

WEAK LINKS AND THE MANAGEMENT OF REPUTATIONAL INTERDEPENDENCIES

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This paper builds on a growing literature that takes into account the fact that firms in an industry may be interdependent with regard to their corporate reputations, thus sharing a “reputation commons.” We argue that the theory of public goods can help us to understand the interdependencies that link corporate reputations and to frame the contexts and requirements for collective action that they induce. In particular, we suggest that more and more frequently these interdependencies make industry reputation a “weak link” public good. We show that this raises new challenges for the strategic management of industry reputation by communities of firms. The discussion of these challenges is based on the case study of the collective action of the European chlorine companies towards restoring their reputation after being accused of not being safe, and on a model of the production of reputation by companies. Copyright © 2013 John Wiley & Sons, Ltd.

INTRODUCTION

The strategic management literature has shown that a firm's reputation can have a strong impact on its performance, and thus an important strategic activity for a firm is “reputation management” (e.g., Fombrun and Shanley, 1990; Hall, 1992; Roberts and Dowling, 2002). But often a firm's reputation is not entirely under its own control: evidence that the actions of other firms in the industry also shape a firm's reputation, and ultimately its performance, has grown substantially in recent years (e.g., Barnett and Hoffman, 2008; Hill and Schneeweis, 1983; Hoffman, 1997; Rees, 1994; Winn, MacDonald, and Zietsma, 2008). And, indeed, very challenging situations have

arisen in which firms share a “reputation commons” because their stakeholders are unable or unwilling to distinguish among firms but instead make a “common assessment of their character” (e.g., Barnett, 2006; King and Lenox, 2000; King, Lenox, and Barnett, 2002: 395). Unfortunately, this tends to occur when the bad actions or performance of one or a few firm(s) are enough to induce stakeholders to form a bad opinion of an entire industry. When this happens, events localized in one firm can lead to punitive damages for all the firms, irrespective of their individual performance and/or behavior (e.g., Barnett and Hoffman, 2008; Hoffman, 1997; Rees, 1994). This situation raises great challenges for a firm attempting to manage its reputation because, in this context, reputation becomes a public good.

This paper investigates collective action by communities of firms sharing a reputation commons, and its aim is to advance our understanding of the collective strategies that firms can deploy in this context. The existing literature is pessimistic, as it predicts that free riding will destroy collective attempts to manage a common reputation. The efforts of some to create or restore positive

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perceptions of their behavior will be undermined by those who seek to benefit from these efforts while making no effective effort to upgrade their performance (e.g., Dawson and Segerson, 2008; King and Lenox, 2000; Rivera, de Leon, and Koerber, 2006). As a result, the best solution, according to the literature, is that those who attempt to comply with stakeholders' requests should privatize the commons. This they can do, it is claimed, by providing stakeholders with private information on individual performance. This should permit stakeholders to distinguish among firms and attack only the poor performers, leaving the others in peace. While a seemingly natural solution and in keeping with much literature on public goods and the risks of free riding, this approach may focus too heavily on the information asymmetry aspect of the issue. While asymmetric information may be the primary concern of stakeholders in some situations, this analysis does not apply to the more and more frequent situations wherein reputation commons originate in a "collective responsibility" problem, where stakeholders decide that all firms in an industry should be made accountable for its collective performance irrespective of their individual behaviors or performances. In this case, obviously, privatizing the reputation commons is no longer an option, and industry reputation remains a public good.

Public goods typically have an additive aspect, where the value of the good is driven by the sum of the (financial) contributions to it. Public radio or street lighting are examples. However, many public goods have a second aspect, where the value of the good is determined by the smallest contribution or weakest link. If citizens are jointly responsible for maintaining a dyke, the value of the dyke is determined by its weakest point. When public goods are purely additive, free riding is the main issue. But when the weak link property dominates, free riding in the usual sense becomes self-defeating. A free rider does not benefit, since his lack of contribution is coupled to his own bad performance, which is as detrimental to the free rider as it is to all the other firms.

Using the European chlorine industry as an example, we discuss a collective strategy that has been overlooked by the literature, namely, that firms with good performance subsidize the efforts of others in an attempt to raise standards for the industry as a whole. We develop a framework that shows when such a strategy is likely to be

observed. This framework is built on the view that industry reputation is a complex public good that can have properties of both *additive* and *weak link* public goods. By recognizing that the weak link property may be predominant in this context, we are able to shed light on this strategy. Then, based on a simple model, we analyze the boundary conditions of this strategy. In particular, we find that industries should be more likely to design such a collective strategy when firms are highly heterogeneous and improvements in the dimension at stake have strong decreasing returns.

We contribute to the literature on reputation commons by extending the current framework and enabling it to account for a larger variety of strategies used to manage reputation commons. In particular, we contribute to a better understanding of the context that industries are increasingly facing, which forces them to design new collective strategies that may not suffer from the normal pitfalls of collective action but may still face other problems or challenges. In the next section, we give an example of an industry that follows the strategy emphasized in this paper. It is a clear example of an industry that has been forced to share a reputation commons and that has had to reflect on its approach to manage this commons.

A BRIEF ILLUSTRATIVE CASE

The chlor-alkali industry is an industry in which safety is a prime concern, and which has been under attack in recent decades for its safety record and practices. As such, it is an industry in which firms' reputations are tied together: any firm is subject to negative repercussions following any major accident or problem experienced by another firm. In this section, we illustrate the arguments laid out above by a case study of the European chlor-alkali industry. We examine how it has attempted to deal with its reputation commons over the past decade.

The data for this study were collected by interview, survey, and questionnaire (see Appendix A for details) between 2003 and 2010. The target was the European chlorine industry, and the entry point was Euro Chlor, the industry association. In the first phase, permanent members of Euro Chlor and representatives of member firms were interviewed. A second phase involved a survey of the population of European firms in the chlorine industry.

The survey was focused on firm (and employee) relationships with Euro Chlor and with other firms, with regard to safety issues, safety information, disclosure issues, patterns of information sharing, and motivation. The contact for the survey was the head of safety of the chlorine firms, but particularly in the case of multiplant firms, the survey was distributed to more than one person. Thus, we have plant-level data on safety practices and sharing within and across firms of information about safety.

The chlor-alkali industry produces chlorine and sodium hydroxide (caustic soda). Chlorine is a dangerous substance according to the European legislation because, at ambient temperature, it is a toxic gas. Accidental releases of chlorine, resulting from operation, maintenance, equipment, or process failures, can be very harmful to the health of employees and civil populations, as well as to the environment.

The chlor-alkali industry is therefore regulated, as is the entire chemical industry. In particular, firms must have permits to operate installations and build new ones, they must conform to safety standards, and they must report incidents. But, more importantly for our purpose, the industry is under strong pressure from external stakeholders. The pressure started in the 1980s with various stakeholders claiming that the industry was not putting safety (or the environment) first, and was not "responsible." Some activist groups, among them Greenpeace, have been lobbying for a chlorine-free world and publicizing the substitutes to chlorine for all possible uses. Chlorine is on their black list of products to ban, and they use every incident to advance their cause.

Safety, however, has improved considerably in the last thirty years. Suppliers have been producing an increasing number of pieces of improved equipment and have made numerous innovations in the material and design of their products. Firms also have learned from their experience and have made important innovations in operation design. Finally, accidents and incidents have been turned into a source of collective learning. Euro Chlor, the European chlor-alkali industry association founded in 1989, is in charge of promoting best practices manuals and operation guidelines to help the industry continuously improve its safety, environmental, and health performance, and to "enhance the European chlorine industry's credibility and prospects for long-term

sustainability" (see website at eurochlor.org). Euro Chlor is a member of the Responsible Care¹ program and operates within this framework to implement risk management measures throughout the chain from production to use, and to thus design its agenda for improvements.

As a result of all of these processes, the number of accidents and severe incidents has decreased sharply in the last thirty years, while at the same time the production of chlorine has increased sharply. However, there is still great variance in the safety of the different firms, as Figure 1(a, b) shows. This figure suggests that some firms are clearly more at risk than others. In fact, firms in this industry are highly heterogeneous. There are 49 companies present in 20 European countries, and 36 of them are members of Euro Chlor. Ten of the 49 companies have multiple plants, but most of the remaining single plant firms are very small. What is not explicit in Figure 1(a, b) for confidentiality reasons, but which was told to us orally, is that while the figures present firms ranked in terms of increasing number of accidents, it is also true that firms fall roughly on the horizontal axis in decreasing size. That is, the smaller firms are on the right side of the figures and had (data are from 2005–2006) considerably more incidents than the larger firms.

Although there is consensus among active participants that the program coordinated by Euro Chlor is critical for helping firms avoid accidents and incidents that would trigger action from their most powerful and influential stakeholders, not all firms participate actively in this program. Some firms do not make the necessary efforts to report their incidents or feed the database with information relative to any incident. The same companies typically neither participate in the safety meetings nor make efforts to invest in any of the other time-consuming activities that are necessary to produce collective learning outputs.

These firms are typically the smallest firms and are also those with the highest risks of accident. This, in a sense, could be good news: the information-sharing program at Euro Chlor should permit observers to screen the high and the low safety performers. And indeed, a few years ago, the active members at Euro Chlor

¹ Responsible Care is a program of the chemical industry, begun in 1985, whose aim is to improve health, safety, and environmental performance in the chemical industry generally.

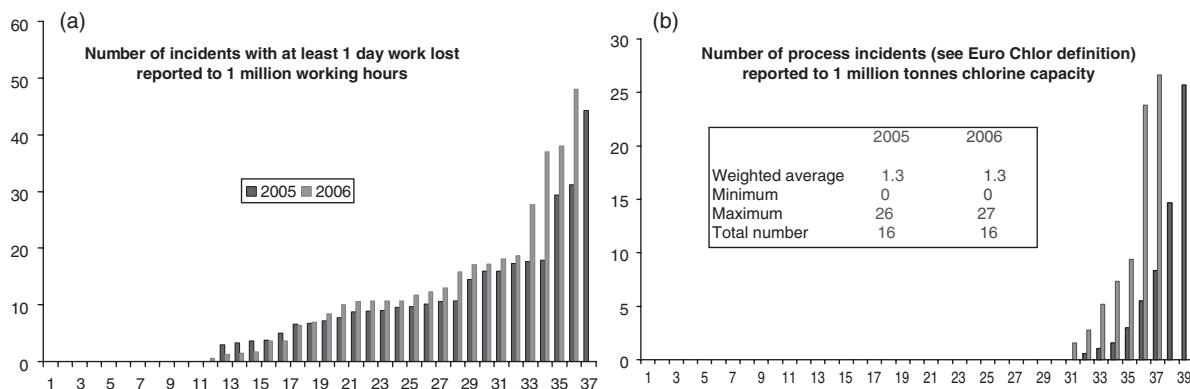


Figure 1. (a) Time lost to accidents, and (b) process incidents by firm. Each pair of bars (labeled with numbers) represents one firm. Source: personal communication, Euro Chlor

decided that they would restrict access to their outputs (e.g., guidelines, best practices manual) to the cooperating members. Essentially, this was an attempt to ban free riders from the information exchange network. It was not precisely a privatization of a common reputation, but would clearly be related to any attempt to do so. Information needed to enhance private reputations was made a club good, and this move could have created, in effect, two groups in the eyes of the stakeholders.

But this strategy quickly appeared problematic. Euro Chlor members realized that stakeholders were not willing to allocate blame selectively. They were watching the industry as a whole and would use the occurrence of any accident or serious incident, regardless of which firm was involved, to advance their cause against the entire industry. During our interviews with several industry association firm representatives, this was clearly expressed. For instance:

What the profession fears is a decision such as “forbidden to transport chlorine” or “forbidden to produce chlorine.” Substitutes will always be found, even if they are more dangerous than chlorine in certain applications. Chlorine (and PVC [polyvinyl chloride]) is one of the privileged targets of activist groups (why??) and the profession is well aware that any serious accident would be used by this kind of group to force the lawmakers to take unreasonable steps.

—Large company employee, Health and Safety department

Realizing that “safety was an absolute necessity to protect the industry” (interview data), the high performers understood that the biggest threat to their assets was not that the smaller firms could access their collective efforts to produce codes of conduct and guidelines “for free,” but rather that the weakest firms were not making progress. This was clearly stated by this interviewee:

The group cannot simply reject the worst performers to show better statistics because, anyway, the public (and the regulatory body) will judge without making distinction (on the contrary); it is necessary to avoid accidents in the absolute and thus to reinforce the performances of the worst performers. [...] A good safety record is not just good for one company; it is good for every company within the entire industry.

—Industry association permanent employee

This idea, that having low performers is in fact harmful for the whole industry, and most specifically for those that have made the biggest efforts to be safe, also appeared unambiguously in the survey responses shown in Appendix B.

What we observe here is a switch of perspective. The initial response to the threat from stakeholders was to make information freely available within the industry so that each firm could better manage its safety. Collective information sharing was meant to protect individual reputations. And collective information management included expulsion of free riders. The industry changed its understanding of the issue, though, and switched to

a strategy explicitly to manage a collective reputation. Important in this revision was the realization that stakeholders refused to distinguish between insiders and outsiders.

As the adoption of safer practices by all in the industry grew as a necessity, the sanction that had been implemented to exclude the nonactive participants appeared as rather counterproductive, as excluding the low performers would further decrease the chance that they would improve, as acknowledged by this interviewee:

[Excluding firms] is not very rational, and it certainly does not help us reach the goal of improving the safety performance of the industry.

—Industry association permanent employee

In addition, the relationship between safety performances and available resources was pretty clear, as stated in these interviews:

Company size is obviously not a direct measure of the resources dedicated to safety but it gives an indication of what are the priorities for a company. [...] In the small companies, a single person has several “caps” and dedicates his time to different subjects depending on the priorities; for the large companies, the safety function is covered by several persons in a safety department, who work full time on the subject; this shows for instance in the reports published by the companies, and this is an image of the absolute effort devoted to safety.

—Industry association permanent employee

Clearly large companies have a lot of resources to manage safety. They will have staff dedicated to introducing and implementing safety procedures and have strong financial backing from the company. Small companies cannot afford these resources.

—Industry association permanent employee

Thus, around 2007–2008, considerable discussion and reflection took place about how the industry could manage its reputation. A consensus emerged that to reduce the risk of an accident

or major incident in the industry, the high performers should directly help the low performers improve their safety performance. Sharing knowledge and defining guidelines was not sufficient, as the lowest performers were also the “poorest” firms and thus the least able to invest resources in significantly improving their safety performance. In addition, they were also those who needed to make the biggest steps to achieve the level of safety considered as acceptable by the high performers and by industry stakeholders. In contrast, the high performers had more resources to allocate to safety, on the one hand, and they had already achieved a very high level of performance, on the other. It would thus make a lot of sense to use some of these resources to help the low performers achieve the level of safety already achieved by the high performers. Concretely, we were told how they have decided to proceed:

As we need to avoid accidents in the absolute, we need to improve the performances of the worst performers. [...] We contact the companies with the worst performances and we discuss face to face with the persons in charge to check whether they are well aware of where they stand in comparison to the others and examine together the way to help them.

—Industry association permanent employee, former large company representative

Experts from the large companies visit the plants “with problems” in order to analyze the situation, to find the causes and propose solutions, both at the operational and organizational levels; the visit can take place the other way around, on the “reference plant” to show how they do things.

—Industry association permanent employee

This example is certainly a very clear illustration of a strategy for managing reputation commons that is emerging in a context where more and more often stakeholders refuse to differentiate among firms and instead treat the industry as a whole. Yet, a strategy where some firms help their competitors improve their performance rather than trying to use performance gaps to better their position is hard to explain in the current framework in which strategies for managing reputation commons are

studied. In the next section, we expose a renewed framework for studying these strategies that allows us to better understand the variety of strategies that can be observed and, in particular, the puzzling strategy designed by the chlorine industry.

LITERATURE REVIEW AND THEORY

Highly visible accidents such as Three Mile Island, Bhopal, or the Exxon Valdez oil spill have triggered concern for overall industry behavior and demands for industry-wide changes in practices in the concerned industries (e.g., Den Hond and De Bakker, 2007; Lounsbury, Ventresca, and Hirsch, 2003; Spar and La Mure, 2003; Winn *et al.*, 2008). In these instances, all the firms in the concerned industries have suffered from the events because they have all been “painted with the same brush” (Hoffman, 2001), meaning that stakeholders have inferred from evidence of one bad performance that all firms had potentially harmful practices. As a result, they have imposed damages on all. Reputation had become a public good.

At the theoretical level, this reputational interdependence has been depicted as firms sharing a reputation commons (Barnett, 2006; Barnett and King, 2008; King and Lenox, 2000; King *et al.*, 2002). The existing literature assumes that reputation commons fundamentally originate in an “information asymmetry” problem: it is because stakeholders cannot distinguish between the high and low performers that they target all and inflict damages on all. As a result, the strategic management of industry reputation is assumed to entail two options. One is collective action at the level of the industry to establish a way for the high performers to identify themselves to their stakeholders. The Responsible Care program of the chemical industry has been considered as an example: by adhering to the program’s best practices and codes of conduct, firms signal to stakeholders that they agree to comply with better practices. Yet, the literature argues, this solution cannot succeed because it “suffers from the normal pitfalls of collective action” (King and Lenox, 2000; King *et al.*, 2002: 400): some low performers will use their membership in the program as a signal but will fail to make efforts to adopt these better practices. As a consequence, the program will fail to screen out the low from the high performers. This is a problem because if one of these low performers has

an accident that stakeholders can observe, stakeholders will again infer that all have bad practices. The second option is therefore recommended: the high performers should try to privatize reputation by revealing information on their performances to their stakeholders. In this case, the high performers will have more incentives to reveal this information and the stakeholders will thus get the proper perception of where the different firms stand.

We believe that this analysis has important limitations. Most importantly, it cannot account for the fact that industry programs seem to persist (Lenox, 2006) nor for the variety of strategies that firms facing reputation commons seem to implement in practice. Indeed, the literature itself admits that it has troubles understanding why some industries establish programs with conflicting goals, such as providing guidelines to improve performances and screening the low from the high performers (King and Toffel, 2007; Terlaak, 2007). We argue that to improve our understanding of the strategic management of reputation commons by communities of firms, it is necessary to recognize two aspects that have not been properly articulated in the current literature.

First, while it is firms that design strategies to manage reputation, it is stakeholders who assess reputation, and therefore there may be discrepancies in the approaches and expectations of the two sets of actors. For instance, the literature suggests that firms are willing to help stakeholders distinguish the low and the high performers so that they can allocate blame more precisely. Yet, while the primary objective of stakeholders is usually to “suppress” low performance and, if specifically targeting low performers, can be a strategy to force them to upgrade their performances, it seems that it is not always the strategy that stakeholders follow. In fact, there is evidence that more and more often stakeholders want to transfer the responsibility of this task to the industry, as we have seen for the chlorine industry (see also Zietsma and Winn, 2008, for evidence from other industries). In this case, the reputation commons should be seen as originating in a collective responsibility problem rather than in an information asymmetry problem.

Second, we need to recognize that industry reputation is a complex public good. Indeed, public good theory teaches that public goods can be of different natures and thus raise very different collective action challenges. In particular, the theory makes a distinction between additive and weak

link public goods (e.g., Cornes, 1993; Hirshleifer, 1983; Varian, 2004). A public good is additive when its value or strength depends on the sum of the efforts made by the contributors. For instance, the quality of lighting on a private road depends on the number of inhabitants who have agreed to fund the implementation of a light in front of their property. In contrast, a public good is a weak link public good when its value or strength depends on the lowest effort made by the contributors. For instance, the protection offered by a dyke depends on the weakest part of the dyke. Pure additive and weak link public goods raise very different collective action challenges (e.g., Hirshleifer, 1983). For instance, the production of additive public goods is typically challenged by free riding: as it is possible to benefit from quality lighting on a private road even if one inhabitant does not contribute to it, it is likely that many inhabitants will declare that they are not interested in the public good. In contrast, weak link public goods do not suffer from free riding: if an inhabitant does not make effort to build his/her share of the dyke, the whole island will be flooded including his/her land. In other words, the one who does not contribute does not benefit from the public good (here, protection of his/her land from the flood).

It seems that industry reputation is, in fact, a complex public good that has both additive and weak link properties. It has additive properties because the more signals sent to stakeholders that firms are complying with their requests, the more this tends to restore industry reputation. Thus, stakeholders may get a better impression of firms' efforts to have high performances when more firms become members of a program such as Responsible Care. From this perspective, failure to make real efforts can logically be interpreted as free riding as it seems possible to benefit from a restored industry reputation without improving one's own performance. But, at the same time, industry reputation has weak link properties because any evidence of a low performance suffices to ruin the reputation of the entire industry. We could even argue that this is the reason the topic has generated so much interest from researchers and why reputation commons are such a critical issue for industries. Yet, when weak link aspects are strong, the persistently low performers should be seen with new eyes as a free rider does not benefit, since his lack of contribution is coupled to his own bad performance, which is as detrimental to the free rider as it

is to all the other firms. This dual nature of industry reputation arises from the fact that assessing industry reputation is a complicated process for stakeholders. Part of the process is driven by making inferences about unobservable performance from observable behavior, but part is driven by possibly rare performance events that are observable.

When direct evidence of the performance of firms is unavailable, stakeholders must make inferences about the safety/health/environmental aspects of firms' activities from observable actions, which may or may not directly affect those things. For example, stakeholders may not be able to get inside a plant to observe practices, but they can observe whether a firm (or firms generally) belong to organizations that promote safe practice, such as Responsible Care. In this case, a common reputation is very much an additive public good. The existence and strength of such an organization sends a signal to the stakeholders. If firms are relatively small, then free riding on the contributions of others to such an organization may be rational, and, as the literature points out, collective action may be very difficult. But, the literature also admits that a concern about free riding assumes the "credulity of stakeholders that ascribe meaning to a program without a rational basis" (King and Toffel, 2007: 19).

In contrast, when there is a significant chance that clear evidence will appear, weak link aspects of the public good become more important. When stakeholders are willing to distinguish among firms and to be selective in their allocation of blame, the best strategy is for the high performers to differentiate themselves from the low performers, possibly by providing firm-specific information to stakeholders so as to address information asymmetries. But, when stakeholders are not willing to make distinctions—thus when the reputation commons originates primarily in a collective responsibility problem—another strategy needs to be designed. In this case, the problem can no longer be solved by privatizing reputation, since even the good performers will suffer when evidence of bad performance by some firm in the industry emerges. In particular, the low performers must now be included in the industry reputation management as they can no longer be "denounced" or excluded by the rest of the industry (Furges, 1997; King and Baerwald, 1998).

Firms that believe either that accidents are low probability events or can be hidden from public

view will obviously feel that investment in safety has little payoff. Evidence of wrong-doing or carelessness will not be available to stakeholders, and thus there is little risk. Others who do not share these ideas about accidents will obviously see much stronger incentives to invest in safety. The coexistence of both views in a single industry will create a situation that resembles free riding, in which some invest and others do not. The noninvestment is derived not by the usual free riding motives (taking advantage of something others provide) but rather a different view of the importance of the effects of the investment. Additionally, though, if this is the case, there may be a tension within industry programs between screening the low and high performers (as this will draw attention to potential accidents) and helping the low performers improve their performance.

The difficulty in understanding or interpreting some important observations about common reputation management has led to the view that improving the strategic analysis of reputation commons requires introducing more “bounded rationality” into existing models: “We believe that the research [...] reveals that the most useful theories might assume that actors have limited ability to anticipate consequences or plan complex strategies and derive predictions of institutional function from this basis” (King and Toffel, 2007: 21). In fact, adding bounded rationality may indeed not be necessary. Recognizing the weak link property of industry reputation suggests that firms and stakeholders may in fact be more rational than it seems.

Public good theory emphasizes that the biggest challenge for the production of weak link public goods does not originate in free riding, but rather originates in the heterogeneity of the economic agents concerned by the public good (e.g., Cornes, 1993). Whereas the theoretical literature agrees that the interest of the agents is to match their efforts when producing weak link goods (e.g., Hirshleifer, 1983; Varian, 2004), an important result of experimental research is that the larger the group, the more likely the subjects will have difficulty coordinating their investments spontaneously (e.g., Knez and Camerer, 1994; van Huyck, Battalio, and Beil, 1990). In fact, failure to coordinate contributions to the public good is likely to be exacerbated by the heterogeneity of the concerned agents because differences in resources or in preferences for the good will create variance in the contributions (e.g., Cornes, 1993). For instance,

it is unlikely, in an industry where firms have very heterogeneous sizes, that small and large firms will agree on the level of protection they want or can afford for their assets, as exemplified perhaps by the chlorine industry example. We should note that resources and preferences are likely to be somehow correlated in the sense that the firms with the least capabilities and resources tend not only to be less able to respond to stakeholders’ requests (e.g., Julian, Ofori-Dankwa, and Justis, 2008; Mitchell, Agle, and Wood, 1997) but also to be the least likely to consider external pressures as manageable and the least likely to believe that responding is urgent, as they are often the least visible firms in their industry (e.g., Mitchell *et al.*, 1997).

However, this inefficiency can be solved or mitigated by transfers towards those with the lowest ability to, or interest in, contributing (e.g., Cornes, 1993; Vicary and Sandler, 2002). For Cornes (p. 270), the high efficiency loss associated with highly heterogeneous resources should constitute a strong incentive for individuals to “agree to bind themselves to an alternative institutional structure for public good provision,” in other words, to engage in collective action. In effect, it seems that, in this context, the high performers should have a strong incentive to help the low performers in order to have their contributions matched by those with fewer resources or less interest and thus to get the level of protection they and their stakeholders desire. In the next section, we investigate these observations formally.

MODEL

We begin by examining an industry in which any accident will close the entire industry, and in which firms are solely responsible for their own investments in accident abatement. Here, one firm’s accidents serve as an externality to the other firm.

Duopoly with no side payments

Consider a duopoly with two firms whose revenues are R_1 and R_2 . Treating a duopoly will illustrate the more general case of n firms. A key assumption here is that any accident will close the entire industry, so any firm cares about the industry-level accident arrival rate. Assume that firms are independent in the sense that the accident arrival processes are independent. That is, in each firm there

is a process of accident arrivals. For firm 1, the arrival rate is $\lambda_1 = \lambda(c_1)$ and for firm 2 $\lambda_2 = \lambda(c_2)$, with $\lambda'(c) > 0$ and $\lambda''(c) < 0$ having the same function for both firms. These are two independent Poisson processes, so the arrival rate of accidents in the industry is $\Lambda = \lambda_1 + \lambda_2$. Expected profits for firm 1 (firm 2 symmetrically) can be written as:

$$\begin{aligned} E\Pi &= \int_0^\infty \int_0^T R_1 e^{-rt} (\lambda(c_1) + \lambda(c_2)) e^{-\lambda(c_1)t} \\ &\quad dT dt - c_1 \\ &= \frac{R_1}{r + \lambda(c_1) + \lambda(c_2)} - c_1. \end{aligned}$$

The simplest case occurs when neither firm can subsidize the other. Thus, each firm takes the other's expenditure as fixed and solves a simple profit maximization problem. Treating the case of firm 1,

$$\frac{\partial E_1 \Pi}{\partial c_1} = \frac{R_1 \lambda'(c_1)}{(r + \lambda(c_1) + \lambda(c_2))^2} - 1 = 0, \quad (1)$$

or solving,

$$(r + \lambda(c_1) + \lambda(c_2))^2 = -R_1 \lambda'(c_1). \quad (2)$$

This describes the equilibrium amount of effort (cost) applied to reducing the probability of an accident in the case that firm 1 takes the efforts, and thus the accident arrival rate, of firm 2 as fixed.²

Taking two firms jointly, Equation 1 becomes a pair of equations, which we can write as

$$\frac{R_1 \lambda'(c_1)}{(r + \lambda(c_1) + \lambda(c_2))^2} = 1 = \frac{R_2 \lambda'(c_2)}{(r + \lambda(c_1) + \lambda(c_2))^2}. \quad (3)$$

And, in equilibrium, it follows simply that

$$\frac{R_1}{R_2} = \frac{\lambda'(c_2)}{\lambda'(c_1)}. \quad (4)$$

We can see from differentiating Equation 1 (and using the second order condition) that firms

² Second order conditions to ensure a maximum: $\lambda''(r + \lambda) - 2\lambda'^2 > 0$.

with higher revenue will put increased effort into abatement (all else equal):

$$\frac{dc^*}{dR} = -\frac{\lambda'(r + \lambda)}{R(\lambda''(r + \lambda) - 2\lambda'^2)} > 0. \quad (5)$$

We can state this as:

Proposition 1: In the absence of cross-subsidies, firms with larger revenue will expend more efforts on abatement, and will have lower accident rates.

The proposition follows directly from Equation 5 and the assumption that $\partial \lambda / \partial c < 0$. It can be illustrated using a simple example. Suppose $\lambda(c) = e^{-ac}$ where a is a positive constant. From Equation 1, we can write:

$$\begin{aligned} -1 - \frac{R_1 \lambda'(c_1)}{(r + \lambda(c_1) + \lambda(c_2))^2} &= 0 \\ = -1 - \frac{R_2 \lambda'(c_2)}{(r + \lambda(c_1) + \lambda(c_2))^2}. \end{aligned}$$

Substituting,

$$R_1 (-ae^{-c_1}) = R_2 (-ae^{c_2}),$$

or

$$\frac{R_1}{R_2} = e^{a(c_1 - c_2)}.$$

The bigger the difference in revenue, the bigger the disparity in effort, and so the larger the difference in firm arrival rates. (It is also clear that this disparity increases with a , which controls how fast the effectiveness of investment falls as investments grow.) This difference in accident rates, with accident rates negatively associated with firm size, was observed in the chlorine industry; see Figure 1(a, b) and its discussion in the text.

Duopoly with side payments

The more interesting case is when it is possible for one firm to invest in abatement in the other firm. We now introduce the possibility that firms can act on each others' abatement and thus affect the accident arrival rate. We assume that firm i can invest, using the same technology, in the

abatement of firm j . For a single firm in this duopoly, the profit maximization problem is the same, but takes into account this new possibility. Now, we write the expected profits of firm 1 as:

$$E\Pi(c_1^1, c_1^2) = \frac{R_1}{r + \lambda(c_1^1 + c_2^1) + \lambda(c_1^2 + c_2^2)} - c_1^1 - c_1^2.$$

Expected profits for firm 2 are written symmetrically, where c_i^j indicates costs paid by firm i , applied to the safety of firm j .

First order conditions for the two firms' maximization problems yield four equations:

$$\frac{\partial E\Pi_1}{\partial c_1^1} = \frac{-R_1\lambda'(c_1^1 + c_2^1)}{(r + \lambda(c_1^1 + c_2^1) + \lambda(c_1^2 + c_2^2))^2} - 1 = 0 \quad (6)$$

$$\frac{\partial E\Pi_1}{\partial c_1^2} = \frac{-R_1\lambda'(c_1^2 + c_2^2)}{(r + \lambda(c_1^1 + c_2^1) + \lambda(c_1^2 + c_2^2))^2} - 1 = 0$$

and

$$\frac{\partial E\Pi_2}{\partial c_2^1} = \frac{-R_2\lambda'(c_1^1 + c_2^1)}{(r + \lambda(c_1^1 + c_2^1) + \lambda(c_1^2 + c_2^2))^2} - 1 = 0 \quad (7)$$

$$\frac{\partial E\Pi_2}{\partial c_2^2} = \frac{-R_2\lambda'(c_1^2 + c_2^2)}{(r + \lambda(c_1^1 + c_2^1) + \lambda(c_1^2 + c_2^2))^2} - 1 = 0$$

It is clear that Equation sets 6 and 7 determine only total expenditures *on* a firm, $c^1 = c_1^1 + c_2^1$ and $c^2 = c_1^2 + c_2^2$, without specifying total expenditures *by* a firm. Solving Equation 6 for the optimal expenditures on safety on each of the firms (c^{1*}, c^{2*}) does not determine how the expenditure is split between the firms. That is, any expenditure allocation satisfying $c^{1*} = c_1^1 + c_2^1$ and $c^{2*} = c_1^2 + c_2^2$ is an equilibrium. This includes an equilibrium in which one firm invests zero. We can see this formally, by rearrangement of Equations 6 and 7, to get:

$$\frac{R_1}{R_2} = \frac{\lambda'(c^1)}{\lambda'(c^2)} = \frac{\lambda'(c^2)}{\lambda'(c^1)}. \quad (8)$$

It is clear from Equation 8 that interior solutions exist only when the two firms are of equal size: $R_1 = R_2$.

Recall that we have assumed that $\lambda'(c) > 0$ and $\lambda''(c) < 0$. Here, standard analysis indicates that the equilibrium will include the condition that the marginal benefit of investment in abatement is equalized over the two firms, that is, $\lambda'(c^1) = \lambda'(c^2)$. Suppose that the two firms have equal revenue streams, $R_1 = R_2 = R$, and, as an extreme case, that firm 2 invests nothing in abatement. Firm 1 will solve Equations 6 for (c_1^{1*}, c_1^{2*}) under the condition that $c_2^1 = c_2^2 = 0$. But if $R_1 = R_2$, then this solution, $(c_1^{1*}, c_1^{2*}, 0, 0)$, is also a solution to Equations 7, and firm 2 is content; its optimal response remains $(0, 0)$, and firm 1 provides a total subsidy. Of course, this is not the only equilibrium. But if firm 2 makes a credible commitment to invest zero, it will be. In this case, when firms are approximately the same size, then the situation resembles a game of "chicken," in which the firms agree on the optimal investment but disagree on who should make it. We can state this as:

Proposition 2: With equal-sized firms and cross-subsidies in equilibrium: (a) investments in abatement, and, thus, accident arrival rates are the same for each firm; (b) abatement expenditures by each firm are undetermined, which implies that (c) equilibria in which one firm subsidizes the other exist.

Proof: This follows directly from the preceding paragraph.

However, if firms are of different sizes, where size is defined by a firm's revenue stream, a more explicit result is possible. It follows from the fact that if $R_1 \neq R_2$, then Equation 8 has no interior solution.³ That is, one but not both firms can satisfy the first order conditions of profit maximization.

Proposition 3: If firms are of different sizes, then the only equilibrium involves the smaller firm making no investment in abatement, and receiving subsidies for its abatement activities, from the larger firm.

Proof: If firms are of different sizes, and abatement technology shows decreasing returns, then the only equilibrium involves the smaller

³ An interior optimum exists if $\lambda(c)$ is linear, but the optimum (in profits) is a minimum rather than a maximum.

firm making no investment in abatement, and receiving subsidies for its abatement activities, from the larger firm. Suppose that $R_1 > R_2$. The conditions 6 and 7 independently imply that total expenditures on each firm will be equal: $c^* = c^{1*} = c_1^1 + c_2^1 = c^{2*} = c_1^2 + c_2^2$. Where they differ is the optimal value of c^* . It is convenient to write this as a function of revenues:

$$c^* = c_1^1 + c_2^1 = c_1^2 + c_2^2 = G(R_i), \quad (9)$$

which is determined by solving

$$-R\lambda'(c^*) = (r + 2\lambda(c^*))^2 \quad (10)$$

The second order condition on the maximization problem ensures that $\partial G / \partial R > 0$. This implies that if $R_1 > R_2$, then $G(R_1) > G(R_2)$. If firm 1 is optimizing, then the values $c_1^1 + c_2^1 = c_1^2 + c_2^2 = G(R_1) > G(R_2)$. From the perspective of firm 2, there is an excess investment in safety. On the other hand, if firm 2 is optimizing, then $c_1^1 + c_2^1 = c_1^2 + c_2^2 = G(R_2) < G(R_1)$, and firm 1 has an incentive to add investments. Thus the only equilibrium is the corner solution in which firm 2 has zero investment, and firm 1 provides a subsidy to firm 2.

This is a very extreme result: that if firm sizes differ at all, the larger firm provides all the investment for the entire industry. A more reasonable interpretation would be that as the difference in firm sizes increases, because of changing incentives, subsidy becomes more likely. What is important, then, is how fast incentives (thought of here as perceived optimal industry accident rates) change with relative firm size. Inspection of Equation 2 or 4 indicates that the steeper is $\lambda(c)$, the faster the optimal abatement investment changes with firm size. If accident rates fall rapidly with investment in abatement, then the larger the discrepancy of optimal investment for firms of different sizes. This suggests the following:

Remark 1: The more responsive are accident rates to investment in abatement, and/or the more different are firm sizes, the more likely are cross-subsidies.

The chlorine industry revisited

Euro Chlor lists 78 chlorine production sites in Europe (of which 70 are Euro Chlor members),

owned by 49 distinct firms. The largest of these sites has annual production capacity of 1,050 megatonnes (MT), the smallest, 4 MT.⁴ So we observe considerable heterogeneity in plant sizes, and it seems clear that a 4-MT plant has much less to lose than a 1,050-MT plant, if the industry is shut down (similarly, a 150-MT firm versus a 1,000-MT firm). So we might conclude that the actors (whether plant level or firm level) have diverse incentives to act on safety issues. Smaller firms might well object to the high standards that larger firms want to impose through the industry association. One of the conditions supporting cross-subsidies suggested by the model seems certainly to be met in this industry.

Euro Chlor describes as part of its activities the sharing of best practice information. It also has a program of equipment approval, associated with safety, health, and environmental protection, and provides lists of approved equipment. Whether or not the technologies involved in abatement show strong decreasing returns at the plant or firm level is difficult to say, in general terms. However, there seem to be two parts of the agenda: getting firms to adopt best practice, and getting firms to replace old, unsafe equipment with new, safer equipment. In both cases, once a firm has completed this, returns to further investment are zero (this is a bit extreme, of course). However, if best practices are relatively general and roughly transferable from one site to another, then the returns to a firm that has adopted (and therefore knows about) best practice to helping another firm do the same could be very large.⁵ Two interview subjects stated: "Learning experiences and good practice from one part of the industry are equally applicable to another quite different part," and "[I]n general, it does not matter what type of

⁴ The distribution of plant sizes by capacity is: ≤ 30 MT, 17; 30–80 MT, 18; 80–200 MT, 22; 200–400 MT, 17; 400–1,000 MT, 3; > 1,000 MT, 1. The size distribution of firms by capacity: ≤ 150 MT, 32; 150–400 MT, 10; 400–1,000 MT, 3; > 1,000 MT, 4. The source is the Euro Chlor website: <http://www.eurochlor.org/facts-figures-glossary/chlorine-production-capacities-per-country.aspx> (accessed September 25, 2012).

⁵ In fact, the results could be stronger than the model suggests. In modeling, we assumed that the costs of investment were the same no matter which firm did it. However, if the issue is implementing best practice, then the costs will be lower if it is done by a firm with experience. The implication here is that total costs of reducing the industry accident rate to a given level will be lower if the experienced firms help (i.e., subsidize, perhaps in-kind) the nonexperienced firms.

technology is used, safety issues are common with management systems being applicable to most sites and operations.” Hence, a firm that has adopted best practice (and replaced all its valves with those on the approved valves list, for example) but which is still of the opinion that industry accident rates are too high, can do nothing unless it acts on other firms. Thus, to the extent that best practice and best equipment is the route to lower accident rates, the second condition supporting cross-subsidies is also satisfied.⁶

This simple model offers an explanation for why we observe the subsidy strategy in the chlorine industry and for why in general this strategy may be implemented: when the industry is concerned with the aggregate performance of the firms, heterogeneity in resources/sizes creates big differences in the efforts made by firms to comply with the (safety) performance requested by the industry stakeholders. This cannot be satisfactory when stakeholders are using any serious incident to take unreasonable steps against the industry.

But, cross-subsidies offer a solution to this heterogeneity as they offer the high performers the opportunity to invest in the performances of the lowest performers. Yet, as the model indicates, this is more likely if investing in the low performers allows considerably higher marginal returns than investing in the high performers. Both these conditions appear to be met in the chlorine industry.

DISCUSSION

The development of the chlorine example, and the simple model sketched above, lead to several general observations.

Implications for the management of reputation commons

Although the existing literature on reputation commons has largely focused on the collective action problems caused by free riding and thus on the “tragedy” of this type of commons,

our analysis suggests that reaching an efficient investment in a common good may be tractable if the problem is of a weak link type. As exemplified by the chlorine case and the model developed in this paper, awareness of the weak link property of a reputation commons creates an incentive for the concerned community of firms to coordinate investments to reach an efficient collective investment in the commons. Yet, this coordination can be made difficult by strong firms’ heterogeneities because in this case it is likely that firms’ optimal investment levels in performance will not be aligned, thus creating an insufficient level of collective performance. The model and evidence from the chlorine case suggest that, in this situation, cross-subsidies can be a coordination mechanism, by allowing the industry to subsidize the efforts of the weakest firms and thus strengthen the weakest link to the desired level of performance. Cross-subsidies on efforts to invest in performance improvement are more likely to take place in specific conditions. First, when the firms are strongly heterogeneous, that is, the differences in revenues between the lowest and the highest performers are big, smaller firms have much lower incentives to reduce the accident rate and are likely to be subsidized by larger firms. By contrast, when heterogeneity is weak, things are less clear: incentives among firms are similar (that is, they have similar opinions regarding optimal aggregate industry accident rates), which can lead to indeterminacy in how the aggregate efforts should be allocated among the firms. Second, if the performance-improvement technology has strong decreasing returns, the expected marginal returns on the investments in the lowest performers will be higher than in the highest performing firms. This will increase the incentives of the large firms to subsidize the smaller ones. Both these conditions appear to be met in the case of the chlorine industry, and this may explain why we observe this strategy. As explained literally by several interviewees, the difference in the resources available for safety investment between the lowest and the highest performers is very large; and as the high performers are at the frontier in their knowledge of safety technologies and procedures, the lowest performers can catch up quickly if helped by those firms. Financial help can ease the adoption of the latest safety equipment, and in-kind help can ease the updating of safety procedures and the training of workers. Clearly,

⁶ Additionally, the discussion in Appendix C offers an economic rationale for the determination of stakeholders to treat the industry as a whole rather than letting the high performers privatize reputation. With this large heterogeneity among firms, the aggregate accident rate is likely to be higher with private than with common reputation.

in this industry, investing in the lowest performing firms yields greater marginal safety improvements than investing in the highest performing firms.

Our analysis does not discard free riding as a potential behavior, as the theory on weak link public goods tends to do, as free riding seems to be relatively common. Indeed, the analysis clearly shows that if the weakest firms opportunistically wait for others to fund their whole effort, this opportunistic behavior should not cause a tragedy of the commons. The firms that have most at stake have a strong incentive to ensure that the common good is provided to the level they desire due to the weak link property, and therefore they are still better off subsidizing the whole effort of the weakest firms than not doing it. Yet, the potential for this sort of free riding needs to be nuanced and should be further researched in practice. First, we have discussed purely economic considerations in the analysis of this issue, how economic considerations give different (sized) firms different incentives, and how that could lead to a rational cross-subsidy of otherwise competing firms. There may, however, also be an element of moral suasion at play. Firms might have a concept of fair share. Small firms may be acknowledged to have a different view of optimal aggregate accident rates (possibly driven purely through the analysis above, possibly associated with differential abilities to invest or specialize in safety). But even with their acknowledgement, there may be a notion that they should at least invest to the point of their optimal arrival rates. Then if the larger firms want more, they could provide it. This would drive the equilibrium away from the extreme “small firms invest nothing” equilibrium. Whether or not this consideration goes beyond simply a moral suasion argument will depend on the extent to which firms are interdependent in other ways. If firms depend on each other in other aspects of their business, then the moral argument can be backed up by threats of noncooperation in other spheres. Naturally, to understand this more fully demands a case-by-case analysis. Second, it is likely that to “absorb” help from others, the weakest firms will need to make some efforts on their part either because they will need to implement and use new equipment or to design and appropriate new procedures. If, furthermore, as in the case of the chlorine industry, the subsidy takes mainly the form of in-kind help, efforts from the subsidized firms cannot in fact be avoided.

Finally, one could wonder whether there are alternatives to the strategy of subsidy. It seems that there could be at least two other strategies in this context. High performers could internalize the problem simply by taking over the lowest performers and either closing down the low-performing plants or upgrading their performance. Of course, this strategy is likely to be possible only in very specific conditions when, for instance, there are very few low performers, or they are located close to the high-performing plants and antitrust regulation allows this action. Another, very different, alternative could be for the highest performers to lobby for stricter regulation with the objective of driving the lowest performing plants out of business.

Avenues for future research

Empirical testing

A first avenue for future research is to exploit the empirical potential of the framework. First, future research could seek to establish the degree of generality of the identified boundary conditions triggering cross-subsidies and helping behaviors. This would require gathering rich data on multiple cases of configurations of stakeholder pressures and firm and industry responses in order to identify regularities in the relationship between stakeholder approach and reputation strategies. In addition, an experimental approach could be used to better understand how recipients of cross-subsidies could behave. Levels of contributions to weak link public goods have been studied through experiments (e.g., Knez and Camerer, 1994), and one could rely on such a setting to further study the agency problems involved with cross-subsidies or resource transfers. For instance, one could start by studying how firms’ beliefs regarding both the expected efforts of the firms with lower stakes and the credibility of cross-subsidies form and might affect the distribution of efforts in the industry. Finally, detailed case studies of industries where firms are rather homogeneous or weakly heterogeneous would help further understand strategies in situations where the model indicates that there should be indeterminacy in who funds the efforts.

Help in practice

The help and subsidizing process also raises important institutional challenges that we need to

better understand. A critical question concerns the governance of the help process. A first issue deals with the institutional mechanisms that should be implemented in order to manage the principal-agent relationship between the "helpers" and the "helped." For instance, how to ensure that the helped will use the money to improve their safety, if help takes the form of a monetary transfer? How to ensure that those helped will pursue the necessary efforts on a daily basis and whether this effort should somehow be institutionalized? A second issue deals with the kind of reputation management capability that should be built by firms and their industry association to ensure the success of collective action aimed at building industry reputation. The literature on strategic alliances has shown that alliance management capability was a critical asset for the success of alliances (e.g., Schreiner, Kale, and Corsten, 2009), and it is expected that a collective strategy aimed at managing industry reputation should entail the building of specific collective management capabilities. They would permit management of the coordination of efforts across firms and, in particular, would help design the proper assignment of effort, suggest how potential conflicts over the distribution of efforts should be resolved, and what joint outcome should be reached. These aspects are likely to be more challenging than in strategic alliances, where alliance partners can select one another as they design their alliance contracts (e.g., Mayer and Argyres, 2004; Reuer and Arino, 2007).

A second question concerns the form that help should take. As in the literature on transnational public goods, future research could investigate the contexts in which different aid forms are effective. There is much debate in this literature on whether aid should take the form of in-kind or cash transfers. In the case when countries have very heterogeneous technical levels, in-kind transfers are generally favored and defended (Vicary and Sandler, 2002). Yet, that recipients be active in the help process and designing of their own projects for achieving the common goal is also perceived as an important impetus for the success of the help (Kanbur, Sandler, and Morrison, 1999). Future research could thus investigate how to structure interfirm assistance to better ensure the effectiveness of the process. This investigation would, in part, be a normative endeavor and could be tested by modeling or experiments.

Finally, future research could investigate capability building in a context where helping others and being helped may become more pervasive practices. In a global context where firms are and will be more and more concerned with major challenges implying changes in their practices, specific capabilities might be needed in order to efficiently absorb and transfer help. What that may add to a resource-based view of the firm would be an important avenue for future research.

Welfare implications

Given the welfare implications associated with forcing all firms in an industry to effectively adopt better practices, another important question is that of knowing whether the help behavior and its potential for substantially improving industry performance could be triggered by mechanisms other than stakeholder pressures. In this regard, the model teaches us that collective fines imposed by the State could also induce some firms to help others to adopt better practices. Consider that an accident imposes a fine on every firm in the industry, no matter where the accident occurs. Suppose first that the fine is of equal size to all firms, regardless of firm size, and regardless of the severity of the accident. Where the fine is independent of revenues, all firms have the same incentive to invest in safety, and the optimal industry arrival rate is the same for all firms. The analysis of this case is identical to that given above. All firms should receive the same investment, but nothing determines who does it. If any firm can make a credible commitment to a particular level of investment, it dictates what the other firms must do. Thus, this can become a game of chicken. If, by contrast, fines are proportional to revenues, then larger firms will have stronger incentives to reduce accident probabilities than will small firms. As in the original model, if the industry investment level is optimal for large firms, it is too high for small firms, and vice versa, and we would expect to see subsidies. Future research could thus study how such collective fines could be implemented in practice, for instance, by classifying firms with similar permits.

Last but not least, this research could be used to question the efficacy of stakeholders' strategies, and could in particular enhance the part of the literature that is interested in understanding how activists can induce field-level changes

(e.g., den Hond and de Bakker, 2007). In fact, it would be very interesting to know whether the strategy that consists in impeding firms to privatize their reputation and in forcing them to share a reputation commons is an efficient strategy. Our model can be used to provide preliminary insights on this question. The mathematical developments are in Appendix C. They suggest that when the industry is compounded of rather similar firms, it is not clear whether this strategy is the best. Indeed, it is possible that industry performance (here measured by the industry accident arrival rate) is better when firms are allowed to privatize their reputation. However, in the case of firms that are highly heterogeneous, the model indicates that industry performance (measured purely in terms of accident rates) should be much better when firms are in a reputation commons than when they are allowed to privatize their reputation. We should note here that the chlorine industry is clearly an example of a heterogeneous industry.

CONCLUSION

This paper points out that in the current context where stakeholders more and more frequently seek industry-wide changes in social or environmental practices, and are more and more able to gather evidences on true performances, efforts by all firms are required. As firms in an industry often differ in their capabilities and resources, and as a result in their sense of urgency and manageability of stakeholder pressures, the management of industry reputation forces firms to design collective strategies aimed at helping the weak links in the industry upgrade their performances. This raises new challenges for the collective action of communities of firms relative to reputation as well as bringing hope that industries can be driven to collectively improve their performance when appropriately challenged.

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APPENDIX A

Data collection for this study proceeded in two phases. The first involved understanding the nature of the collective action of the European chlorine companies, what had motivated it, who was participating, what problems had been encountered, and what solutions had been designed. In this phase, we interviewed permanent members of the European association Euro Chlor, in particular, the two heads of safety (one of whom succeeded the other during the period of study), as well as representatives of the companies at the association. Most were interviewed several times in person, by phone, and via e-mail, from 2003 to 2010. Second, we conducted a quantitative questionnaire to gather information at a more decentralized level. The questionnaire asked employees of chlorine companies about various aspects of their relationships with the industry association, and about safety issues, safety information, disclosure issues, patterns of information sharing, and motivations. This both enlarged the set of information on the formal activities of the firms in the context of the industry association and produced information on their various activities that were aimed at increasing their safety records, in particular their more informal and bilateral sharing activities with other companies. Thereby, we created a small dataset on safety performance, distinguishing between activities supporting the coordinated collective action of the firms on the one hand, and activities that were independently pursued by individual firms on the other.

Given the delicate matter of the question, the questionnaire was distributed by the industry association—safety is a sensitive issue and companies often do not communicate on this issue to anyone asking. The head of safety at Euro Chlor sent the questionnaire to every company member of Euro Chlor, 40 firms at the time, in

three languages. For matters of confidentiality, questionnaires were sent back to the association, and names of company and respondent were removed. Among the 40 companies that were contacted, 1 refused to fill in the questionnaire, 2 had stopped producing chlorine within the year of study, and 11 did not respond. The response rate (at the company level) is thus 68 percent. Initial contact was with the head of safety in each firm, but to improve the representativeness, those contacts were asked also to forward the survey to other employees, particularly those from different plants of their company, when those companies had multiple plants. We received 123 questionnaires from the 26 respondent companies, among which 112

were kept for questionnaire with a letter—each questionnaire from a given company would have the same letter—and a number. In addition, we asked that the production capacity of the plant and company as well as the nationality of the company and the position of the respondent be indicated on the front of each returned questionnaire. Table A1 indicates the average number of questionnaires completed and returned in relation to the size of the company. One can observe that the larger the company, the larger the number of questionnaires filled in. In fact, based on footnote 4, one can see that most of the large firms responded while only about half of the smaller firms did.

Table A1. Average number of questionnaires completed by company

Company size (measured by total production capacity in tons)	Number of respondent companies	Average number of questionnaires completed by company
≤ 150,000	15	1.26
150,000–400,000	4	2
400,000–1,000,000	3	4.66
> 1,000,000	4	18

APPENDIX B

Table B1 of responses to selected survey questions indicates the extent to which firms in the industry see reputations as common.

APPENDIX C

In our initial discussion of reputation commons, we observed that a strategy suggested in the literature is to privatize the commons. In effect, each firm

Table B1. Responses to survey questions on safety issues among employees of the E.U. chlorine companies

	Totally wrong (1)	Rather wrong (2)	Rather right (3)	Totally right (4)	Mean	S.D.	Median
A publicized accident in a European chlorine plant can threaten the survival of the E.U. chlorine industry	4.8%	11.9%	42.9%	40.5%	3.19	0.83	3
A publicized accident involving the transportation of chlorine can threaten the survival of the E.U. chlorine industry	7.1%	11.9%	50%	31%	3.04	0.85	3
Differences in safety performance across companies are good for the best performers because the presence of lower performers reduces the level of regulatory requirements	52.4%	42.9%	2.4%	2.4%	1.54	0.67	1
Differences in safety performance across companies are bad for the best performers because the presence of lower performers increases the risk of accidents and threatens the survival of the industry	2.3%	2.3%	46.5%	48.8%	3.41	0.66	3

becomes the master of its own reputation. We can use the simple model to illustrate the kinds of effects this might have. Solving in general terms is nontrivial, so we illustrate the effects by means of a specific example.

If a firm successfully isolates its reputation, its profits are no longer determined by other firms' activities (obviously we are ignoring market or price effects here). Using the subscript M to denote individual reputations, the firm's profit function becomes:

$$\begin{aligned} E\Pi_M &= \int_0^\infty \int_0^T Re^{-rt} dt (\lambda(c_M)) e^{-\lambda c_M T} - c_M \\ &= \frac{R}{r + \lambda(c_M)} - c_M, \end{aligned}$$

which is solved by

$$\frac{dE\Pi_M}{dc_M} = \frac{R\lambda'(c_M)}{(r + \lambda(c_M))^2} - 1 = 0 \quad (\text{C1})$$

The firm's optimal investment c_M^* is the solution to Equation C1, its accident rate is thus $\lambda(c_M^*)$, and the industry accident rate (since we assume, for the moment, two identical firms) is $\Lambda_M = 2\lambda(c_M^*)$.

Now consider the common reputation problem. The general solution is given by Equations 6 and 7. To simplify exposition here, we can use the results from above and assume that firm 1 is going to provide all the funding for abatement (suppose firm 2 makes a credible commitment to invest zero). Thus we need only consider Equations 6 and set $c_2^1 = c_2^2 = 0$:

$$\frac{\partial E\Pi_1}{\partial c_1^1} = \frac{-R_1\lambda'(c_1^1)}{(r + \lambda(c_1^1) + \lambda(c_1^2))^2} - 1 = 0$$

$$\frac{\partial E\Pi_1}{\partial c_1^2} = \frac{-R_1\lambda'(c_1^2)}{(r + \lambda(c_1^1) + \lambda(c_1^2))^2} - 1 = 0$$

We can also use the fact that investment in each of the firms will be the same to simplify to a single equation:

$$-R\lambda'(c_D) = (r + 2\lambda(c_D))^2 \quad (\text{C2})$$

Using a simple functional form for accident prevention, we can compare the industry accident rates in the two cases. Suppose $\lambda(c) = e^{-ac}$. As a benchmark, set $R = 1$, $r = 0.05$, $a = 1$. Solving Equation C1 under these conditions yields $c_M^* = 5.88$ and $\lambda_M(c_M^*) = 0.0028$. Since two firms each solve this problem independently, the industry rate is simply double the individual firm rate: $\Lambda_M = 0.0056$. Similarly, from Equation C2, when reputations are common, $c_D^* = 6.24$ and $\lambda_D(c_D^*) = 0.0032$, with the industry accident rate $\Lambda_D = 0.0064$. The industry accident arrival rate with private reputations is slightly lower than that when joint reputation prevails (the ratio Λ_M/Λ_D increases with R and a , and decreases with r).

This has assumed two equal-sized firms. If, however, we assume that firm 2 is smaller than firm 1, this result changes. Suppose that $R_1 = 1$ and $R_2 = 0.5$. With joint reputations, the larger firm faces the same problem and so the industry accident rate remains at $\Lambda_D = 0.0064$. However, if reputations are private, firm 2 will invest only $c_2 = 5.06$, giving $\lambda_D^2 = 0.006$ and now $\Lambda_D = 0.009$, which is significantly higher than when reputations are common.