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GOOD FENCES MAKE GOOD NEIGHBORS: A LONGITUDINAL ANALYSIS OF AN INDUSTRY SELF-REGULATORY INSTITUTION

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We extend theories of self-regulation of physical commons to analyze self-regulation of intangible commons in modern industry. We posit that when the action of one firm can cause "spillover" harm to others, firms share a type of commons. We theorize that the need to protect this commons can motivate the formation of a self-regulatory institution. Using data from the U.S. chemical industry, we find that spillover harm from industrial accidents increased after a major industry crisis and decreased following the formation of a new institution. Additionally, our findings suggest that the institution lessened spillovers from participants to the broader industry.

Interest in self-regulatory institutions, whereby firms in an industry create and voluntarily abide by a set of governing rules, has gone through a renaissance of late (cf. Prakash & Potoski, 2006). Scholars have investigated self-regulatory institutions in industries as diverse as chemicals (King & Lenox, 2000; Lenox, 2006), hospitality and recreation (Rivera & de Leon, 2004), nuclear power (Rees, 1994), and maritime shipping (Furger, 1997). Drawing from the work of Elinor Ostrom (1990) and Douglas North (1981), many of these scholars have argued that self-regulatory institutions arise to constrain individual actions that might harm an industry as a whole. Ostrom's (1990) work on community self-regulation has been particularly influential in framing recent research on industry self-regulation. She demonstrated that those who share in common pool resources like fisheries or forests can unite to create an institution that helps them avert the "tragedy of the commons" (Hardin, 1968), wherein individuals overuse and destroy commonly held resources.[1]

[1] The concept of the tragedy of the commons arose as a rebuttal to the common belief that the "invisible hand" of the market causes the pursuit of individual self-interest to aggregate into improved public welfare. In contrast, Hardin (1968), building on ideas advanced by Lloyd (1833), argued that because an individual's gains from increased consumption of a public good exceed the individual's costs (the individual captures all the gains, but the costs are shared by the members of the commons), individuals have a dominant incentive to overexploit unregulated public goods. As a result, "Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all" (Hardin, 1968: 1244).

However, the theoretical and empirical foundations of this growing stream of research on industry self-regulation remain uncertain and contradictory. First, the common pool resource dilemmas that Ostrom considered are not apparent in many industries in which self-regulation has arisen. Research has yet to establish whether the same logic that Ostrom applied to the governance of shared physical resources can be extended to modern industries. Second, empirical studies of self-regulation have often fallen victim to what Granovetter (1985) dismissed as "bad functionalism"—the tendency to infer the function of an institution by assuming conditions it might serve to ameliorate rather than by actually observing conditions before and after the institution's creation. Third, research on some frequently studied institutions seems to provide contradictory evidence with respect to their functions. For several important self-regulatory institutions, scholars have failed to find any evidence that they limit the harmful practices of member firms, yet studies of these same institutions show that they provide a benefit to firms in their industries (King & Lenox, 2000; Lenox, 2006; Rivera & de Leon, 2004).

In this article, we address some of the deficiencies in previous research and so strengthen the theoretical and empirical foundation of the literature on self-regulatory institutions. First, we draw attention to a novel type of "commons problem" that exists in many industries. We argue that a firm's error can harm other firms in its industry and thus cause all firms in the industry to share a pooled risk. Second, we avoid bad functionalism by measuring this shared risk over a time period that spans both the emergence of our hypothesized commons problem and the formation of the self-regulatory institution. Finally, by more precisely identifying the mechanism by which the institution provides benefits to the industry, we provide insight on how inconsistencies in the existing literature may be resolved.

THEORY AND HYPOTHESES

Institutions are the "humanly devised constraints that structure political, economic and social interaction" (North, 1990: 97). North separated institutions into those that operate through formal constraints (e.g., rules, laws, and constitutions) and those that operate through informal constraints (e.g., norms of behavior, conventions, and self-imposed codes of conduct). Ingram and Clay (2000) refined North's typology by suggesting that institutions should be classified as (1) public or private and (2) centralized or decentralized. Public institutions are usually compulsory and are often run by the state. Private institutions—those run by organizations or individuals—are voluntary in nature, because actors can opt in or out. In the centralized form of these institutions, a central authority sets rules, incentives, and sanctions for noncompliance. For example, many private institutions (e.g., for-profit firms) have a principal that is ultimately in charge of internal procedures. Decentralized forms of these institutions lack a powerful central authority and thus rely on the action of numerous independent actors to encourage compliance with institutional rules. In many industrial settings, antitrust laws forbid centralized industry bodies from controlling and sanctioning member firm behaviors, and so industry self-regulation tends to take the form of a private and decentralized institution.

Until recently, many scholars dismissed the viability of self-regulatory institutions. Influential analyses by Olson (1965) and Hardin (1968) suggested that since participation is voluntary and free from enforcement by a central authority, each actor has an incentive to defect from agreements and that consequently, such institutions should never arise. As a result, absent government regulation or privatization, public goods should generally fall victim to the tragedy of the commons.

However, widespread skepticism about self-regulatory institutions began to change as a result of a series of investigations in the 1980s and 1990s (cf. Acheson, 1988; Berkes, 1989; Ostrom, 1990; Wade, 1988). Ostrom's work, in particular, changed perceptions of the potential for self-regulation. Through a series of comparative case studies, she demonstrated that individuals could, in fact, organize institutions to cope with overuse of commonly held resources such as fresh water aquifers, fisheries, and forests (Ostrom, 1990). When actors could negotiate, observe, and enforce compliance with common rules, she argued, self-regulatory institutions could protect commonly held resources, and the benefits provided by protection of these common resources could spur actors to create and participate in these institutions. In her own assessment, her work helped "shatter the convictions of many policy analysts that the only way to solve common pool resource problems is for external authorities to impose full private property rights or centralized regulation" (Ostrom, 1990: 182). Drawing on experimental and field research conducted by her workshop, she concluded that "individuals in all walks of life and all parts of the world voluntarily organize themselves so as to gain the benefits of trade, to provide mutual protection against risk, and to create and enforce rules that protect natural resources" (Ostrom, 2000: 138).

Although self-regulatory institutions have often been overlooked in the management literature, research on the topic is not without precedent (e.g., Gupta & Lad, 1983; Maitland, 1985). Yet it is only in recent years that growing awareness of research in other fields and increasing recognition of the importance of protecting common resources has caused management scholars to take a more active interest in self-regulatory institutions (Furman & Stern, 2006; Jiang & Bansal, 2003; King & Lenox, 2000). Most of these studies have focused on the determinants or consequences of participation in a self-regulatory institution. Few have explored the conditions both before and after an institution's formation. In their review, Ingram and Clay (2000) identified only one study in the management literature that analyzed antecedent and consequent conditions longitudinally, as is necessary to understand the relationship between the existence of a commons problem and self-regulation. In the identified study, Ingram and Inman (1996) showed that when faced with the threat of potential damage to a commonly valued resource, Niagara Falls, local hoteliers were able to form a self-regulatory institution that limited development and so protected the scenery of the Falls, thereby increasing the probability of survival of nearby hotels.

Ingram and Inman (1996) followed Ostrom (1990) in arguing that the need to protect a shared physical resource such as water or land can act as the catalyst for effective self-regulation. Yet many modern industries engage in self-regulation, even though few are challenged by dwindling stocks of a physical resource openly shared with rivals. For example, the Institute of Nuclear Power Operations did not arise in the face of overuse of shared stocks of uranium in the nuclear power industry, nor did the Beer Institute Code arise in the face of threatened shortages of communal supplies of barley or hops in the brewing industry. What might explain the frequent presence of self-regulation in settings such as these?

One explanation, as we elaborate next, is that firms in an industry share an intangible commons that binds them to a shared fate. As with a physical commons, when the intangible commons is damaged, it can pose a serious threat to the success and survival of the firms that share it. We hypothesize that industry self-regulation in modern industries may function as a means of resolving this type of commons problem.

Industry Commons: A Shared Fate through Shared Sanctions

Firms are considered to be members of the same industry when the outputs they produce are closely substitutable. To produce closely substitutable outputs, firms in an industry tend to have similar characteristics and make use of similar processes. As a result, when new information is revealed about the characteristics of one firm, it reflects to some degree on all firms within its industry. Such interdependence can be favorable if, for example, one firm's success helps to legitimize an emerging industry and so eases all such firms' access to resources (cf. Hannan & Carroll, 1992), but it can also be problematic. Just as one firm's successes can "spill over" to other firms, so too can its problems. For example, recent news of contaminated spinach harmed the sale of all salad products—not just the products of those firms where the contamination was found (Galvin, 2007).

Tirole (1996) developed "a theory of collective reputations" to explain how the reputation of a group and those who compose the group, past and present, are intertwined. Building from the premise that a group's reputation is only as good as that of its members, Tirole (1996) argued that imperfect observability of individual behavior is the underlying cause of collective reputations. Because individual characteristics are observed with noise, a group cannot separate itself from the behaviors of its individual members, and these past behaviors of individuals within the group establish expectations that others hold of the entire group. As a result, "new members of an organization may suffer from an original sin of their elders long after the latter are gone" (Tirole, 1996: 1).

Whereas Tirole (1996) defined a group at the firm level, explaining how the behaviors of individuals within a firm culminate in a "collective" reputation for the firm, management scholars have since applied similar logic in pushing collective reputation to the interfirm level, particularly to the industry level (Barnett & Hoffman, 2008). King, Lenox, and Barnett (2002) argued that firms in an industry share a "reputation commons." A firm's reputation is based on observers' judgments of the actions of that firm over time (Fombrun, 1996). If observers can judge the actions of a firm independently of the actions of its rivals, no commons exists, but when one firm's actions influence the judgments observers make of another firm or an industry as a whole, a commons arises. This reputation commons intertwines the fates of firms in an industry because all firms suffer when any firm engages in actions that damage the industry's shared reputation.

A shared reputation is just one mechanism that may cause firms in an industry to share a common fate. King et al. (2002) further noted the role of collective stakeholder sanctions or rewards. Firms may be grouped together because it is easier to administer a common policy over a number of firms. For example, U.S. water pollution regulation often follows categorical guidelines for each industry (Environmental Protection Agency [EPA], 1999). Such common policies also reduce the potential for regulatory corruption (Blackman & Boyd, 2002).

Regulators and other stakeholders also may impose common sanctions because they are unable to discriminate between high- and low-performer firms in an industry. For example, unable to ascertain which firms had contributed to toxic waste dumps, the U.S. government imposed a fee on all chemical producers to fund the Superfund cleanup effort. Nongovernmental stakeholders often have even greater difficulty evaluating the relative performance of firms, because such stakeholders usually lack the access and financial resources available to regulators. As a result, these stakeholders may advocate a general boycott of certain types of goods, or they may select individual firms arbitrarily for sanctioning, thereby putting all firms in the industry at risk (Spar & La Mure, 2003). For example, activist discontent with working conditions in the coffee, athletic shoe, and apparel industries led to high-profile protests and boycotts against individual firms in these industries (Starbucks, Nike, and Kathy Lee Gifford, respectively) that used suppliers with working conditions that were no worse than their rivals'—and were in some cases superior (Hornblower, 2000; Malkin, 1996). Although these sanctions were individually targeted, the arbitrariness with which firms were targeted for sanction created a risk that all firms in these industries shared.

Though it has not isolated the mechanisms that produce such effects, empirical research in financial economics has established that an error[2] attributable to a single firm can indeed have adverse financial consequences for an entire industry. Jarrell and Peltzman (1985) found that a drug recall by one pharmaceutical firm caused a portfolio of 50 rival firm stocks to drop by 1 percent. They found an even stronger industrywide effect in the automobile industry. When Ford or Chrysler initiated a recall, General Motors actually experienced a larger loss than the recalling firm. Hill and Schneeweis (1983) reported a loss in market value of a portfolio of all electrical utility stocks following the 1979 accident at the Three Mile Island nuclear plant. Mitchell (1989) concluded that the firms in the over-the-counter pharmaceutical industry lost $4.06 billion following the deadly Tylenol tampering incident. Accordingly, we hypothesize:

Hypothesis 1. An error at one firm harms other firms in the same industry.

Industry Commons as a Problem

An industry commons cannot be physically depleted in the same manner as a fishery, but it can become damaged in a way that significantly harms firms and even threatens the industry's ongoing legitimacy. For example, the crisis at Three Mile Island in 1979 sparked such deep and enduring public concern about nuclear safety that regulators have not since approved any new nuclear power plants in the United States. Major crises like this can be a catalyst for shifts in stakeholder perceptions of an industry (Hoffman & Ocasio, 2001; Meyer, 1982; Rees, 1997). Yu, Sengul, and Lester (2008) argued that crises alter stakeholders' mental classifications of firms. These mental classifications are simplistic and so can produce broad-brushed responses. As a result, a crisis stemming from the actions of one firm can cause stakeholders to update their beliefs about the reliability and accountability of other firms in the same industry. Greenwood, Suddaby, and Hinings (2002) described a similar process in which "jolts" (Meyer, Brooks, & Goes, 1990) deinstitutionalize established industry practices and set in motion a process of "theorization" that determines how observers will view future industry practices.

Hoffman argued that stakeholder perceptions of an industry are based on metaphors. These perceptions can change "suddenly and unpredictably" (1999: 366) as significant events influence taken-for-granted assumptions and create new metaphors about the industry. These new metaphors influence the interpretation of future events, and they can cause even minor events to draw attention and raise the threat of greater sanctions across an industry. Consider the airline industry in the aftermath of the events of September 11, 2001. These events shifted how observers viewed the airline industry, causing many to assess airplanes not merely as a means of transportation, but also as a means of terrorism. Under this shifted mind-set, observers focused much more attention on airline activity and interpreted new events in light of their potential to be part of a terrorist plot. As a result, minor breaches of security that had previously gone unnoticed or unquestioned now drew media attention and engendered public calls for more stringent security protocols that raised costs and sometimes lowered demand for the entire industry.

Reports of executives in the petroleum and nuclear power industries validate the perspective that a major crisis can alter perceptions of an industry and, as a result, future problems within the industry carry the risk of more severe industrywide harm. As Hoffman (1997) recounted, following the Exxon Valdez oil spill in 1989, an Amoco executive noted that now his firm would "have to live with the sins of our brothers. We were doing fine until Exxon spilled all that oil. Then we were painted with the same brush as them" (Hoffman, 1997: 189). According to the founding chairman of the Institute of Nuclear Power Operations, in the aftermath of the Three Mile Island crisis, "It hit us that an event at a nuclear plant anywhere in our country . . . could and would affect each nuclear plant. . . . Each licensee is a hostage of each other licensee" (Rees, 1994: 2). Therefore, we hypothesize the following:

Hypothesis 2. A major crisis increases the degree to which an error at one firm harms other firms in the same industry.

[2] We use the term "error" to describe an event associated with a firm that carries adverse consequences. We later operationalize errors as industrial accidents. However, we do not use the terms "accident" or "mistake" because our theoretical framework deals with events that, though unintended and unplanned, may reveal intentional actions by managers and so reflect on the characteristics of the firm and, in particular, similar other firms. For example, an accident may reveal a managerial decision to underinvest in safety systems, and the discovery of child labor in a supplier's factories may reveal a managerial failure to adequately oversee suppliers.

Industry Self-Regulation as the Solution

How might an industry respond to a commons problem? Until recently, many scholars would have predicted there would be little response at all. Publications by Lloyd (1833/1968) and Hardin (1968) on the tragedy of the commons firmly established the dominant expectation that actors sharing a common resource cannot effectively self-govern their use of this resource. In the last few years, research on common pool resources has begun to change such expectations by suggesting that the risks from inefficient use of common resources can motivate members of a commons to create a self-regulatory institution (Ostrom, 1990). Yet it is also clear that forming a self-regulatory institution can be difficult. Competition, inertia, and the inherent cost of forming such an institution inhibit rival firms from coming together (Barnett, 2006).

Research has suggested that a sudden worsening of a commons problem, as described in the prior section, is often the catalyst that brings actors together to form a self-regulatory institution (Gunderson, Holling, & Light, 1995; Gunningham & Rees, 1997). For example, self-regulation in the Maine lobster industry arose after a collapse of the fishery caused the closure of important canneries (Acheson & Knight, 2000). Similarly, environmental emergencies in New Brunswick, the Everglades, and the Chesapeake Bay precipitated changes to governing institutions (Gunderson, Holling, & Light, 1995). Crises such as these can help actors overcome cognitive barriers and recognize the existence and importance of a commons (Weber, Kopelman, & Messick, 2004), and they can also change expectations of the value of taking action (Vasi & Macy, 2003).

Institutions created in response to a threat to a shared natural resource, scholars have argued, tend to reduce the shared threat (Acheson & Knight, 2000; Ostrom, 1990). This prediction matches a "functionalist" interpretation of institutions that suggests they arise to facilitate more efficient social exchange (cf. North, 1981; Williamson, 1985). However, evidence supporting the functionality of self-regulatory institutions remains largely lacking, in part because scholars often cannot access the information about conditions prior to the creation of the institution. As a result, many attempts at empirical validation have been soundly criticized as "bad functionalism." In an influential critique, Granovetter (1985) quoted Schotter's statement that many studies begin with a theory of the function of an institution and then infer "the evolutionary problem that must have existed for the institution as we see it to have developed" (Schotter [1981: 2], quoted in Granovetter, 1985: 489).

Herein, we advance a functional theory of self-regulatory institutions, but rather than inferring the problem that must have existed for such institutions to have arisen in modern industry, we use theory to hypothesize the creation of a particular type of problem: a major crisis exacerbates an industry commons, placing firms at heightened risk of harm from errors at other firms in the industry. To validate our functional theory, then, we next hypothesize that the institution formed in response to this crisis indeed functions to reduce the heightened commons problem.

Hypothesis 3. An industry self-regulatory institution created following a major crisis reduces the degree to which an error at one firm harms other firms in the same industry.

By specifying the existence of a particular commons problem and then testing whether or not an industry self-regulatory institution alleviated this problem, the prior set of hypotheses constitutes a proper test of a functional theory of self-regulation in modern industry. However, a thorough analysis of a self-regulatory institution should include a specification of the means through which it achieves its function. We next explore the institution's mechanisms.

Exploring the Mechanisms of Industry Self-Regulation

As we have theorized thus far, firms in an industry are subject to "spillover" harm from the errors of other firms, and an industry self-regulatory institution functions to lessen this harm. We have not yet specified how the institution might accomplish this objective. The literature on industry self-regulation suggests two possible mechanisms: the institution might forestall the threat of industrywide stakeholder sanctions (Stefanadis, 2003), or it might direct sanctions away from it members (Terlaak & King, 2006).

Forestalling sanctions to an industry. One way an institution might help firms forestall industrywide stakeholder sanctions would be by facilitating collective performance improvements relative to criteria of concern to stakeholders (Barrett, 2000; Dawson & Segerson, 2005). In doing so, the institution would impose costs on its members, but it would create greater value by reducing the risk of stakeholder action (e.g., government regulation). Although it is influential in setting research agendas, the general applicability of this model has been called into question by empirical evidence that participants in industry programs for environmental improvement do not have better performance than nonmembers, nor do they seem to improve more rapidly (Howard, Nash, & Ehrenfeld, 2000; King & Lenox, 2000; Rivera & de Leon, 2004).

Even if a self-regulatory institution failed to improve average industry performance, it might still reduce the threat of industrywide sanction by coordinating a unified "non-market strategy" among firms in the industry (Baron, 1995). For example, by acting together, firms might more efficiently and effectively lobby state regulators and so counter threats of increased regulation. Even if the target stakeholder is more diffuse than a state regulator (e.g., consumers or stakeholder groups), the institution might still aid in forestalling sanctions by assisting in the creation of a consistent message or by allowing firms to pool resources and so access economies of scale in communication (e.g., television advertisements).

Some mechanisms of forestalling stakeholder sanctions could differentially reduce the spillover harm from errors occurring at a member of an institution. One common case occurs when an institution facilitates the transfer of reassuring information following an error at a member firm. Research has demonstrated that open provision of information about an error such as an accident, spill, or drug-tampering incident can reduce the degree to which stakeholders sanction the focal firm (Shrivastava & Siomkos, 1989). Thus, when member firms do suffer errors, their coordinated efforts at communication could provide an efficient and effective means of reducing spillover harm.

A self-regulatory institution could also reduce spillover harm from the errors of member firms by coordinating communication before an error occurs. From the perspective of information economics, if a stakeholder already understands the propensity for an error, the occurrence of an error should provide no new information. From a psychological perspective, information provided in advance of an error may also influence how the error is interpreted by reducing the degree to which stakeholders view any observed error as informative about unobserved dangers, thus resulting in a soothing effect. Slovik and Weber (2002) reported that:

> The informativeness or signal potential of a mishap, and thus its potential social impact, appears to be systematically related to the perceived characteristics of the hazard. An accident that takes many lives may produce relatively little social disturbance (beyond that caused to the victims' families and friends) if it occurs as part of a familiar and well-understood system (e.g., a train wreck). However, a small incident in an unfamiliar system (or one perceived as poorly understood), such as a nuclear waste repository or a recombinant DNA laboratory, may have immense social consequences if it is perceived as a harbinger of future and possibly catastrophic mishaps. (2002: 13)

Thus, an industry self-regulatory institution may fulfill its function of reducing spillover harm by disclosing key information about its member firms, so that future errors at these firms reveal little or no new information of relevance and so draw few or no industrywide stakeholder sanctions. Consistently with this notion, the first code of one influential self-regulatory institution, the chemical industry's Responsible Care Program, was focused on stakeholder outreach. It obliged managers of facilities of participating firms "to identify and respond to community concerns, [and] inform the community of risks associated with company operations" (Canadian Chemical Producers' Association [CCPA], 2007).

If a self-regulatory institution forestalls broad stakeholder sanctions by coordinating improvement, lobbying, or public relations for an industry, it should provide a general benefit to the industry as a whole.[3] However, if it forestalls industrywide sanctions by providing additional information about its members only, either before or after errors, spillover harm from members' errors should be reduced. Thus, we hypothesize the following:

Hypothesis 4. An industry self-regulatory institution decreases the degree to which an error at a member firm harms other firms in the same industry.

Diverting sanctions from members. In contrast to functioning as a means of forestalling industrywide sanctions, a self-regulatory institution might instead function as a type of "market signal" that directs sanctions away from members by helping stakeholders distinguish the superior but unobserved characteristics of member firms from those of nonmember firms.

As discussed earlier, stakeholders often cannot

[3] A prediction consistent with this method of industrywide stakeholder forestalling would be that the institution would reduce spillover harm evenly (to members and nonmembers), wherever an error occurs (at member or nonmember firms). We do not develop this prediction into a formal hypothesis because it requires a test of the null hypothesis of indistinguishable coefficient estimations for both variable pairs. Confirmation of Hypothesis 3 and disconfirmation of Hypotheses 4 and 5 would represent consistent but insufficient evidence of this institutional mechanism.

directly observe important attributes of a firm. For example, they may not be able to see the degree of accident preparedness in a particular petrochemical facility. Lacking such information, stakeholders may assume that all such firms tend to perform similarly. If participation in an institution acts as a market signal, it would credibly reveal to stakeholders information about desirable characteristics they could not otherwise observe. As a result, members of the institution should be less at risk of spillover harm than nonmembers, as only members are believed to possess these superior characteristics.

For an institution to allow firms to credibly signal their superior attributes, it must meet several restrictive conditions (Spence, 1973). First, there must be some way to keep firms with lower performance from joining the institution. This is commonly accomplished by setting rules for participation that make membership too costly for firms with inferior attributes. Second, high-performing firms must wish to participate. Stakeholders must be able to differentially reward participants, and the cost of participation must not exceed these benefits. Third, there must be a credible mechanism, usually a third-party auditor, for evaluating and certifying compliance with the institution's rules. Finally, there must be some way for stakeholders to sanction or reward individual firms (e.g., by boycotting or buying their products). Evidence supporting signaling theories has been found for institutions that seem to target buyers and suppliers, such as the International Organization for Standardization (ISO) management standards (Corbett, Montes-Sancho, & Kirsch, 2005).

Hypothesis 5. An industry self-regulatory institution decreases the degree to which an error at another firm in its industry harms a member firm.

RESEARCH SETTING AND METHODOLOGY

To test our hypotheses, we needed an industry that experiences frequent errors of varying significance, has suffered a major crisis, and has created a self-regulatory institution to recover from this major crisis. The U.S. chemical industry meets all of these requirements. Members of the industry suffer multiple errors each year, and these errors vary in significance. Most are small and involve the unplanned release of potentially toxic chemicals. More serious errors injure or kill employees or local citizens. Industry experts and industry members report that one error precipitated a major crisis for the industry. On December 3, 1984, methyl isocyanate leaked from a Union Carbide facility in Bhopal, India, and killed between 3,000 and 10,000 people. Many thousands more were injured (Shrivastava, 1987). It remains the most deadly industrial accident on record.

Anecdotal reports from managers in the chemical industry around the time of this event support the perspective on industry commons we have hypothesized. Numerous respondents reported that the incident at Bhopal created a crisis for the entire chemical industry by changing how observers viewed the risks of chemical manufacturing. Ronald Lang, then executive director of the Synthetic Organic Chemical Manufacturers Association, noted, "Bhopal focuses concern on something that had not been adequately addressed before—the possibility of catastrophe" (Gibson, 1985a: 21). Another industry leader described the post-Bhopal environment as "chemophobia" (Gunningham, 1995: 72).

Contemporaneous reports provide evidence that industry participants now had a greater sense of being part of a commons. Then-chairman of Union Carbide, Warren Anderson, remarked, "This is not a Carbide issue. This is an industry issue" (Gibson, 1985a: 21). Others noted that with such a close focus on the industry, further accidents at any chemical firm would have significant consequences for all chemical manufacturers (Gibson, 1985b). Industry managers also noted that one stakeholder in particular—insurance companies—formally implemented this increased perception of risk in a way that affected all firms in the industry, regardless of their individual characteristics: "Now the Bhopal tragedy has reinforced the new conservatism of insurance underwriters and, as one broker puts it, given them 'an excuse to say no.' . . . When they see any operations associated with chemicals—even chemical operations posing no hazard to the public—[underwriters] are ready to paint them with the same brush as Bhopal's" (Katzenberg, 1985: 30).

Respondents also reported that the crisis drove industry members to create a prominent self-regulatory institution: The Responsible Care program of the American Chemistry Council (ACC).[4]

> "More than anything else," recalls [then] Union Carbide CEO Robert Kennedy, "it was Bhopal that finally put us on the path that would lead to Responsible Care." "Bhopal was the wake-up call," says [then] Dow Chemical vice president Dave Buzelli. "It brought home to everybody that we could have

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[4] At the time of the events reported in this study, the American Chemistry Council was known as the Chemical Manufacturers Association.

the best performance in the world but if another company had an accident, all of us would be hurt, so we started to work together." (Rees, 1997: 485)

The first element of the program, Community Awareness and Emergency Response (CAER), appeared designed to reduce concern about accidents. Responsible Care encouraged firms to "open the doors and let the fresh air flow through" (Coombes, 1991) so that a skeptical public would be convinced that the dangers that Bhopal had brought to light were being rigorously dealt with and that there was no imminent danger. Responsible Care required extensive outreach efforts with local officials in communities where plants were located. As part of CAER, firms conducted thousands of plant tours. The ACC also spent millions on advertising campaigns to humanize the industry (Heller, 1991).

The potential of the program to actually change the operations of members has been questioned from its inception. Critics noted that the program did not include a mechanism for third-party certification of compliance with the rules and thus argued that it was unlikely to help stakeholders accurately determine those firms with higher performance (Ember, 1995). Others argued, however, that close connections within the industry could allow members to police adherence to the rules (Rees, 1997). As discussed earlier, empirical studies have suggested that member firms did not reduce their pollution any faster than nonparticipants but that the industry still benefited from the existence of the program (King & Lenox, 2000; Lenox, 2006).

Sample

Our sample included all firms in the Center for Research on Security Prices (CRSP) database that reported any operations in the chemical industry (SIC 2800–2899) in the Compustat business segment database between 1980 and 2000 or reported to the Environmental Protection Agency (EPA) that they operated a production facility in these sectors. We chose this time period to allow a nearly 5-year pretest window before the Bhopal crisis (1980–84), a 5-year interval between the Bhopal crisis and the creation of Responsible Care (1985–1989), and an 11-year posttest window after the creation of Responsible Care (1990–2000). We chose the sample to include all firms that reported any chemical operations, rather than only those with a primary denomination in the chemical industry, so as to include diversified firms with significant though nondominant chemical operations. Our final sample included 735 unique firms.

We obtained data about our sample firms from the CRSP database, the Compustat business sector database, and the EPA's Toxics Release Inventory (TRI). Reporting to the TRI began in 1987 and covers facilities with ten or more employees that produce, store, release, or transfer more than a threshold amount of any of more than 600 listed chemicals. We obtained data about errors by performing keyword searches of the major international and U.S. regional newspapers and wire databases within the Lexis-Nexis service. In some cases, we supplemented information from news articles with information from the Hoovers online database and Dialogweb.

Dependent Variable

Managers in the chemical industry consider industrial accidents to be serious errors (Greening & Johnson, 1997). Industry experts further claim that the Bhopal crisis changed the degree to which industrial accidents harmed the industry (Gibson, 1985b). Thus, we used industrial accidents at chemical plants as our measure of error.

To find industrial accidents, we performed keyword searches using terms such as "fire," "gas leak," "explosion," "chemical spill," "chemical release," and "chemical discharge." These are terms that top managers in the chemical industry associate with serious accidents (Greening & Johnson, 1997). Our search uncovered 359 possible accidents. As with any keyword search, however, we netted numerous inappropriate events, such as chlorine burns in swimming pools or ammonia spills on restaurant floors. We also found numerous accidents related to transportation (e.g., a tanker truck flipped and exploded into flames on a ramp to the Capital Beltway) and accidents related to petroleum transport and refining. We included accidents at refineries, since the petroleum and chemical industries are closely associated (i.e., petrochemicals; see Hoffman [1997]),[5] but we excluded leaks and spills from crude oil pumping or transport (e.g., the Exxon Valdez accident) because transportation is often subcontracted, and it is unclear if accidents in transport would reflect on the transporter, the producer, or the wholesaler/retailer. Incomplete reporting about key aspects of accidents further narrowed the sample. In total, we were able to qualify and determine the date, mag-

[5] In analyses not reported here, we created a dummy variable to indicate accidents that occurred at refineries (rather than at chemical plants) and found it to be insignificant in various analyses.

nitude, location, and responsible firm for 123 of the raw events.

Problems with the size of events or contemporaneous firm actions caused removal of an additional 31 accidents. Fifteen accidents resulted in neither an injury nor death. Our preliminary analysis showed that such accidents were too minor to affect the stock price of even the firms directly responsible for them, and so we excluded these events from our study of the spillover effects. At the opposite end of the scale, we removed the Bhopal event because of its extreme nature. Finally, events should not be confounded with endogenous actions that might bias coefficient estimates (McWilliams & Siegel, 1997). We excluded 15 events because other significant activities were mentioned in the newspaper accounts of them (e.g., leadership changes). The exclusions left us with 92 accidents.

To measure the degree to which these accidents "harmed" other firms in the industry, we evaluated the stock price movements of other firms with chemical operations following each accident. Market theory suggests that stock prices reflect the best assessment of future cash flows for firms. If investors think that an accident might decrease a firm's future cash flows, perhaps as a result of decreased demand resulting from increased stakeholder sanctions or increased costs resulting from increased government regulation, then that firm's stock price should fall.

Appendix A describes how we captured the harm of each accident with our dependent variable, cumulative abnormal return (CAR) on day 5. CAR is a measure of how much a stock's value deviates from its expected value over a particular period of time. Though our study focuses on the extent to which an accident at one firm causes harm to other firms, we first explored the effect of these accidents on CAR for the firms directly responsible for the events in order to validate that our search uncovered a set of accidents that might influence stock value. As Appendix B shows, in model 1, the stocks of the firms responsible for these 92 events lost an average of 1.01 percent of their expected values in the five days immediately following their accidents. If we use instead the point estimates from model 2, we find that an average accident (one that injured about 3.5 employees) caused about a 1.4 percent reduction in a firm's stock price. An accident that killed an employee caused an additional loss of 2.6 percent of market value. In model 3, we show how other variables influence the direct effect of an accident. For example, the positive coefficient for the variable "assets of perpetrator" shows that losses are greatly reduced for larger firms that experience accidents. We explain these variables below and return to them for comparative analysis later in the article.

Independent Variables

We hypothesize that one firm's error can spill over to other firms within the same industry. Scholars commonly use the Standard Industrial Classification (SIC) code as the definition of an industry. Since we were examining spillovers from accidents in the chemical industry, we limited our set of firms to those that reported at least one segment in the 2800 SIC range, which encompasses chemicals. We also created a more refined measure of operations in the same industry by creating a binary variable, *same SIC,* that captures whether a firm owned a facility that was in the same four-digit SIC code as the one that had an accident.[6]

Our second hypothesis predicts that a major crisis will increase this spillover effect. As previously discussed, industry insiders assert that Bhopal caused a major crisis that affected all firms with chemical operations. To capture the changes caused by Bhopal, we created a dummy variable, *pre–Bhopal,* that captures the time period from the beginning of our sample through the end of 1984, when the Bhopal leak occurred. Events occurring in this period were coded 1, and those occurring later were coded 0.

Our third hypothesis predicts that industry self-regulation decreases this spillover effect. Aspects of the Responsible Care program began shortly after the Bhopal crisis, but no elements of the program were promulgated until late in 1989. Thus, to capture the *post–Responsible Care* period, we created a dummy variable coded 1 if after 1989 and 0 otherwise.

Finally, in order to explore the mechanisms of industry self-regulation, we had to distinguish Responsible Care participants from nonparticipants. To capture this effect, we measured membership in the parent association, the American Chemistry Council. We assigned this variable (*ACC member*) a value of 1 if the ACC listed the company as a member in a given

[6] We investigated whether a percentage measure would provide similar results or results with greater explanatory power. We found that a continuous specification provided no significant increase in explanatory power. It may be that spillover risk is not linearly related to the scale of a firm's operations in a given industry or that our continuous specification (the percentage of a firm's total employees employed in any of the firm's facilities that share the same four-digit SIC as the firm at fault) does not precisely measure relative scale across industries. Thus, we used the binary measure.

year, and 0 otherwise. From 1990 onward, participation in Responsible Care was a condition of membership in the ACC. We further separated out the unique attributes of the Responsible Care program by creating a dummy variable, *Responsible Care member*, that indicated ACC membership during a year when the Responsible Care program was in existence. We also sought to understand whether Responsible Care membership might have different effects, depending on the identity of the firm responsible for an accident. Thus, we created two variables, *perpetrator in ACC* and *perpetrator in Responsible Care*, that captured whether or not a firm that had an accident was a member of the American Chemistry Council or of the Responsible Care program.

Control Variables

Variation in the magnitude of an event should cause variation in the market's response, so we included two measures of each accident's severity. *Employee killed* was a binary variable assigned a value of 1 if an employee was killed in the accident. Only about 25 percent of the accidents in our study included a fatality, so the binary parameterization is appropriate and truncates little information. In contrast, we measured the number of employees injured (*employees injured*) using a continuous measure (log[number injured + 1]). We used the log parametric form to reduce the effect of outliers and to account for possible diminishing effects. Alternative parametric forms (binary and linear) for our measure of injuries reduce model fit but do not change the sign and significance of reported results.

The size of both a perpetrator (firm responsible for an accident) and a recipient firm (another firm in the industry that is subject to spillover) may influence the market response to accidents. Larger perpetrators often have better public relations and so may be able to diffuse public reaction and response to their own accidents and to the accidents of others that might reflect on them. Moreover, larger firms tend to be more diversified, and so their overall stock price would suffer less from adverse events in any single industry. Finally, the size of a firm has been shown to influence the variability of its stock performance (Fama & French, 1992). We measured firm size as the log of total *assets* reported in Compustat for the year an accident occurred, and we further added *assets of perpetrator*, the log of the total assets of the firm where the accident occurred.

Table 1 provides descriptive statistics and correlations. We used several approaches to reduce the potential for unobserved firm differences or endogenous managerial choice to bias our coefficient estimates. We included fixed effects of different types to control for unobserved (but constant) differences in our sample (e.g., accident industry, spillover industry, and the year of the accident). To control for unobserved differences among the industries in which accidents occurred, we included fixed effects for all industries in which there was more than one accident. To control for unobserved firm-level differences, in some models we included fixed effects for a firm itself. These fixed effects account for constant attributes of any firm that might influence spillover effects. Endogenous choice processes might also bias our sample, particularly if they are based on changing firm characteristics not captured by our fixed effects. To help account for these, we also conducted a Heckman two-stage treatment model.

Analysis

Event study methodologies are commonly used to understand how stockholders interpret a single event (Blacconiere & Patten, 1994; Brown & Warner, 1980,

TABLE 1
Descriptive Statistics and Correlations for Spillover Analysis[a]

Variable	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11
1. CAR, day 5	0.14	9.80											
2. Pre-Bhopal	0.04	0.19	−.01										
3. Post–Responsible Care	0.79	0.41	.05	−.35									
4. Same SIC	0.44	0.50	−.05	−.06	.04								
5. Employee killed	0.27	0.45	−.03	.11	−.29	−.10							
6. Employees injured	1.44	1.17	−.05	.09	−.11	.08	.03						
7. Assets of perpetrator	9.52	1.43	.07	.05	.04	−.33	−.08	−.20					
8. Perpetrator in ACC	0.74	0.44	.01	.12	−.04	.13	−.01	−.15	.30				
9. Perpetrator in RC	0.57	0.50	.05	−.21	.59	.13	−.18	−.21	.30	.71			
10. ACC member	0.17	0.38	−.01	.09	−.11	.03	.04	.03	−.01	.01	−.06		
11. Responsible Care member	0.12	0.32	−.00	−.06	.16	.04	−.03	.00	−.001	.00	.10	.82	
12. Assets	4.87	2.36	.00	.04	.02	−.07	−.02	−.01	−.003	.01	.02	.52	.44

1985; Hamilton, 1995; Patten & Nance, 1998). McWilliams and Siegel (1997) criticized the use of this method when firms might be able to alter or time focal events so that they occur concurrently with other announcements. Accidents, however, are by their very nature unplanned and not amenable to strategic timing. Thus, such manipulation is not a concern in this study.

Our event study analysis allowed us to connect an accident with abnormal stock price movements. To understand the causes of variance within these movements, we used a linear regression:

$$CAR_{ij} = a + B\boldsymbol{X}_{ij} + e_{ij} + \upsilon_p + u_l + v_i + \delta_t,$$

where CAR_{ij} is the cumulative abnormal return for firm *i* five days following event *j* and $\boldsymbol{X}_{ij}$ is a vector of independent variables for firm *i* at the time of event *j*. Clearly, we could not measure every possible factor that might influence the effect of an accident or the spillover from that accident to other firms. We used a series of fixed effects to try to reduce potential problems from unobserved heterogeneity. First, we attempted to account for unobservables in the industries in which the accidents occurred. We included a fixed effect (υ_p) for all *p* industries in which we had more than a single accident (16 of 22 industries). These effects help to control for unobserved industry differences (e.g., the propensity to use subcontractors), which might affect the number or type of accidents. Second, we accounted for potential differences among industries that were affected by an accident (but not necessarily the industry in which it occurred) by including fixed effects for every two-digit SIC code (u_l). Alternatively, when we considered issues of variable spillover among firms and were interested in the effect of variables that were not collinear with firm identity, we included both firm (ν_i) and year (δ_t) fixed effects.

Clearly, the decision to join the American Chemistry Council and participate in Responsible Care is endogenous to our analysis; that is, managers make decisions about participation conditional on the characteristics of their organization. To the extent that we capture the important firm characteristics through the inclusion of a direct measure or by the use of fixed effects, our coefficient estimate should be unbiased. However, these methods will fail to capture the effect of endogenous choice based on changing and unmeasured factors. To account for such factors and test the robustness of our analysis, we performed a two-stage Heckman treatment model.

The first stage consists of the model predicting participation in Responsible Care. We based the treatment selection function on a model of membership proposed by King and Lenox (2000), who found that participation in Responsible Care is influenced by a firm's relative emissions, the relative emissions of the industries in which it operates, the degree to which it is focused in chemicals, its size, and its reputation. Following their study, we used TRI data to estimate the median emissions for each industry (four-digit SIC) and create a weighted measure of this value (based on percentages of sales in this SIC) for each firm.[7] The log of this value became our measure of the degree to which a firm operated in sectors with many toxic chemicals (*industry emissions*). We measured the degree to which a firm operated in chemicals (*chemical focus*) by calculating the percentage of sales from chemical sectors (as estimated from Compustat data). We already had a measure of firm size (assets). Because of the limitation of the TRI, we could not estimate relative performance prior to 1987. We also could not develop contemporaneous measures of reputation for all of the firms in our sample. We provide descriptive statistics for these variables in Appendix C.

RESULTS

To explore the effect of spillovers from accidents, we evaluated the abnormal stock price movements of each firm in our sample (excluding the perpetrator) after each accident in our sample. To get a sense of the average scale of such spillovers, in Table 2 we first specify a simple model without fixed effects. In support of Hypothesis 1, model 1 shows that a firm that operated a facility in the same industry in which an accident occurred indeed experienced a negative spillover. We also found that accidents in which employees were killed or injured resulted in additional negative spillovers. Note that the effects are smaller than those to the focal firm (see Appendix B) but are still significant. Following an accident that injured an average number of employees (3.5), a chemical firm with operations in the same industry as that in which an accident occurred could expect to lose 0.15 percent of its stock price. After an accident that caused the death of an employee, the firm could expect to lose an additional 0.83 percent.

To explore whether the accident at Bhopal or the formation of Responsible Care influenced spillovers from accidents, we specified a new model (model 2) with the two dummy variables respec-

[7] For the years 1980–86, we estimated industry emissions on the basis of the 1987 TRI data.

TABLE 2
Spillover Effect of Accidents on Firms Not At Fault

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Pre-Bhopal		0.75** (0.32)	1.01*** (0.33)	1.06*** (0.34)	1.16*** (0.34)	1.21*** (0.42)		
Post–Responsible Care		1.02*** (0.15)	0.92*** (0.17)	0.79*** (0.19)	0.27 (0.31)	0.18 (0.35)		
Accident in same SIC	−0.88*** (0.11)	−0.87*** (0.11)	−0.60** (0.27)	−0.58** (0.27)	−0.60** (0.27)	−0.66** (0.32)	−0.57** (0.27)	−0.57** (0.27)
Employee killed	−0.83*** (0.13)	−0.59*** (0.13)	−0.38*** (0.14)	−0.37** (0.14)	−0.41*** (0.14)	−0.43*** (0.16)	−0.27* (0.16)	−0.27* (0.16)
Employee injured	−0.36*** (0.05)	−0.34*** (0.05)	−0.38*** (0.06)	−0.38*** (0.06)	−0.36*** (0.06)	−0.39*** (0.06)	−0.24*** (0.07)	−0.24*** (0.07)
Assets of perpetrator			0.37*** (0.05)	0.37*** (0.05)	0.33*** (0.06)	0.34*** (0.06)	0.23*** (0.06)	0.23*** (0.06)
Perpetrator in ACC					−0.81*** (0.31)	−0.97*** (0.36)	−1.16*** (0.32)	−1.16*** (0.32)
Perpetrator in Responsible Care					1.08*** (0.35)	1.25*** (0.41)	1.43*** (0.36)	1.49*** (0.37)
ACC member					0.21 (0.30)	0.04 (0.38)	0.00 (0.00)	0.00 (0.00)
Responsible Care member					−0.53 (0.33)	−0.59 (0.43)	−0.30 (0.36)	
Assets			0.01 (0.03)	−0.002 (0.10)	0.02 (0.03)	−0.03 (0.05)	0.02 (0.12)	0.02 (0.12)
Mills ratio						−0.20* (0.10)		
Responsible Care perpetrator → Responsible Care member								−0.40 (0.37)
Non–Responsible Care perpetrator → Responsible Care member								0.01 (0.47)
Constant	1.28*** (0.11)	0.34* (0.18)						
n	30,751	30,751	30,751	30,751	30,751	26,139	30,751	30,751
R^2	0.01	0.01	0.01[a]	0.01[a]	0.01	0.01	0.02[a]	0.02[a]
Likelihood-ratio chi-square (comparison model)		44.59** (1)	161.63** (2)		12.49* (3)			
Accident (four-digit)			Yes	Yes		Yes	Yes	Yes
Industry (two-digit)			Yes			Yes		
Firm				Yes		Heckman	Yes	Yes
Year							Yes	Yes

[a] Within-R^2 (ω) reported for the fixed-effects analysis.
* $p < .05$
** $p < .01$

tively capturing the time period before the Bhopal accident and after the formation of Responsible Care. In support of Hypotheses 2 and 3, our results suggest that spillovers from accidents indeed increased after Bhopal and diminished after the formation of Responsible Care. In the intervening period, an average accident could be expected to reduce the stock price of other firms with operations in that industry by about 1.1 percent. We found that before Bhopal, this loss was only about 0.3 percent, and that after the creation of Responsible Care it was negligible. The increased spillovers after the Bhopal accident provide corroborating evidence for the observations of industry members. Speaking after the Bhopal accident, Dan Bishop, then Monsanto's director for environmental communication, remarked, "Every chemical incident becomes a national story now. A minor spill becomes front page stuff, and that tends to exaggerate the event and reinforce the public's concern" (Gibson, 1985b: 90).

In model 3, we included fixed effects and additional variables to account for unobserved differences among the industries in which the accidents occurred, as well as differences in the characteristics of the firms. In model 4, we conducted an alternative analysis in which we added a fixed effect for each firm. Because this would be collinear with a measure of industry, we removed the industry effects. In both models, we again find support for Hypotheses 1, 2, and 3. Accidents do cause spillover harm; this harm increased following a crisis in the industry; and it decreased after the formation of a self-regulatory institution.

We begin our exploration of the mechanism of Responsible Care with model 5. To explore whether Responsible Care provided a general benefit to the industry or only acted when one of its member firms was responsible for an accident (Hypothesis 4), we included additional interaction terms to capture spillovers from an accident at an ACC member firm in both time periods. In support of Hypothesis 4, we obtained a positive and significant coefficient for the variable identifying a perpetrator as a member of the program, indicating reduced harm to firms in our sample when an accident occurred at an ACC firm after the creation of the Responsible Care program. Interestingly, the inclusion of this variable also reduced the significance of the coefficient for our variable denoting the Responsible Care time period (post–Responsible Care). Thus, once we capture (through our inclusion of "perpetrator in Responsible Care" one hypothesized mechanism through which the program could have provided benefit, we no longer find significant evidence that the program provided a general benefit to the industry through another mechanism.

Our argument that information disclosure may be the mechanism by which Responsible Care reduced spillover harm when one of its members experienced an accident is corroborated by the contemporaneous reports of industry experts. After touring the site of a chemical plant belonging to Exxon (a Responsible Care member) in his city, a city manager noted a change in how he viewed this plant:

> I don't harbor the fears that I had. I have learned about what they do. I hadn't realized the safety precautions, the amount of testing of final products, the monitoring of air and water that goes on. But I don't think this will eliminate all skepticism. It's ludicrous to think that industry is going to be safe all the time. But the fact that they have been open and honest is extremely important to me as city manager. (Heller, 1991: 82)

Others reported that when accidents inevitably did occur, Responsible Care coordinated a quick response. "Mutual assistance is on all Responsible Care practitioners' lips, with large firms helping out small firms an important dynamic" (Heller & Hunter, 1994: 31). Richard Doyle, vice president of Responsible Care, quoted in Begley (1994), described such efforts as operating out of a "war room":

> The emergency response effort in the war room also led to an upgrade in Chemtrec, recognized as the chemical emergency response center in the U.S. It was established in 1972 to provide timely information and connect emergency responders with industry experts on the chemicals they were dealing with. After Bhopal, CMA set about upgrading Chemtrec's operations and improving its mutual assistance activities. (Begley, 1994: 33)

We found no evidence to support Hypothesis 5, which states that an institution provides additional protection from spillover harm to its members. We tested this hypothesis by including a dummy variable for participation in the Responsible Care program. As shown in model 5, the coefficient for Responsible Care member is negative and insignificant, indicating that members received no more benefit than nonmembers. In the section below on robustness testing, we discuss an alternative test of this hypothesis, in which we separate spillover to Responsible Care members from accidents at (1) other members and (2) nonmembers. This analysis also failed to support Hypothesis 5.

Robustness Testing

To ensure the robustness of our analysis, we specified several alternative models. First, we accounted for endogenous choice processes based on unobserved fixed firm differences through the use of a Heckman correction technique. In model 6, we report the result for the second stage of a fully specified model. In the first stage of this specification we used a probit analysis to estimate the tendency of firms to participate in the ACC and Responsible Care in each year. The probit for the first stage (using 1990 as the example) is shown in Appendix C. The probit results are consistent with King and Lenox (2000) and suggest that ACC members tend to be in sectors with more toxic emissions and more focused in chemicals, and to have more assets. We controlled for the effect of endogenous decisions to participate in ACC and Responsible Care by including the Mills ratio obtained from the probit analysis as a variable in the second-stage regression. The Mills ratio represents the selection hazard for the treatment (participation in ACC/Responsible Care) occurring for a given firm in a given year. The coefficient estimations from model 6 provided confirmatory evidence of the robustness of our findings. Similarly, conducting an identical modification to models 1, 2, and 3 confirmed the findings already reported. To account for unobserved firm differences, we also ran all of the models (except those with Heckman corrections) using firm fixed effects and obtained consistent results.[8]

In model 7, we did not analyze the effect of time periods so as to allow the use of year fixed effects to account for any underlying macroeconomic changes that might distort our results. Once we included these year effects, we had to remove the time period dummy variables. As shown, an analysis with year fixed effects again suggests that Responsible Care provided a benefit to the industry by reducing the spillover effect of an accident at a firm participating in the Responsible Care program. Thus, we again confirmed our support for Hypothesis 4.

In model 8, we further explore our failure to find support for Hypothesis 5 by including a new operationalization of spillover effects to Responsible Care members. These two variables separate spillover harm to members from (1) accidents at another Responsible Care member firm and (b) accidents at a nonmember firm. The coefficients estimated for both variables were insignificant, and so we again found no support for Hypothesis 5.

[8] Interestingly, the coefficient estimate for the inverse Mills Ratio is consistently negative. This suggests that firms with unobserved attributes that tended to cause them to join RC also tended to experience greater spillover harm from accidents at other firms.

We conducted additional robustness testing to determine if our time period dummy variables (pre-Bhopal and post–Responsible Care) might be capturing some other temporal effect. First, we tested whether differences in the frequency of reporting might influence responses to accidents. To rule out this possibility, we specified models that included measures of the accident prior to the one under consideration. We included the days since the accident, whether an employee was killed, and whether an employee was injured. Models with additional variables confirmed the sign and significance of the reported results. We also explored whether we were simply capturing a wearing off of stakeholder concern as the Bhopal accident became a distant memory. We tested alternative models with a variable measuring linear and logged time since Bhopal in days. Coefficient estimates on both variables were not statistically significant. The log form of the time estimate is highly correlated with the pre-Bhopal variable ($\rho = -0.81$) and thus it reduces the significance of this measure in some models. Neither variable provided significant additional explanatory power.

Throughout our analysis, we explain little of the observed variance in stock prices—between 1 and 2 percent. This is not surprising. Our method essentially removes fixed differences in firm stock prices, leaving only noise and the effect of new information about a firm. When we conducted fixed-effects analysis, we further removed two types of industry effects, and we report only our ability to explain the remaining variance within groups. We evaluate the effect of only one type of news; clearly, numerous additional factors play an important role in determining stock prices. However, so long as this other news is not correlated with our events and uncaptured by our variables, our estimates should be unbiased. As discussed earlier, we carefully screened out events that were contemporaneous with other corporate news. Moreover, the robustness of our analysis to multiple specifications and controls suggests that we have significant and stable estimates.

It might seem that the effects found in our analysis are too small to justify the creation of a self-regulatory institution. Indeed, we are agnostic regarding whether or not these effects drove the observed behavior. We do believe that firms were concerned with the potential for larger accidents to have a serious effect on market values, and industry experts confirmed that these fears provided some of the impetus for self-regulation. We also believe that the response of the stock market to each of the smaller accidents analyzed in our study provides a useful test of the functioning of the institution.

In summary, our analysis suggests that Bhopal indeed increased the interdependence of firms with chemical operations in such a way that an accident at one would have a negative effect on another. Our analysis also suggests that Responsible Care reduced this spillover effect, but it did so not by insulating its members from the consequences of accidents at other facilities but by reducing the industrywide consequences of accidents at Responsible Care facilities.

DISCUSSION AND CONCLUSION

In this article, we have explained industry self-regulation occurring when physical commons are absent. We posited that firms in modern industries share in a nonphysical type of commons—what some have termed a "reputation commons" (King et al., 2002)—that stems from the difficulty that stakeholders face in distinguishing the relative performance of individual firms and from the application of arbitrary or industrywide sanctions. We hypothesized that the risks associated with this commons can become particularly acute following a major industry crisis. We further hypothesized that industries create self-regulatory institutions as a means of ameliorating this heightened threat of shared sanctions.

Through a longitudinal analysis, we found that firms in the U.S. chemical industry did face such an industry commons and that the shared sanctions stemming from this commons became more severe after the industry suffered a major crisis caused by an accident in Bhopal, India. Furthermore, we found that this increased risk of shared sanctions preceded the creation of the industry's self-regulatory program, Responsible Care, and that Responsible Care was able to ameliorate industrywide harm from the errors of individual chemical firms. Thus, in finding that an aggravated commons problem led to the formation of a governing institution and that the institution operated to reduce this problem, our study provides a "good functionalism" perspective on the role of self-regulation in modern industry.

We also explored the mechanism through which Responsible Care functioned. We found that it reduced industrywide harm resulting from the errors of Responsible Care members, but we found no evidence that it provided members more protection from spillovers than nonmembers. Thus, member firms appear to have provided a public benefit to the industry, and the need to coordinate this benefit may have provided a key motivation for the institution's creation.

In *Mending Wall*, the poet Robert Frost wrote of a type of self-regulation of a physical commons, in the form of a tradition that caused neighbors to cooperate in the creation of stone walls between their properties. Each winter, storms and hunters knocked down some stones in these walls, and every spring Frost would "let [his] neighbor know beyond the hill" that they need to "meet to walk the line, and set the wall between us once again." But, as he worked on the wall one year, he wondered why they were remaking it and asked his neighbor:

> He only says, "Good fences make good neighbors."
> Spring is the mischief in me, and I wonder
> if I could put a notion in his head:
> "Why do they make good neighbors? Isn't it
> where there are cows?"
> But here there are no cows.
> Before I built a wall I'd ask to know
> what I was walling in or walling out, . . .

Our analysis suggests that firms in the chemical industry, like Frost and his neighbor, share in the construction of a wall between them. We found that they "wall in" the effects of their own accidents rather than "wall out" the effects of others'. Responsible Care appears to serve the function of ensuring that each firm maintains its walls and so protects its neighbors from the harm its accidents could otherwise cause the broader industry.

Though skepticism about cooperative solutions to commons problems has a lengthy history in scholarship (Hardin, 1968; Lloyd, 1833/1968), as illustrated in Frost's poem, traditions of mending fences to prevent spillover harm have a lengthy history in practice. Societies all over the world have developed norms to ensure that each member acts to protect his neighbor. Indeed, the very normalcy of such traditions represents the culmination of Frost's poem. Speaking of his neighbor, Frost writes, "He will not go behind his father's saying/ And he likes having thought of it so well/ He says again, 'Good fences make good neighbors.'"

Our analysis suggests that analogs to such traditional responses can be found in modern industries. Firms unite with rivals to ensure that each protects the other from a future problem. Because they are "walling in" their own effect on their neighbors, firms cannot achieve such results independently. Rather, at-risk firms must come together to create an institution that helps ensure that each protects its neighbor, so that, in the aggregate, all are subject to less harm.

Implications

Our study suggests a revised interpretation of recent research on industry self-regulation. As discussed earlier, many of these studies show that self-regulatory programs have not measurably improved firm performance (Howard et al., 2000; King & Lenox, 2000; Rivera & de Leon, 2004; Rivera, de Leon, & Koerber, 2006). As a result, scholars have tended to conclude that such programs are a failure and have blamed such failure on the inability of industry associations to control the behavior of member firms. Our analysis suggests that this skepticism may be based on an incorrect assumption about the institutions' function. Rather than acting as a means of improving firm performance or of signaling unobserved attributes, these institutions may be acting to directly reduce the probability of stakeholder sanctions by encouraging firms to engage in greater outreach and communication. From contemporaneous accounts, we know that such outreach occurred following the formation of Responsible Care. Using quantitative data over a number of years, we found evidence consistent with a hypothesis that such outreach and communication may have a positive effect on stakeholder relations, regardless of the performance of the member firms, and so can aid in reducing spillover harm.

Our research also suggests that an industry can maintain a self-regulatory institution, even when it provides benefit to nonmembers. Our findings suggest that the institution examined here protected all firms from the errors of its members. Thus, participants in the program provided a public good to the industry. Despite the incentive of a free ride, however, firms agreed to participate and (over the years of our analysis, at least) the program provided a benefit to the industry. Thus, in accordance with Ostrom's (1990) work demonstrating that actors can self-regulate to avoid destruction of physical commons, we have demonstrated that firms can voluntarily come together to protect an intangible industry commons, despite the risk of free riding.

For policy makers, our research reveals that private institutions may substitute in part for public regulation on information disclosure. The need to prevent spillover harm can help drive the creation of institutions that require the disclosure of information to stakeholders. Thus, government programs on information disclosure should be analyzed by considering both their direct effect on firm behavior and their indirect effect on the formation and function of self-regulatory institutions.

Limitations and Future Research

Although our study addresses several long-standing issues, it also raises several new ones. We used stock price movements to measure changes in stakeholder expectations about firms over time, following specific industry events. This methodology did not allow us to observe the mechanisms that created changes in stakeholders' expectations of a firm's future performance. We did not directly observe, for example, the provision of information from the firm to these stakeholders. In our particular empirical setting, we noted that the CAER program, which is at the core of Responsible Care, requires members to engage in significant communication with stakeholders, but we did not actually measure the degree to which members abided by these requirements. In future research, we hope to directly evaluate differences in communication rates and styles among participants and nonparticipants. We encourage others to further investigate how outreach and communication reduce spillovers rather than focusing on performance differences between members and nonmembers of self-regulatory industry institutions.

In our study, we described industry self-regulation as a private decentralized institution, but it typically involves some central authority. In examples such as Responsible Care, there exists a governing body that oversees compliance with the program's codes. However, compliance is often gauged through self-reporting, and punishment tends to be limited or nonexistent, given antitrust concerns, as well as the institution's desire to retain as many members as possible. Thus, even in exemplary and robust instances such as Responsible Care, industry self-regulation tends toward a decentralized model, relying on peer pressure for compliance. Nonetheless, we could also have categorized Responsible Care as a hybrid form of private institution, since it contains both centralized and decentralized aspects.

This argument suggests that Ingram and Clay's (2000) centralized-decentralized dichotomy for institutions might better be treated as a continuum, and it raises the question of how institutions choose to position themselves along this continuum, both initially and over time. Our study addresses temporal changes, but it does not address changes within the ACC program itself. Responsible Care started as a primarily decentralized institution, but over time it has shifted toward more centralized authority. The program evolved over the 1990s as new codes were hammered out and promulgated to members. After our study time frame ended, Responsible Care's leadership changed—in part because of several articles that suggested the program had not reduced the pollution generated by its members—and reportedly, with the new leadership, the "velvet glove came off" and some members were disciplined for their lax behavior (Reisch, 1998). Future research should investigate how self-regulatory programs balance centralization and decentralization and the stringency of enforcement in order to attract members without diminishing the legitimacy of the institution, as well as how this balance changes over time. The drivers of such changes are poorly understood. Weak enforcement may be necessary to attract members, yet the appearance that standards are enforced may be essential to maintaining the legitimacy of a program in the eyes of observers. In future research, we hope to explore the drivers and mechanisms of these changes.

Finally, our study does not resolve the issue of why firms choose to participate in self-regulatory programs. If participating firms essentially "wall in" their spillovers, safeguarding the rest of the industry, then an institution provides a pure public good. Given the dominating incentive to free ride on pure public goods (Olson, 1965), how then does the institution hold together? Scholars have suggested that the incestuous nature of the chemical industry allows bilateral sanctions that enforce participation. According to Rees, "The chemical industry is its own best customer" (1997: 489), and large firms use their power over subordinate suppliers as "leverage" (Gunningham, 1995: 85) to obtain their compliance. Yet, aside from a few anecdotes, such sanctions remain unobserved. In future research, we hope to further explore the centripetal forces that hold this and similar institutions together.

Despite these limitations, our research makes a significant contribution to emerging scholarship on self-regulatory institutions and broadens understanding of what constitutes a commons problem and how such problems may be resolved. It shows that exchange problems caused by shared reputation and risk of sanction exist in modern industries. It shows that a major crisis can intensify problems associated with this industry commons. Finally, it shows that when faced with exchange problems caused by these commons, the choice is not between "Leviathan or oblivion" (Ophuls, 1973: 215). Industry members can take matters into their own hands and repair shared problems by forging a new institution.

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APPENDIX A

Calculation of Cumulative Abnormal Return (CAR)

To calculate *CAR*, we first calculated the relationship between the value of each company's stock and the market as a whole (measured by the CRSP value-weighted index with dividends for the entire market):

$$R_{it} = a_i + B_i R_{mt} + e_{it},$$

where R_{it} represents the value of the security i on day t, a_i is a constant, R_{mt} represents the value of the market portfolio for day t, B_i represents the beta of security i, and e_{it} represents the error term. Beta is computed over the period $t = -254$ to $t = -1$, where $t = 0$ is the day of the event.

The abnormal return of a stock is the difference between the actual return of that stock and its expected return. The abnormal return of security i at time t, AR_{it}, is:

$$AR_{it} = R_{it} - (a_i + B_i R_{mt}).$$

The cumulative abnormal return for a firm, CAR_i, is the sum of abnormal returns over the event window:

$$CAR_i = \sum AR_{it}.$$

To allow for continuous compounding when aggregating the abnormal returns, $\ln(1 + R)$ is used in place of R. Thus,

$$CAR_i = \sum[\ln(1 + R_{it}) - (a + B_{im}\ln(1 + R_{mt}))].$$

Key to computation of *CAR* is determination of the event window, the period of time over which to cumulate abnormal returns. Event studies commonly begin the event window prior to the actual event announcement in order to account for information leakage, but dangerous accidents are, by nature, unanticipated events. Therefore, in this study, if the event occurred during trading hours on a trading day, the window begins that day; if not, the window begins with the next trading day.

While it is straightforward to choose the beginning of the event window for this study, it is less clear when to close the window. The occurrence and magnitude of events sometimes take several days to become apparent to the market. News travels fast and markets update their values nearly instantaneously, yet many characteristics of major accidents take time to establish. For example, the enormous toll of Bhopal took many days to unfold, and the magnitude of the Exxon Valdez oil spill was not immediately evident. Whereas a long event window increases the likelihood of capturing the full impact of unfolding events, a long event window also increases the opportunity for intervening events to confound results (McWilliams & Siegel, 1997). Therefore, researchers should use the shortest possible window that captures the fullest extent of an event. The bulk of the effects tended to occur within five days after the events. Thus, our dependent variable in this study is the cumulative abnormal return on the fifth day after an event.

APPENDIX B

TABLE B1
Direct Effect of Accidents on At-Fault Firms[a]

Variable	Model 1	Model 2	Model 3
Employee killed		−2.60** (1.06)	−2.25** (1.10)
Employee injured		−1.72 (1.15)	−1.50 (1.15)
Assets of perpetrator			0.73* (0.38)
ACC member			−1.69† (1.20)
Pre-Bhopal			−1.33 (1.95)
Post–Responsible Care			0.29 (1.17)
Constant	−1.01* (0.51)	1.13 (1.06)	−4.86 (3.92)
R^2		.08	.16

[a] $n = 92$.
† $p < .10$
* $p < .05$
** $p < .01$

APPENDIX C

Probit Analysis of ACC Participation

TABLE C1
Descriptive Statistics for All Years (1980–2000)[a]

Variable	Mean	s.d.	1	2
1. Industry emissions	9.58	2.52		
2. Chemical focus	0.54	0.48	.10	
3. Assets	4.49	2.37	.20	−.15

[a] $n = 5{,}073$.

TABLE C2
Results of Probit Analysis of ACC Membership[a]

Variable	Membership in 1990
Industry emissions	0.15** (0.05)
Chemical focus	0.61* (0.30)
Assets	0.40** (0.06)
Constant	−5.45** (0.64)
n	276
χ^2	74.24
Pseudo-R^2	.38

[a] We estimated separate probit models for each year from 1980 to 2000 to obtain the Mills ratio and included it in the second-stage regression estimation to reduce the effect of nonrandom treatment. Inclusion of this term accounts for changes in the expectation of the treatment coefficient but does not correct for heteroskedastic changes in the error terms that result from nonrandom treatment. We used a standard White's method to help correct for these effects.
* $p < .05$
** $p < .01$

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