correlation matrix for the primary variables used in the analyses are provided in Table 1. We observe that all independent and control variables are positively correlated with the dependent variable, EMP adoption. This suggests that firms with more environmental accidents and more severe accidents, larger firms, more profitable firms, and firms who use a certified environmental

[2] http://unfccc.int/paris_agreement/items/9485.php

management system adopt more EMPs. We also observe generally high levels of correlation between independent and control variables, suggesting potential multicollinearity concerns. We discuss this below.

Insert Table 1 about here
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4. Empirical Approach and Results

4.1 Empirical approach

We investigate the relationships in our study using negative binomial regression because our dependent variable, EMP adoption, is a 'count' of the number of EMPs a firm adopts with an over-dispersed distributional profile, i.e., the ratio of variance to mean is greater than one. Given the nature of our data, several alternate methods were considered, including ordinary least squares (OLS), Poisson, and General Estimating Equation (GEE). OLS regression is not appropriate because it requires variance assumptions not likely to be met (Gardner et al. 1995). Poisson regression is a single parameter model which assumes the mean and variance of the dependent variable are equal. In our data, the ratio of variance to mean is 14.5, suggesting significant over-dispersion. The negative binomial distribution is a better match for our data structure because it accounts for the over-dispersion with a second parameter (Gardner et al. 1995). GEE regression is another method appropriate to analyze over-dispersed count data when autocorrelation and unobserved cross-sectional heterogeneity may be present (Di Gregorio and Shane 2003, Greene 2012, Liang and Zeger 1986, Sine et al. 2003). While an Arellano-Bond test does not indicate autocorrelation, we evaluate the GEE model as a robustness check to address potential unobserved cross-sectional heterogeneity.

4.2 Results

4.2.1 Spill and pollution accidents and the adoption of EMPs

Results from negative binomial regression analysis are presented in Table 2. Variance Inflation Factors (VIFs) in all models are below 4, ameliorating multicollinearity concerns (Kutner et al. 2005).

Insert Table 2 about here

We first include only control variables (column 1) and find that firm size and a certified EMS are positively associated, and profitability is negatively associated, with the number of EMPs a firm adopts. Although not shown, each year dummy variable is significant and steadily increasing in magnitude over time, as observed visually in Figure 1. To assess the impact of SP accident on EMP adoption, we first evaluate a binary operationalization (*SP accident*) in the time period immediately preceding the period in which we measure EMP adoption (t-1), i.e., the firm did or did not experience an accident in the prior period (column 2). We find that a prior year accident is negatively associated with the number of EMPs a firm adopts in the current year (β= -0.10). The beta coefficient translates into a firm adopting 10% fewer EMPs (~ 2.0 EMPs) than they would have adopted had the accident not occurred (the beta coefficient in negative binomial regression is interpreted multiplicatively after exponentiation as $1 - exp^{\beta} = 1 - exp^{-0.10} = 1 - 0.90 = 0.10$ or a 10% reduction (Gardner et al. 1995). Using 2013 EMP adoption averages from Figure 1 (19.5 EMPs), a 10% reduction equates to de-escalation of approximately 2.0 EMPs, i.e., 10%*19.5=1.95). Since firms increase EMP adoption each year in the absence of an accident by about 2.1 EMPs (the slope of the line in Figure 1 when regressing EMP adoption on year), the de-escalation we observe does not equate to reduction in EMP adoption from the prior year, but rather de-escalation in annual increases and a reduction in the number of EMPs the firm would have adopted in the absence of an accident.

We next evaluate how the number of accidents (*Count of SP accidents)* experienced in the prior period influences EMP adoption in the current period (column 3). We again observe a negative and statistically significant relationship (β= -0.07), indicating that as firms incur more accidents, they de-escalate the number of EMPs they adopt more than if they had experienced a single accident. The beta coefficient translates into a firm adopting 7% fewer EMPs (~ 1.3 EMPs) for each accident than they would have adopted in the absence of an accident. This suggests that should a firm incur a single accident, they will de-escalate adoption and should they incur multiple accidents in the same year, they will de-escalate adoption even further.

In the final investigation of H1a, the binary and count measures of accident are included together in one model (column 4). We find that the direction, magnitude, and significance of the beta coefficient connected to the count measure is relatively unchanged from the prior analysis, while the beta coefficient associated with the binary measure has lost significance. This is expected since a count measure (*Count of SP accidents*) exhibits greater variation and retains more information than a binary measure (*SP accident*). The count measure is thus used in all subsequent analyses. The results provide strong support for H1a.

To assess how the severity of a SP accident impacts EMP adoption following a SP accident (H1b), we replace the count measure (*Count of SP accidents*) with the SP accident severity measure and repeat the analysis displayed in Column 3. As discussed in Section 3.3, *SP accident severity* is measured as a dummy variable which broadly captures the stage in the resolution process to which the underlying spill or pollution accident had progressed when disclosed publicly. The results (column 5) show that if the article only mentions the occurrence of a spill event, not any legal or financial ramifications (*Spill Event Only*), the beta coefficient is positive but not statistically significant (β = 0.07, p = 0.15). This suggests that firms continue with the annual increases in the number of EMPs they adopt, although they may drop some and add others to improve environmental performance. However, as the article progressively discloses a more serious SP accident, such as details of a lawsuit (*Legal Action Taken,* β = -0.12, 11% de-escalation, ~ 2.2 EMPs) and then articulation of a specific fine or settlement (*Settlement Details,* β = -0.18, 16% de-escalation, ~ 3.2 EMPs), the magnitude of de-escalation increases steadily. Using t-tests to compare beta coefficients across severity levels, we find a statistically significant difference between low severity accidents ('Spill Event Only') and medium severity ('Legal Action Taken') or high severity ('Settlement Details') accidents, but not between medium and high severity accidents. This suggests that firms respond to accidents only when they are sufficiently severe so as to be a threat to the firm (news announcement mentions legal action). The results provide support for H1b, that the severity of a SP accident is negatively associated with the number of EMPs a firm adopts.

4.2.2 Sustainability leading firm's response to spill or pollution accidents

The final analyses investigate whether the relationships between *Count of SP accidents* and EMP adoption (H2a), and between *SP accident severity* and EMP adoption (H2b), depend on a firm's sustainability performance. To evaluate the hypotheses, we use a firm's sustainability record to create two sub-samples, 'sustainability leaders' and 'all others', and replicate the regression analysis within each sub-sample for each hypothesis (Table 3). The resulting beta coefficients associated with the independent variable are then compared across subsamples using a t-test (Bruning and Kintz 1987, p. 226–228). Moderation is signaled by a statistically significant t-test (Venkatraman 1989).

Insert Table 3 about here

Regarding the impact of *Count of SP accidents* on EMP adoption (H2a), we find that the beta coefficient associated with the 'sustainability leader' subsample (column 1) is almost zero and not significant, while the corresponding beta coefficient in the 'all other' subsample (column 2) is negative and highly significant (β = -0.10, ~ 10% de-escalation or 2.0 EMPs). A t-test confirms the difference between betas, providing evidence that sustainability leading firms do not significantly alter their approach to EMP adoption in response to a SP accident, while all other firms respond by de-escalating adoption. The results provide support for H2a.

Results regarding the impact of *SP accident severity* on EMP adoption (H2b) demonstrate a similar pattern. Each dummy variable used to measure SP accident severity in the 'sustainability leader' subsample is statistically unrelated to EMP adoption (column 3). T-tests subsequently show no differences between each severity level suggesting that 'sustainability leaders' do not escalate or de-escalate the number of EMPs they adopt in response to a SP accident, regardless of the severity of the SP accident. This could happen because sustainability leaders have experience with, and belief in, their current course of action. Alternately, selection to a sustainability index might create momentum propelling sustainability leaders to continue with the current course of action. In contrast, 'all other' firms quite significantly and unexpectedly alter their approach to EMP adoption. If the news article connected to the accident only mentions that an SP event occurred, without referring to any legal or financial consequences, 'all other' firms *escalate* EMP adoption (β= +0.10, ~ 10% escalation or 2.0 EMPs). However, as the accident becomes increasingly severe, such that the article mentions legal action (β= -0.12, ~ 11% de-escalation or 2.2 EMPs) or mentions details of a legal settlement (β= -0.20, ~ 18% de-escalation or 3.5 EMPs), firms reverse course and *de-escalate* the number of EMPs they adopt. As with our evaluation of H1b, t-tests comparing beta coefficients across severity levels confirm the difference between low severity accidents ('Spill Event Only') and medium severity ('Legal Action Taken') or high severity ('Settlement Details') accidents, but not between medium and high severity accidents. The summary conclusion is that only firms that are *not* sustainability leaders (~85% of all firms) respond to SP accidents with changes in the number of EMPs they adopt. They *escalate* the number of EMPs they adopt following low severity accidents and *de-escalate* the number of EMPs they adopt following medium and high severity accidents. While the results generally match our expectation, we did not expect firms to escalate adoption after low severity accidents. One possible explanation is that since experiencing a low severity accident does not necessarily mean the firm will be subject to legal or financial consequences, i.e., their culpability is unclear, they may escalate adoption to publicly signal their commitment to environmental management, as a form of reputation management (Bansal and Clelland 2004, Deegan and Rankin 1996). The results provide partial support for H2b.

4.3 Robustness checks

We conduct several robustness checks to ensure that the results are not biased by the choice of research method, panel or sample (selection bias), or the operationalization of the two independent variables, SP accident and SP accident severity. Results are presented in Appendix B, Tables B.1 – B.4, for H1a, H1b, H2a, and H2b respectively. For comparison purposes, results from the original analyses are included in the first column of each table.

GEE model: We used negative binomial regression with fixed-effect estimators for our main analyses. However, GEE models have also been used to evaluate negative binomially distributed count data such as ours (Hofer et al. 2012, Shah et al. 2016). They are attractive because they can accommodate serial correlation, allow for robust standard errors, and address potential unobserved cross-sectional heterogeneity concerns, a source of latent heterogeneity (Greene 2012, Wowak et al. 2015). Although our data did not exhibit autocorrelation (p=0.11), unobserved cross-sectional heterogeneity may be present and affect the results. The GEE model is implemented with a negative binomial distribution, a log-linear link function, and an exchangeable working correlation structure (it corrects for potential serial correlation by allowing shared correlation between observations within a group). As shown in Tables B.1 - B.2 (column 2), and Tables B.3 – B.4 (columns 3 and 4), the results with the GEE model are substantively similar to the original results.

Panel choice: Our initial analyses included all firms for which data was available. However, new firms entering the panel each year may systematically differ from those entering the panel earlier in how they respond to a SP accident, with respect to EMP adoption. To ensure that our results are not driven by our panel choice, we re-evaluate each hypothesis using a reduced set of 150 firms for which data was available for each year in the panel. This resulted in 1611 firm-year observations (as compared to 442 firms and 3100 firm-year observations in the original model). The results from this reduced sample (Tables B.1 - B.2, column 3; Tables B.3 – B.4, columns 5 & 6) are similar to the main results with the full sample.

Selection bias: Selection bias would occur if certain firms have a higher or lower propensity to experience a SP accident than other firms based on characteristics of the industry in which they compete or attributes of the firm itself, such as size. If selection bias occurs, these characteristics and attributes would be over or under represented in the treated (experienced an accident) versus untreated samples. Empirical results could then reflect overdue influence from these characteristics and attributes, as opposed to the effect of the treatment alone. A common method used to address selection bias is Propensity Score Matching (PSM). In this method, firms are first evaluated with regard to their propensity to experience a SP accident. Firms that 'did' and 'did not' experience an accident, but had similar propensities to experience an accident, are then matched against each other in the analysis. The results from PSM are shown in Tables B.1 – B.2, column 4, Tables B.3 - Table B.4, columns 7 & 8. Matching variables included all of the original control variables and propensity scores were estimated using Logit. Again, the substantive results are consistent with the main analyses suggesting that selection bias is not responsible for the results observed.

Ordinal measure of SP accident: The count measure of SP accident is positively skewed with a long tail. While most firms that experience an accident experience only a single accident in a given year, a small number of firms experience multiple accidents, with one firm experiencing 15 accidents. To reduce the potential impact of outliers on our results, we re-evaluate H1a and H2a using an ordinal measure of SP accident; 0=no accidents, 1=1 accident, 2=2 accidents, 3=3 accidents, 4=4 or 5 accidents, and 5=6 or more accidents in a single year. The results from this analysis are almost identical to the main results (Table B.1, column 5; Table B.3, columns 9 & 10), suggesting the results are not driven by outliers.

Alternate measures of SP accident severity: We used dummy variables to measure *SP accident severity* in the main analysis. While this unique operationalization allowed us to test our belief that firms will de-escalate the number of EMPs they adopt only when an accident exceeds some minimum threshold of severity, binary variables are problematic because they attenuate variation. Further, SP events can be quite varied (Oetzel and Oh 2014, Oh and Oetzel 2011, Pek et al. 2018). SP accident severity could thus be measured in alternate ways which more granularly capture the potential threat to the firm. To capture other dimensions of severity, we measure two additional aspects of the SP accident: the total cost of the SP event (fines and clean-up costs) and the geographic scope of the SP event's impact (see Section 3.3 for a detailed description of the measures). We repeat the analysis presented in Table 2 (Model 5) using these alternate measures and find that the conclusions are identical in every replication, i.e., the beta coefficients are negative and statistically significant and get progressively larger as severity increases (results not included due to space limitations, but available upon request). The results substantiate our belief that most firms which experience a SP accident will increasingly de-escalate EMP adoption as the severity of the accident increases.

4.4 Post hoc analyses

We conduct post hoc analyses to address three questions regarding the impact of a SP accident on EMP adoption: (1) How long does the de-escalation behavior persist? (2) Do firms de-escalate both the magnitude and breadth of adoption? (3) Does de-escalation depend on the type of EMP?

Persistence of the impact on firm behavior: Understanding how long a SP accident affects firm behavior has important implications for the natural environment because the longer the impact persists, the greater the gap between the number of EMPs a firm adopts and the number of EMPs it would have adopted in the absence of a SP accident. In the main analysis, we lagged SP accident by one year. The persistence of the impact is now examined by progressively adding older accidents to the base model (see Table 4). We notice that as older accidents are added to the model (from periods t-2, t-3, and t-4), the beta coefficient associated with *Count of SP accidents* in period t-1 (column 1) gets progressively smaller. This suggests that these older accidents are responsible for some portion of the de-escalation we observe in period t. We also observe that the beta coefficients connected to *Count of SP accidents* from period t-2 (column 2) are significant in all models and the beta coefficient connected to *Count of SP accidents* from period t-3 (column 3) is significant in model 3. The suggests that firms de-escalate the number of EMPs they adopt following a SP accident for at least 2 years and possibly 3 years.

Insert Table 4 about here

Magnitude vs. breadth of EMP adoption: While each EMP may be unique in its approach to improve firm environmental performance, they may be similar in their broad purpose or improvement focus area, such as reduce energy consumption, reduce emissions, manage supplier environmental performance, implement environmental standards or improve environmental product innovation (see "activities" in Hofer et al. (2012) or "environmental practices" in Montabon et al. (2007)). As such, a firm may implement many EMPs (high *magnitude*) but focus their environmental management effort on a narrow set of improvement areas (narrow *breadth*). Our original measure of EMP adoption captures the *magnitude* of adoption, i.e., the total number of EMPs a firm adopts to manage their impact on the natural environment (Hofer et al. 2012). H1a and H1b thus show that firms de-escalate the magnitude of EMP adoption following a SP accident.

To evaluate whether firms also de-escalate the breadth of adoption following an accident, we first develop a measure of adoption breadth using information provided by ASSET 4. The dataset includes details of each EMP, including a unique identifier (Appendix A, Table A.1, column 2), the improvement area domain (Appendix A, Table A.1, column 3), and details of what is being assessed (Appendix A, Table A.1, column 4). We grouped the 50 EMPs into 17 categories using the improvement area domain (see Appendix C for the final categories). Our measure of breadth is a count of all the categories in which a firm had adopted at least one EMP. Using this alternate dependent variable, we repeated the analyses for H1a and H1b. Results (Table B.1, column 6 and Table B.2, column 5, for H1a and H1b respectively) are similar to the main results (column 1 of both tables) and demonstrate that firms respond to SP accidents by de-escalating both the magnitude and breadth of EMP adoption.

Different types of EMPs: Prior researchers have shown that EMPs vary in purpose and performance impact (Klassen and Whybark 1999, Montabon et al. 2007). To capture and isolate the impact of these differences, researchers have grouped EMPs into various classification schemes, such as whether the EMP addresses pollution prevention, pollution control or product stewardship (Bansal 2005, Hart 1995), addresses pollution prevention, pollution control or a management system (Klassen and Whybark 1999), or whether it is directed externally or internally (Matten and Moon 2008). Such differences may impact adoption decisions, i.e., firms might focus on certain types of EMPs relative to other types following a SP accident.

To evaluate this possibility, we repeat analyses H1a and H1b using two distinctly different types of EMPs. The two groups are developed using a popular classification scheme developed initially by Sroufe et al. (2002), and subsequently used by Montabon et al. (2007) and Hofer et al. (2012), in which EMPs are classified as operational, tactical, and strategic. Operational practices are internally focused and pertain to firm operations. Examples include new production techniques and energy efficiency initiatives. Tactical practices fall between operational and strategic practices and can be internally or externally focused. Examples include environmental supply chain management and conducting product life-cycle assessments. Strategic practices are usually externally focused and define a firm's environmental posture to key stakeholders. Examples include establishing environmental partnerships and creating an environmental management team. We first allocate the set of 50 EMPs into operational, tactical, and strategic categories using the operational definitions and examples provided by Montabon: 23 EMPs were designated as operational, 15 were designated as tactical, and 12 were designated as strategic. Because there was limited data on tactical and strategic EMPs, we combined these categories into one group to create two final groups with roughly equivalent numbers of EMPs. Results show that the pattern of de-escalation is common across both groups (Table B.1, columns 7 & 8 and Table B.2, columns 6 & 7 for H1a and H1b respectively) and indicate that firms de-escalate different types of EMPs similarly. As additional robustness checks, we evaluate each EMP categorization scheme mentioned previously and again find no difference in de-escalation across the various types of EMPs (results available upon request).

5. Discussion and Conclusions

Despite ever-growing global interest in protecting the natural environment, more and more companies experience SP accidents each year. As the first study to evaluate how firms respond to such accidents, with respect to on-going environmental management activity, it is especially timely and relevant since changes in environmental management activity can significantly affect a firm's impact on the natural environment. We find that most firms respond to a SP accident by de-escalating EMP adoption (H1a), i.e., they adopt fewer EMPs in future years than they would have adopted had the accident not occurred. Moreover, the results from post hoc analyses show that the pattern of de-escalation is not restricted to certain types of EMPs or the EMP improvement focus area. Since firms adopt more EMPs each year in the absence of an accident (Figure 1), de-escalation does not necessarily equate to a reduction in EMP adoption from the prior year, but rather a slowdown in annual increases and a reduction in the number of EMPs the firm would have adopted in the absence of an accident. More accidents (H1a), or more severe accidents (H1b), lead to greater de-escalation and the slowdown seems to last for at least two years and possibly three years (Post hoc). Finally, most firms do not seem to recover from the slowdown in future years, i.e., they do not return to the level of adoption they would have realized had they not experienced an accident[3]. The summary conclusion (visually summarized in Figure 3) is that firms which experience SP accidents may realize significant future-year gaps between what they do adopt and what they would have adopted had they not experienced an accident, with significant potential ramifications for environmental performance.

Insert Figure 3 about here

Fortunately, not all firms de-escalate the number of EMPs they adopt following a SP accident. Sustainability leaders resist the temptation to de-escalate (H2a), regardless of the severity of the accident

[3] For a firm, the adoption slope prior to the first SP accident was compared with the adoption slope beginning 3 years after the last accident. Similar or lesser slopes after the last accident signaled no recovery.

(H2b), despite the conflicting evidence a SP accident would provide as to the efficacy of a firms existing approach to environmental management (EMP adoption). We propose that a sustainability leader's decision to continue with the annual increases they pursue in the absence of a SP accident is due in part to their strong pro-environmental leadership and culture. In addition, decision-makers in these firms will have gained significant experience and expertise in environmental and social sustainability, which would improve self-confidence in an existing course of action. In short, sustainability leaders do not de-escalate EMP adoption following an accident because they prefer, and have confidence in, the existing course of action.

In contrast, all other firms significantly alter their existing pattern of EMP adoption following a SP accident, with the direction and magnitude contingent on the severity of the accident. Specifically, firms that are not sustainability leaders escalate adoption following low severity accidents and de-escalate adoption following more severe accidents. Since a low severity accident does not necessarily indicate that a firm acted irresponsibly, i.e., there is no mention of legal or financial accountability, firms may escalate adoption following low severity accident to publicly signal their commitment to environmental preservation, as a form a reputation management (Bansal and Clelland 2004, Deegan and Rankin 1996). In contrast, firms may de-escalate adoption following more severe accidents because the heightened potential for financial and reputational losses increases the threat to the firm and behavioral rigidity (Staw et al. 1981). Behavioral rigidity would cause firms to avoid the risk associated with adopting new EMPs and instead focus on conserving valuable resources.

These results are robust to various econometric specifications, alternate measures of key variables and panel choice. Results are summarized in Table 5.

Insert Table 5 about here

5.1 Managerial and policy implications

Taken together, the results paint a rather nuanced picture of how U.S. manufacturing firms manage their environmental responsibilities. On one hand, we observe a direct and positive relationship between time and the number of EMPs a firm adopts (Figure 1). This is very encouraging since the number of EMPs a firm adopts is positively associated with improved environmental performance. On the other hand, a SP accident can lead many firms to de-escalate the annual increases in EMP adoption they pursue in the absence of an accident. Given that de-escalation can last for up to three years and firms do not seem to recover from de-escalation in future years, significant gaps may develop over time between the number of EMPs a firm adopts and the number they would have adopted in the absence of an accident (Figure 3), with potentially significant consequences on environmental performance. Especially at risk for de-escalation are firms which are not sustainability leaders. Future environmental performance improvements from these firms may need to come from stronger stakeholder oversight and regulation, rather than self-generated improvements initiated by responsible firm leaders (Short and Toffel 2010). As a note, an alternate explanation for the de-escalation in EMP adoption we observe following more severe accidents could be that they spur management to reevaluate the existing set of EMPs, rather than adopt new EMPs. Realizing full value from the existing set of EMPs might be more important than adopting more EMPs.

For policy-makers, the results suggest limitations to traditional compliance-based approaches for managing firm environmental performance following a SP accident. While regulation will encourage firms to resolve harm caused by an accident, it has no mechanism to motivate firms to maintain annual increases in EMP adoption following an accident. De-escalation is a compelling option when firms must address potentially significant resource conflicts connected to the accident. Alternately, policy-makers might consider incentive-based approaches or technical assistance programs (TAPs) to incent adoption in the years following an accident. Several TAPs exist in the U.S. and they could be used to provide direct assistance to firms. At a minimum, they could offer assistance and make the firm aware of de-escalation risks and pitfalls. More importantly, they could develop innovative approaches to integrate supportive and punitive tactics (Dhanorkar et al. 2017) to ensure on-going environmental performance improvements. For example, the TAPs could help facilitate best practice sharing between sustainability leaders and all other firms.

The results from this study are interesting because previous research has not demonstrated the lingering effects of a SP accident on managerial decision making. Although anecdotal evidence suggests long term effects, they have not been empirically demonstrated previously. The results are particularly interesting because "small, incremental managerial decisions and actions are not easy to observe and evaluate objectively" (Klassen and McLaughlin 1996, p. 1204). Our results show that many firms which face a SP accident not only adjust their decisions based on their experience and values, but also exhibit institutional memory where those decisions are concerned.

5.2 Theoretical implications

The study also makes several contributions to the academic literature. First, we identify and examine how spill and pollution accidents impact the number of EMPs a firm adopts. To our knowledge, this is the first study to examine the relationship. While most firms de-escalate the adoption of EMPs following a SP accident, a firm's sustainability record plays a key role in how a firm responds. We also demonstrate that accident severity plays an important role in the firm response, especially for firms that do not prioritize sustainability efforts. The combined results have important implications for on-going firm environmental performance. Previous researchers have asserted that the patterns of managerial action required for developing and maintaining a preventative management system, like that needed to manage environmental performance, only evolve over long periods of time. Perhaps previous studies were not able to identify these short-term relationships because the measures used to assess EMP adoption were high level proxies, such as an environmental award (Klassen and McLaughlin 1996) or ISO certification (Delmas and Toffel 2008, Gavronski et al. 2008, 2013, King et al. 2005, King and Lenox 2001), which only result from longer term patterns of decision making. Perhaps aggregated and lagging proxies of EMP adoption do not provide an accurate estimate of which practices firms adopt to manage their environmental performance, nor do they allow researchers to track changes in the pattern of actions over time. By measuring the actual practices firms use to manage their environmental impact, we can immediately and accurately evaluate how firms respond to various stimuli, such as a SP accident.

Second, we identify an important driver of EMP adoption which has not been studied previously and is unrelated to stakeholder or institutional pressure. While numerous studies have examined why firms adopt EMPs, a majority of them use stakeholder and institutional theory to hypothesize that firms adopt in response to pressure from various stakeholders, both external and internal to the firm (Delmas 2001, Delmas and Toffel 2008, Foster Jr et al. 2000, Hofer et al. 2012, Reuter et al. 2010, Sarkis et al. 2010). By showing that the number of EMPs a firm adopts is a function of a SP accident, we identify a driver of EMP adoption disconnected from stakeholder or institutional theories. While external pressure is identified as a critical force in driving firms to adopt more EMPs, our study shows that sudden negative events can have the opposite effect, i.e., cause a slowdown in EMP adoption. Further, our panel data structure lends credibility to the cause-effect nature of the relationship. Future studies may need to account for these intermittent setbacks (e.g., SP accidents) that can alter a firms' EMP adoption trajectory and ensuing environmental performance. Such sudden setbacks might qualify as 'rare events' (Rerup 2009), which reshape managerial attention and invoke novel learning processes to understand why the crisis occurred and develop strategies for preventing its reoccurrence.

Third, we broaden the conceptual domain of EMPs and present a more robust and nuanced operationalization of EMP adoption. The new operationalization allows for a deeper understanding of the relationships connected to EMP adoption. Fourth, using publicly reported, longitudinal, secondary data is a valuable complement to other methods often used to conduct research in this area. It not only buttresses the value of using publicly reported data to conduct research on firm environmental activity, but also increases the possibility of replicating the results in future analyses. Because the data are compiled from multiple sources, it is not subject to the key informant or common method biases often associated with survey methods (Gattiker and Parente 2007, Roth 2007). Further, its panel structure lends itself to incorporating lagged relationships and using more advanced econometric methods which provide greater control for rival explanations. Finally, our dataset includes a significantly larger set of EMPs and industries, as compared to prior studies. This improves the generalizability of, and confidence in, our conclusions.

5.3 Limitations and future research

While we are confident that the results provide compelling evidence in support of our conclusions, several potential limitations deserve mention. The results clearly demonstrate that most firms de-escalate the adoption of EMPs in response to a SP accident, and that they do not seem to recover from the slowdown in future years. However, we did not directly examine the impact of a slowdown in EMP adoption on future environmental performance. While we do not expect environmental performance to decline as a result of a SP accident because de-escalation does not necessarily equate to reduced EMP adoption from the prior year, we do expect future environmental performance to be less than it would have been had the accident not occurred. Such an investigation might be a productive avenue for future research.

Another limitation is that although we measure the number of EMPs a firm adopts, we do not capture the cost of implementing each EMP. It is possible that the marginal costs of implementing latter EMPs may be cheaper because of learning or complementarity effects from EMPs adopted earlier (Darnall and Edwards Jr 2006). Alternately, it is possible that implementing the initial EMPs is cheaper because they represent low-hanging opportunities. In either case, the variable costs of adopting new EMPs, or the savings realized from dropping old EMPs, may affect EMP adoption decisions. This again might be a productive avenue for future research.

There are also potential limitations related to our measures. We use annual measures for EMP adoption and SP accidents. More granular time slices (e.g., quarterly or monthly) could help identify the detailed sequence of actions and reactions which define the broader firm response to a SP accident. However, given that preventive management systems often evolve over time, our aggregated view might provide a better understanding of overall management intent than a micro analysis of each individual step involved in that transition. Further, while we operationalized SP accident severity in several different ways, other measures exist (e.g., deaths, loss of habitat). However, only the most severe SP accidents would result in deaths or loss of habitat. Our measures allow us to establish that firms respond to accidents of much lower severity. Future research could focus on alternate measures of SP accident severity. We use a binary variable of sustainability performance to identify firms likely to have the environmental leadership characteristics and cultures that help resist the temptation to de-escalate the number of EMPs they adopt when faced with a SP accident. Future research could develop and evaluate a more extensive measurement system which directly assesses the sustainability leadership traits in firms.

A final limitation is related to possible over-reporting of EMP adoption due to socially desirable response bias (Paulhus 2002). This would be problematic if a firm changes from over-reporting to under-reporting following a SP accident, which could contribute to the observed de-escalation. However, reporting biases become inconsequential if the firm follows a consistent approach from year-to-year. Further, the desire to over-report may be tempered because, (1) many firms have their environmental reports audited, while others leverage external reporting standards to ensure consistency in their reporting, and (2) informal auditing by customers, non-government organizations (NGO's) or government entities can result is severe consequences for firms which provide misleading information (Delmas and Burbano 2011).

Beyond the research opportunities already identified, an additional idea would be to assess whether other resource-consuming, unanticipated negative firm events trigger a slowdown in EMP adoption. Product recalls, for example, occur frequently and thus could have significant ramifications on environmental performance. A second idea would be to evaluate whether adopting more EMPs reduces the frequency (risk) of future SP accidents. As discussed, while no specific EMP is specifically designed to reduce the possibility of a SP accident, a more robust environmental management system derived from increased EMP adoption should improve overall environmental performance and thus could be more robust to spill or pollution accidents.

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Figure 1: Average # of EMPs adopted per firm by year

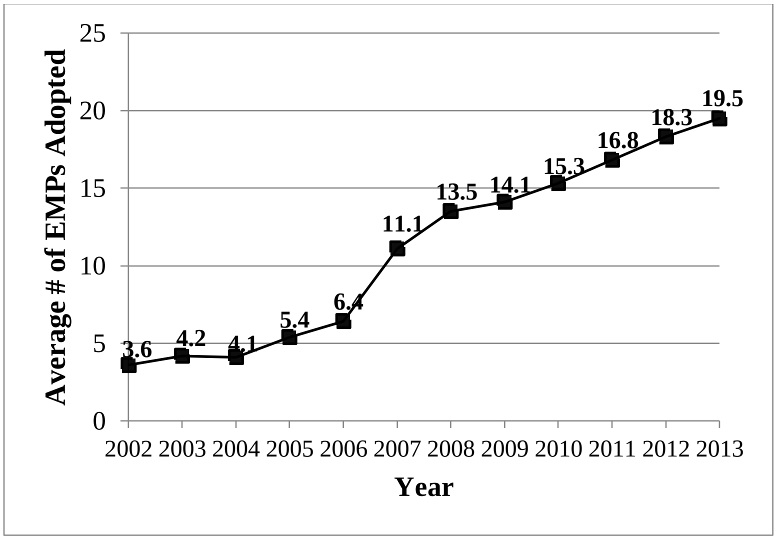

Figure 2: Possible response options to a SP accident

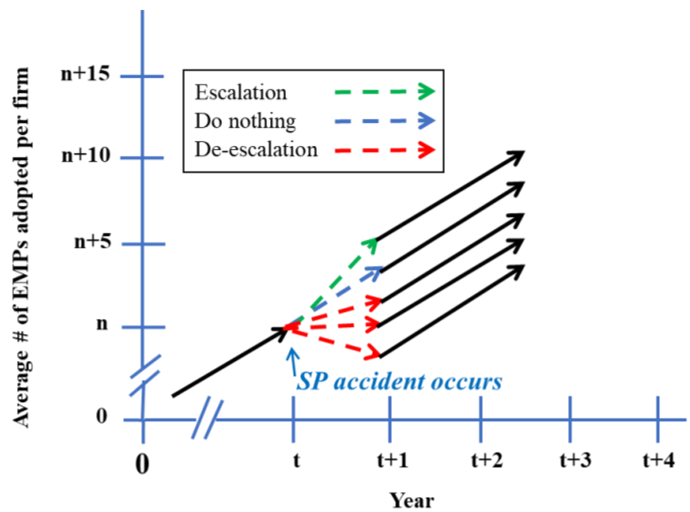

Figure 3: Conceptual schema to represent results

Table 1: Descriptive statistics and correlations

	Variable	Obs	Mean	Stdev	Min	Max	1	2	3	4	5	6	7	8	9	10
1	EMP adoption$_t$	3,582	12.70	12.29	0	46	1									
2	SP accident$_{t-1}$	3,637	0.09	0.28	0	1	0.24*	1								
3	Count of SP accidents$_{t-1}$	3,637	0.15	0.65	0	15	0.23*	0.73*	1							
4	SP accidents_ordinal$_{t-1}$	3,637	0.14	0.53	0	5	0.23*	0.83*	0.95*	1						
5	SP accident severity$_{t-1}$	3,626	0.20	0.69	0	3	0.24*	0.94*	0.74*	0.84*	1					
6	Firm sustainabilty record$_t$	3,595	0.14	0.35	0	1	0.58*	0.13*	0.12*	0.12*	0.14*	1				
7	Other environmental incidents$_{t-1}$	3,582	0.04	0.27	0	5	0.14*	0.24*	0.38*	0.36*	0.25*	0.09*	1			
8	Firm size$_t$	5,146	15.00	1.63	3.7	19.9	0.51*	0.31*	0.31*	0.32*	0.29*	0.37*	0.18*	1		
9	Firm profitability$_t$	5,366	6.51	11.93	-126	108	0.07*	-0.03*	-0.01	-0.02	-0.03	0.07*	0.01	0.26*	1	
10	Certified EMS$_t$	3,675	0.40	0.49	0	1	0.58*	0.11*	0.11*	0.12*	0.12*	0.34*	0.06*	0.32*	0.07*	1

*p<0.05

Table 2: Negative binomial regression analysis (Dependent Variable = EMP adoption)

	H1a				H1b
	1 Controls	2 Binary	3 Count	4 Both	5 Severity
Other environmental incidents$_{t-1}$	-0.04 (0.03)	-0.03 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.02 (0.03)
Firm size$_t$	0.16*** (0.03)	0.17*** (0.03)	0.16*** (0.03)	0.16*** (0.03)	0.16*** (0.03)
Firm profitability$_t$	-0.00* (0.00)	-0.00* (0.00)	-0.00* (0.00)	-0.00* (0.00)	-0.00* (0.00)
Certified EMS$_t$	0.62*** (0.03)	0.62*** (0.03)	0.62*** (0.03)	0.62*** (0.03)	0.63*** (0.03)
SP accident$_{t-1}$		-0.10*** (0.03)		0.01 (0.04)	
Count of SP accidents$_{t-1}$			-0.07*** (0.01)	-0.08*** (0.02)	
SP accident severity$_{t-1}$ (spill event only)					0.07 (0.05)
SP accident severity$_{t-1}$ (legal action taken)					-0.12** (0.04)
SP accident severity$_{t-1}$ (settlement details)					-0.18*** (0.04)
Constant	-0.93+ (0.54)	-1.06+ (0.55)	-0.93+ (0.54)	-0.92+ (0.55)	-0.86 (0.55)
Observations	3111	3100	3100	3100	3099
Chi-square model fit statistic	5956.38	5947.62	5966.01	5966.03	5964.26

Standard errors in parentheses, + $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$
Year and company fixed-effects included in all models, but not shown

Table 3: Moderating impact of Firm Sustainability Record (subgroup analysis)

	H2a		H2b	
	1 Sust. leader	2 All other	3 Sust. leader	4 All other
Other environmental incidents$_{t-1}$	-0.02 (0.03)	0.01 (0.04)	-0.02 (0.03)	-0.01 (0.04)
Firm size$_t$	0.03 (0.05)	0.18*** (0.04)	0.03 (0.05)	0.16*** (0.04)
Firm profitability$_t$	0.00 (0.00)	-0.00*** (0.00)	0.00 (0.00)	-0.00** (0.00)
Certified EMS$_t$	0.13* (0.05)	0.56*** (0.04)	0.14* (0.05)	0.56*** (0.04)
Count of SP accidents$_{t-1}$	-0.00 (0.01)	-0.10*** (0.02)		
SP accident severity$_{t-1}$ (spill event only)			0.01 (0.06)	0.10+ (0.05)
SP accident severity$_{t-1}$ (legal action taken)			0.00 (0.04)	-0.12* (0.06)
SP accident severity$_{t-1}$ (settlement details)			-0.03 (0.04)	-0.20*** (0.04)
Constant	2.22** (0.78)	-0.48 (0.71)	2.20** (0.78)	-0.16 (0.72)
Observations	484	2616	484	2615
Chi-squared model fit statistic	812.72	4992.20	813.50	4981.58

Standard errors in parentheses, + $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$
Year and company fixed-effects included in all models, but not shown

Table 4 - Post hoc analysis for H1a – Persistence of impact

	1	2	3	4
	t-1	t-2	t-3	t-4
Other environmental incidents$_{t-1}$	-0.01	0.01	0.02	0.02
	(0.03)	(0.02)	(0.02)	(0.02)
Firm size$_t$	0.16***	0.11***	0.08**	0.08**
	(0.03)	(0.03)	(0.03)	(0.03)
Firm profitability$_t$	-0.00*	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Certified EMS$_t$	0.62***	0.51***	0.39***	0.31***
	(0.03)	(0.03)	(0.03)	(0.03)
Count of SP accidents$_{t-1}$	-0.07***	-0.04***	-0.03***	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)
Count of SP accidents$_{t-2}$		-0.05***	-0.03*	-0.02*
		(0.01)	(0.01)	(0.01)
Count of SP accidents$_{t-3}$			-0.02*	-0.01
			(0.01)	(0.01)
Count of SP accidents$_{t-4}$				-0.02+
				(0.01)
Constant	-0.93+	0.19	1.00*	1.07*
	(0.54)	(0.50)	(0.45)	(0.50)
Observations	3100	2673	2253	1858
Chi-square model fit statistic	5966.01	5576.19	5077.39	4687.53

Standard errors in parentheses, + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Year and company fixed-effects included in all models, but not shown

Table 5: Summary of results

Hypothesis	Empirical Test	Hypothesized Sign	Empirical Results
Direct Effect			
H1a (Count of SP accidents)	SP$_{t-1}$ → EMP$_t$	(−)	(−), sig
H1b (SP accident severity)	SP severity$_{t-1}$ → EMP$_t$	(−)	(−), sig
Post Hoc of H1a (impact over time)	SP$_{t-2}$ → EMP$_t$	N/A	(−), sig
	SP$_{t-3}$ → EMP$_t$	N/A	(−), partial sig
	SP$_{t-4}$ → EMP$_t$	N/A	Not sig
Post Hoc of H1a (adoption breadth)	SP$_{t-1}$ → EMP breadth$_t$	N/A	(−), sig
Post Hoc of H1b (adoption breadth)	SP severity$_{t-1}$ → EMP breadth$_t$	N/A	(−), sig
Post Hoc of H1a (types of EMPs)	SP$_{t-1}$ → EMP types$_t$	N/A	No differences
Post Hoc of H1b (types of EMPs)	SP severity$_{t-1}$ → EMP types$_t$	N/A	No differences
Moderation – firm sustainability			
H2a (SP Count & Sustainability)	Subgroup analysis (SP$_{t-1}$ → EMP$_t$)	High: Not sig All other: (−), sig	Supported
H2b (SP Severity & Sustainability)	Subgroup analysis (SP severity$_{t-1}$ → EMP$_t$)	High: Not sig All other: (−), sig	Partial support

APPENDICES

Appendix A – EMP selection process

We followed an extensive process to identify the final set of environmental management practices (EMPs) used in the current study. First, we developed a candidate list of EMPs by identifying activities in the environmental pillar of Thomson Reuter's ASSET4 database which firms report as doing to reduce the impact of their operations, or supply chain, on the natural environment. This step yielded 104 candidate EMPs. Second, we developed an operational definition of EMPs which is inclusive of recent advances in leading academic journals and new approaches taken by firms to improve their environmental performance. Based on our investigation, we define EMPs as '*the activities firms undertake to reduce the impact of their operations, or supply chain, on the natural environment*'. Third, we mapped the candidate list of EMPs identified in Step 1 against this new operational definition. The mapping process eliminated activities that were either not undertaken with the intent to improve environmental performance or were merely an outcome of EMP activity, not an EMP itself. This resulted in a reduced list of 86 candidate EMPs. Fourth, we asked two research assistants to validate the outcome of Step 3 by repeating the mapping process. Only EMPs deemed by both research assistants to be consistent with the operational definition were retained. Finally, we dropped EMPs that were either not adopted by a single firm in our panel or which had significant missing data. The final set included 50 EMPs, as detailed in Table A.1 below. See Hardcopf et al. (2019) for further details on the EMP identification, selection, and validation process.

Table A.1 – Final list of EMPs included in study

No.	Asset4 Code	Title/Description	Assessment
1	enerdp0011	Emission Reduction Policy Elements/Emissions	Does the company have a policy to reduce emissions?
2	enerdp0012	Emission Reduction Policy Elements/Biodiversity	Does the company have a policy to reduce its impact on biodiversity?
3	enerdp0013	Emission Reduction Policy Elements/ Environmental Management Systems	Does the company have a policy to maintain an environmental management system?
4	enerdp0051	Emission Reduction Processes/Emissions	Does the company describe, claim to have or mention processes in place to improve emission reduction?
5	enerdp0052	Emission Reduction Processes/Biodiversity	Does the company describe, claim to have or mention processes in place to reduce its impact on biodiversity?
6	enerdp0053	Emission Reduction Processes/ Environmental Management Systems	Does the company describe, claim to have or mention processes in place to maintain an environmental management system?
7	enerdp006	CERES Valdez Principles	Is the company endorsing the CERES principles (or Valdez principles)?
8	enerdp0101	Emission Reduction KPI Monitoring/Emissions	Does the company claim to use key performance indicators (KPI) or the balanced scorecard to monitor emission reduction?

9	enerdp0102	Emission Reduction KPI Monitoring/Biodiversity	Does the company claim to use key performance indicators (KPI) or the balanced scorecard to monitor its impact on biodiversity?
10	enerdp0103	Emission Reduction KPI Monitoring/ Environmental Management Systems	Does the company claim to use key performance indicators (KPI) or the balanced scorecard to monitor its use of an environmental management system?
11	enerdp020	Biodiversity Restoration Protection	Does the company report on initiatives to restore or protect native ecosystems or the biodiversity of protected and sensitive areas?
12	enerdp028	CO2 Equivalents Emission Reduction Production	Does the company show an initiative to reduce, reuse, recycle, substitute, phased out or compensate CO2 equivalents in the production process?
13	enerdp029	CO2 Equivalents Emission Reduction Transportation	Does the company show an initiative to reduce, reuse, recycle, substitute or phase out CO2 equivalents in the product transportation process?
14	enerdp062	Waste Reduction Total	Does the company report on initiatives to recycle, reduce, reuse, substitute, treat or phase out total waste?
15	enerdp063	e-Waste Reduction	Does the company report on initiatives to recycle, reduce, reuse, substitute, treat or phase out e-waste?
16	enerdp067	Production Concentration	Does the company report on the concentration of production locations in order to limit the environmental impact during the production process?
17	enerdp068	Emissions Trading	Does the company report on its participation in any emissions trading initiative?
18	enerdp069	New Production Techniques	Does the company report on new production techniques to improve the global environmental impact (all emissions) during the production process?
19	enerdp070	Environmental Partnerships	Does the company report on partnerships or initiatives with specialized NGOs, industry organizations, governmental or supra-governmental organizations, which are focused on improving environmental issues?
20	enerdp076	Environmental Restoration Initiatives	Does the company report or provide information on company-generated initiatives to restore the environment?
21	enerdp081	Staff Transportation Impact Reduction	Does the company report on initiatives to reduce the environmental impact of transportation used for its staff?
22	enerdp082	Logistics and Product Transportation Impact Reduction	Does the company report on initiatives to reduce the environmental impact of the transportation of its products?
23	enerdp095	Environmental Investments Initiatives	Does the company report on making proactive environmental investments or expenditures to reduce future risks or increase future opportunities?
24	enpidp0011	Product Innovation Policy Elements/Life Cycle Assessments	Does the company have a product life-cycle assessment policy?
25	enpidp0012	Product Innovation Policy Elements/Eco Design	Does the company have an eco-design policy?
26	enpidp0013	Product Innovation Policy Elements/Dematerialization	Does the company have a de-materialization policy?
27	enpidp0014	Product Innovation Policy Elements/Product Innovation	Does the company have a general, all-purpose policy regarding environmental product innovation?
28	enpidp022	Energy Footprint Reduction	Does the company describe initiatives in place to reduce the energy footprint of its products during their use?
29	enrrdp0011	Resource Efficiency Policy Elements/Water Efficiency	Does the company have a policy to improve its water efficiency?
30	enrrdp0012	Resource Efficiency Policy Elements/Energy Efficiency	Does the company have a policy to improve its energy efficiency?

31	enrrdp0013	Resource Efficiency Policy Elements/Resource Efficiency	Does the company have a general, all-purpose policy regarding resource efficiency?
32	enrrdp0015	Resource Efficiency Policy Elements/ Environmental Supply Chain	Does the company have a policy to lessen the environmental impact of its supply chain?
33	enrrdp004	Environment Management Team	Does the company have an environmental management team?
34	enrrdp008	Environment Management Training	Does the company train its employees on environmental issues?
35	enrrdp011	Environment Management Improvement Tools	Does the company have the appropriate internal communication tools (whistle blower, ombudsman, suggestion box, hotline, newsletter, intranet, etc.) to ensure better environmental management?
36	enrrdp0121	Resource Efficiency Processes/ Water Efficiency	Does the company describe, claim to have or mention processes in place to improve its water efficiency?
37	enrrdp0122	Resource Efficiency Processes/ Energy Efficiency	Does the company describe, claim to have or mention processes in place to improve its energy efficiency?
38	enrrdp0123	Resource Efficiency Processes/Resource Efficiency	Does the company describe, claim to have or mention processes in place to improve its resource efficiency in general?
39	enrrdp0125	Environmental Supply Chain	Does the company describe, claim to have or mention processes in place to include its supply chain in the company's efforts to lessen its overall environmental impact?
40	enrrdp0131	Resource Efficiency KPI Monitoring/Water Efficiency	Does the company claim to use key performance indicators (KPI) or the balanced scorecard to monitor water efficiency?
41	enrrdp0132	Resource Efficiency KPI Monitoring/Energy Efficiency	Does the company claim to use key performance indicators (KPI) or the balanced scorecard to monitor energy efficiency?
42	enrrdp0133	Resource Efficiency KPI Monitoring/Resource Efficiency	Does the company claim to use key performance indicators (KPI) or the balanced scorecard to monitor resource efficiency in general?
43	enrrdp0135	Resource Efficiency KPI Monitoring/Environmental Supply Chain	Does the company claim to use key performance indicators (KPI) or balanced scorecard to monitor the environmental impact of its supply chain?
44	enrrdp029	Materials Sourcing Environmental Criteria	Does the company claim to use environmental criteria (e.g., life cycle assessment) to source or eliminate materials?
45	enrrdp046	Renewable Energy Use	Does the company make use of renewable energy?
46	enrrdp052	Green Buildings	Does the company report about environmentally friendly or green sites or offices?
47	enrrdp053	Energy Efficiency Initiatives	Does the company report on specific initiatives to improve its energy efficiency?
48	enrrdp057	Water Efficiency Initiatives	Does the company report on initiatives to reuse or recycle water?
49	enrrdp058	Environmental Supply Chain	Does the company use environmental criteria (ISO 14000, energy consumption, etc.) in the selection process of its suppliers or sourcing partners?
50	enrrdp059	Environmental Supply Chain	Does the company report or show to be ready to end a partnership with a sourcing partner, if environmental criteria are not met?

Appendix B – Robustness checks & Post hoc analyses for H1a – H2b

Table B.1 - Robustness checks and post hoc analyses for H1a (Count of SP accidents$_{t-1}$ → EMP adoption$_t$)

	Robustness checks					*Post Hoc analyses*		
Dependent Variable	EMPs adopted$_t$					Adoption	EMP types$_t$	
	1	2	3	4	5	6	7	8
	neg. bin.	xtgee	2002-	PSM[a]	ordinal	neg. bin.	Operational	Tactical
Other environmental incidents$_{t-1}$	-0.01	-0.02	-0.00	0.00	-0.01	0.01	0.00	0.01
	(0.03)	(0.04)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Firm size$_t$	0.16***	0.39***	0.11*	0.09*	0.17***	0.11***	0.17***	0.08*
	(0.03)	(0.03)	(0.05)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)
Firm profitability$_t$	-0.00*	-0.00+	-0.00	-0.00	-0.00*	-0.00	-0.00*	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Certified EMS$_t$	0.62***	0.65***	0.62***	0.49***	0.62***	0.51***	0.71***	0.54***
	(0.03)	(0.09)	(0.04)	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)
Count of SP accidents$_{t-1}$	-0.07***	-0.09**	-0.10***	-0.04***		-0.06***	-0.06***	-0.06***
	(0.01)	(0.03)	(0.02)	(0.01)		(0.01)	(0.02)	(0.01)
SP accidents_ordinal$_{t-1}$					-0.08***			
					(0.02)			
Constant	-0.93+	-5.16***	0.02	0.57	-0.99+	1.01+	-1.75**	0.30
	(0.54)	(0.47)	(0.78)	(0.60)	(0.54)	(0.57)	(0.58)	(0.56)
Observations	3100	3100	1611	1555	3100	2986	2787	2939
Chi-square model fit statistic	5966.01	1797.18	2588.15	3079.93	5964.04	2649.41	2800.83	3156.25

Standard errors in parentheses, + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Year and company fixed-effects included in all models, but not shown, with the exception of the xtgee model
[a]PSM = Propensity Score Matching

Table B.2 - Robustness checks and post hoc analyses for H1b (Accident severity$_{t-1}$ → EMP adoption$_t$)

	Robustness Checks				*Post Hoc analyses*		
Dependent Variable	EMPs adopted$_t$				Adoption	EMP types$_t$	
	1	2	3	4	5	6	7
	neg. bin.	xtgee	2002-	PSM[a]	neg. bin.	Operational	Tactical
Other environmental incidents$_{t-1}$	-0.02	-0.03	-0.03	-0.01	0.00	-0.01	-0.01
	(0.03)	(0.04)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
Firm size$_t$	0.16***	0.39***	0.10*	0.08*	0.11***	0.17***	0.08*
	(0.03)	(0.03)	(0.05)	(0.04)	(0.03)	(0.04)	(0.04)
Firm profitability$_t$	-0.00*	-0.00+	-0.00	-0.00	-0.00	-0.00*	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Certified EMS$_t$	0.63***	0.66***	0.63***	0.49***	0.52***	0.72***	0.55***
	(0.03)	(0.09)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
SP accident severity$_{t-1}$ (spill event only)	0.07	0.15	0.07	0.08+	0.03	0.04	0.03
	(0.05)	(0.13)	(0.07)	(0.04)	(0.05)	(0.06)	(0.05)
SP accident severity$_{t-1}$ (legal action taken)	-0.12**	-0.15	-0.19**	-0.05	-0.09*	-0.12*	-0.06
	(0.04)	(0.09)	(0.06)	(0.04)	(0.04)	(0.05)	(0.05)
SP accident severity$_{t-1}$ (settlement details)	-0.18***	-0.22**	-0.27***	-0.08*	-0.13***	-0.16***	-0.13***
	(0.04)	(0.07)	(0.05)	(0.03)	(0.04)	(0.04)	(0.04)
Constant	-0.86	-5.09***	0.13	0.70	1.03+	-1.75**	0.36
	(0.55)	(0.46)	(0.78)	(0.61)	(0.58)	(0.59)	(0.56)
Observations	3099	3099	1611	1554	2985	2786	2938
Chi-square model fit statistic	5964.26	1810.71	2588.50	3077.60	2656.02	2815.31	3158.54

Standard errors in parentheses, + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Year and company fixed-effects included in all models, but not shown, with the exception of the xtgee model
[a]PSM = Propensity Score Matching

Table B.3 - Robustness checks for H2a (Firm sustainability record moderates, Count of SP accidents$_{t-1}$ → EMP adoption$_t$)

	1	2	3	4	5	6	7	8	9	10
	neg. bin.		xtgee		2002-2012		PSM[a]		ordinal	
	High	All other	High	All other	High	All other	High	All other	High	All other
Other environmental incidents$_{t-1}$	-0.02	0.01	-0.02	0.03	-0.01	0.03	-0.01	0.03	-0.02	-0.00
	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)	(0.03)	(0.04)
Firm size$_t$	0.03	0.18***	0.10***	0.44***	0.03	0.12*	-0.05	0.15***	0.03	0.17***
	(0.05)	(0.04)	(0.02)	(0.04)	(0.05)	(0.06)	(0.06)	(0.04)	(0.05)	(0.04)
Firm profitability$_t$	0.00	-0.00***	0.00	-0.01***	0.00	-0.00	0.00+	-0.00*	0.00	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Certified EMS$_t$	0.13*	0.56***	0.19*	0.65***	0.15**	0.54***	0.19**	0.41***	0.14*	0.56***
	(0.05)	(0.04)	(0.09)	(0.07)	(0.06)	(0.05)	(0.06)	(0.05)	(0.05)	(0.04)
Count of SP accidents$_{t-1}$	-0.00	-0.10***	-0.01	-0.11***	-0.01	-0.16***	-0.00	-0.07***		
	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)	(0.02)		
SP accidents_ordinal$_{t-1}$									-0.01	-0.10***
									(0.02)	(0.02)
Constant	2.22**	-0.48	0.56+	-6.60***	2.05*	0.40	3.56***	0.07	2.21**	-0.47
	(0.78)	(0.71)	(0.33)	(0.59)	(0.83)	(1.08)	(1.05)	(0.74)	(0.77)	(0.71)
Observations	484	2616	484	2616	373	1238	353	1199	484	2616
Chi-square model fit statistic	812.72	4992.20	590.22	13365.24	648.42	1992.57	598.73	2477.09	812.80	4984.30

Standard errors in parentheses, + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Year and company fixed-effects included in all models, but not shown, with the exception of the xtgee model
[a]PSM = Propensity Score Matching

Table B.4 - Robustness checks for H2b (Firm sustainability record moderates, Accident severity$_{t-1}$ → EMP adoption$_t$)

	1	2	3	4	5	6	7	8
	neg. bin.		xtgee		2002-2012		PSM[a]	
	High	All other	High	All other	High	All other	High	All
Other environmental incidents$_{t-1}$	-0.02	-0.01	-0.02	0.01	-0.02	-0.02	-0.01	0.01
	(0.03)	(0.04)	(0.03)	(0.05)	(0.03)	(0.05)	(0.03)	(0.03)
Firm size$_t$	0.03	0.16***	0.10***	0.43***	0.04	0.09	-0.05	0.12**
	(0.05)	(0.04)	(0.02)	(0.04)	(0.05)	(0.06)	(0.06)	(0.04)
Firm profitability$_t$	0.00	-0.00**	0.00	-0.01***	0.00	-0.00	0.00+	-0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Certified EMS$_t$	0.14*	0.56***	0.19*	0.65***	0.15**	0.55***	0.19**	0.42***
	(0.05)	(0.04)	(0.09)	(0.07)	(0.06)	(0.05)	(0.06)	(0.05)
SP accident severity$_{t-1}$ (spill event only)	0.01	0.10+	0.02	0.16	-0.00	0.14	0.03	0.10*
	(0.06)	(0.05)	(0.03)	(0.15)	(0.06)	(0.09)	(0.06)	(0.05)
SP accident severity$_{t-1}$ (legal action taken)	0.00	-0.12*	0.01	-0.22**	-0.01	-0.22*	0.01	-0.06
	(0.04)	(0.06)	(0.05)	(0.08)	(0.05)	(0.09)	(0.04)	(0.05)
SP accident severity$_{t-1}$ (settlement details)	-0.03	-0.20***	-0.05	-0.21**	-0.07	-0.33***	-0.02	-0.12**
	(0.04)	(0.04)	(0.04)	(0.07)	(0.05)	(0.07)	(0.04)	(0.04)
Constant	2.20**	-0.16	0.56+	-6.51***	2.01*	0.93	3.61***	0.57
	(0.78)	(0.72)	(0.33)	(0.58)	(0.83)	(1.09)	(1.04)	(0.75)
Observations	484	2615	484	2615	373	1238	353	1198
Chi-square model fit statistic	813.50	4981.58	644.51	14155.66	650.18	1987.17	599.31	2467.73

Standard errors in parentheses, + p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Year and company fixed-effects included in all models, but not shown, with the exception of the xtgee model
[a]PSM = Propensity Score Matching

Appendix C – EMP categories developed to measure 'breadth of EMP adoption'

	Category name	EMPs included[a]
Reduced Process Inputs	**Water efficiency** (processes, practices, policies, performance monitoring, reuse, recycle)	enrrdp0011, enrrdp0121, enrrdp0131, enrrdp057
	Energy efficiency (processes, practices, policies, performance monitoring, use renewable energy)	enrrdp0012, enrrdp0122, enrrdp0132, enrrdp046, enrrdp053
	Resource efficiency (processes, practices, policies, performance monitoring, reduction, phase-out)	enrrdp0013, enrrdp0123, enrrdp0133, enrrdp029
Reduced Process Waste	**Emission reduction** (processes, policies, performance monitoring)	enerdp0011, enerdp0051, enerdp0101, enerdp028
	Waste reduction in *production* areas (ex. revised production techniques, recycling, reuse, substitute, consolidate production locations)	enerdp062, enerdp067, enerdp068, enerdp069
	Waste reduction in *non-production* areas (ex. logistics, transportation, buildings, e-waste)	enerdp029, enerdp063, enerdp081, enerdp082, enrrdp052
	Biodiversity impact reduction/protection/restoration (processes, practices, policies, performance monitoring)	enerdp0012, enerdp0052, enerdp0102, enerdp020
Others	**Environmental product innovation** (ex. life cycle assessments, eco-design policy, dematerialization policy, product innovation)	enpidp0011, enpidp0012, enpidp0013, enpidp0014, enpidp022
	Supply chain environmental performance improvement (ex. environmental supplier selection criteria, policies, processes, performance monitoring)	enrrdp0015, enrrdp0125, enrrdp0135, enrrdp058, enrrdp059
	Environmental management system usage - EMS (processes, practices, policies & performance monitoring)	enerdp0013, enerdp0053, enerdp0103
	Environmental management team	enrrdp004
	Environmental management improvement tools (ex. whistle blower, ombudsman, suggestion box, hotline, newsletter, intranet)	enrrdp011
	Environmental standards adoption (ex. Ceres Valdez Principles)	enerdp006
	Environmental restoration initiatives	enerdp076
	Environmental partnerships	enerdp070
	Environmental investments	enerdp095
	Environmental training	enrrdp008

See Appendix A, Table A.1 for details on the EMPs which map to each category