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Deepwater Drilling: Law, Policy, and Economics of Firm Organization and Safety

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RESOURCES FOR THE FUTURE

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Abstract

Although the causes of the *Deepwater Horizon* spill are not yet conclusively identified, significant attention has focused on the safety-related policies and practices—often referred to as the safety culture—of BP and other firms involved in drilling the well. This paper defines and characterizes the economic and policy forces that affect safety culture and identifies reasons why those forces may or may not be adequate or effective from the public's perspective. Two potential justifications for policy intervention are that: a) not all of the social costs of a spill may be internalized by a firm; and b) there may be principal-agency problems within the firm, which could be reduced by external monitoring. The paper discusses five policies that could increase safety culture and monitoring: liability, financial responsibility (a requirement that a firm's assets exceed a threshold), government oversight, mandatory private insurance, and risk-based drilling fees. We find that although each policy has a positive effect on safety culture, there are important differences and interactions that must be considered. In particular, the latter three provide external monitoring. Furthermore, raising liability caps without mandating insurance or raising financial responsibility requirements could have a small effect on the safety culture of small firms that would declare bankruptcy in the event of a large spill. The paper concludes with policy recommendations for promoting stronger safety culture in offshore drilling; our preferred approach would be to set a liability cap for each well equal to the worst-case social costs of a spill, and to require insurance up to the cap.

Key Words: Deepwater Horizon, BP oil spill, safety culture, government policy, liability caps, financial responsibility, insurance

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Executive Summary

After the *Deepwater Horizon* explosion on April 20, 2010 and the subsequent oil spill, policymakers, researchers, industry experts and the public began to question the safety of deepwater drilling. Several preliminary reports have concluded that, before the accident, it was widely believed among industry and regulators that the possibility of a spill of this magnitude was minimal. Consequently, industry, federal and state governments were unprepared to respond effectively to such a large spill. These events have spurred calls for legislation that promotes safety in the offshore oil drilling industry.

This paper examines the role of *safety culture* in preventing accidents on deep water offshore oil rigs, where safety culture is defined as the set of values held by employees and the firm's policies that lead employees to prioritize health, safety, and the environment. We evaluate the economic grounds for government intervention in promoting a stronger safety culture at firms involved in deepwater drilling. Potentially, there are two reasons why firms may not choose the socially optimal level of safety culture: (1) firms do not fully internalize the social

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costs of a spill; and (2) principal-agency problems within the firm may cause incentives for adopting safety culture to be different for employees and owners of the firm. Using this framework, we conclude that current economic and policy incentives are insufficient for promoting safety culture, which provides two rationales for government policy intervention. Policies should force internalization of spill costs and promote third-party monitoring to reduce principal-agency problems within the firm.

In this context we examine several potential policy changes, including raising liability caps, increasing financial responsibility requirements (that is, the assets a firm must have), requiring third-party insurance, increasing government oversight, and imposing risk-based fees. Each policy individually has a positive effect on safety culture, but policy makers and the public should be aware of the interactions among policies. Liability caps, for example, are particularly effective when complemented by financial responsibility requirements or third-party insurance; raising liability caps without raising financial responsibility requirements or requiring insurance would have little effect on safety culture at small firms that would declare bankruptcy because of an inability to pay damages.

Summary of Findings:

- Current liability caps are below the worst case damages from drilling, although liability caps are often not binding because of access to other remedies, such as state law actions. Liability caps do, however, reduce expected damages in some cases (such as when state law includes caps), and create legal barriers for plaintiffs that likely affect settlement terms.
- Raising liability caps increases the benefit of adopting a strong safety culture provided that the expected damages plus other costs are not greater than the firm's assets. High exposure to liability forces firms to internalize costs, thus promoting a stronger safety culture.
- Current financial responsibility requirements are well below expected worst-case damages. For small firms, raising liability caps would have a small effect on safety culture because they would declare bankruptcy in the event of a large spill (in the absence of insurance).
- Significantly increasing liability caps and financial responsibility may push some nonmajor oil exploration companies out of the Gulf if they would be unable to afford liability insurance. These effects are likely outweighed by small firms' failure to fully internalize social costs.

- Following the *Deepwater Horizon* spill, the federal government has required drilling firms to adopt safety and environmental management systems. Without adequate monitoring or enforcement, firms could satisfy these requirements on paper without significantly strengthening their safety culture.
- Risk-based fees, either as part of an insurance pool or permitting fees, would encourage a strong safety culture and could provide third-party monitoring.
- Increasing the liability cap and mandating equivalent insurance has a similarly positive effect on safety culture as raising the liability caps and financial responsibility requirements.

Irrespective of other policy changes, the *Deepwater Horizon* spill demonstrates a need for stronger government oversight. Our recommendation is a set of policies that, together, would improve safety culture for offshore drilling:

- Raise the liability cap to the level of social damages expected from the estimated worst-case spill for each well.
- Require third-party insurance to cover cleanup and containment costs, and economic and natural resources damages associated with a spill.
- If insurance is not feasible, firms should be required to display proof of financial responsibility equal to the maximum liability of the well, if not higher.
- Risk-based drilling fees should be used as part of an insurance pool, the MWCC, or in other contexts such as leasing and permitting.

1. Introduction

Although the causes of the *Deepwater Horizon* spill are not yet conclusively identified, significant attention has focused on the safety-related policies and practices—often referred to as the safety culture—of BP and other firms involved in drilling the well. The magnitude of the spill has stirred public interest in ensuring that the safety culture of these firms, and indeed of the offshore drilling industry generally, are appropriate for their high-risk activities. This paper defines and characterizes the economic and policy forces that affect safety culture and identifies reasons why those forces may or may not be adequate or effective from the public's perspective. We conclude by offering policy recommendations designed to improve safety culture in the industry.

Following the *Deepwater Horizon* spill, organizations, analysts, and policymakers have advanced a wide range of proposals that aim to reduce the likelihood of a future catastrophe. Many proposals would mandate the use of specific technologies and engineering practices, such as requiring more extensive testing of blowout preventers and designing wells to have a minimum number of barriers (Joint Industry Task Force 2010). Other proposals address the system level, such as requiring a safety case that would demonstrate to the regulator that the entire system meets a particular level of safety (U.S. Department of Interior 2010). Even more broadly, some analysts and observers have suggested that a stronger safety culture—particularly on the part of BP but also other firms—might have prevented the spill and would reduce the likelihood of future spills. For example, it was said to be acceptable at BP to increase the risk of a spill in order to reduce costs. Rep. Joe Barton stated, "Our hearings discovered that significant cost-cutting measures resulted in decreased maintenance and inspections of the pipeline, and BP's management culture deterred individuals from raising safety concerns" (U.S. House of Representatives 2010). The University of California–Berkeley's Deep Water Horizon Study Group concluded, "Cost cutting, failure to invest, and production pressures characterized BP executive manager behaviors" (DHSG 2010b, 4). Some proposals call for changes in government policy that could affect the organization and safety culture at a firm, such as increases in the liability cap; others simply suggest that firms ought to adopt a stronger safety culture.

Will the *Deepwater Horizon* spill cause the industry to adopt a stronger safety culture on its own, in the absence of policy changes? Some evidence suggests this may be occurring already. In September 2010, for example, BP announced significant changes in its internal structure and the way in which safety will be handled company-wide (BP 2010). But the reasons behind such safety-related changes are impossible to determine. Perhaps BP was responding to new information about risks. Or the changes might be a reaction to public pressure—in other words, new terms in the social contract under which they operate. Or they could anticipate future policy changes, such as stricter regulation (or even be an attempt to preempt such changes), in which case they may actually prove the need for stronger government policy.

Two broad questions have received little attention since *Deepwater Horizon*: first, is there economic justification for government policy aimed at improving safety culture; and second, if justified, what policies would encourage—or hinder—a stronger safety culture at firms? This paper provides a framework for evaluating potential justifications for government intervention, and it assesses policy options for improving safety culture.

The next section discusses the safety culture literature and provides a theoretical framework for assessing different safety culture policies. Studies of past major accidents in

different industries have given rise to a substantial management literature. Researchers have examined a range of "high reliability" industries and tried to identify the characteristics most commonly associated with firms that have a strong safety culture. One definition of safety culture in this literature is *the set of values held by employees and the firm's policies that lead employees to prioritize health, safety, and the environment* (von Thaden and Gibbons 2008).[1] Many policies, initiatives, and procedures affect a deepwater drilling firm's safety culture, and thereby affect employees' actions that could cause a spill. Examples include providing worker training and using a compensation structure that encourages individuals to make decisions that increase safety. The central premise of our framework is that upper management chooses internal policies that affect safety culture and makes decisions that embody it. Lower-level managers and other employees respond to incentives created by upper management, thereby creating a link between safety culture and safety outcomes. In this context, there are two general reasons that the firm may not choose the socially optimal level of safety culture: a) not all of the social costs of a spill may be internalized; and b) there may be principal-agency problems within the firm. Both factors create a potential justification for government policy aimed at promoting a strong safety culture.

The framework in Section 2 applies to any industry; Section 3 discusses economic factors that affect safety culture in deepwater drilling, with particular focus on whether these factors encourage the socially optimal level of safety culture. Although markets do create positive incentives for safety culture, there are important informational problems that may prevent firms from choosing the socially optimal safety culture. These problems create a justification for policies that provide some monitoring (that is, policies that reveal to the public the degree of safety culture), in addition to policies that promote a stronger safety culture.

Section 4 discusses five policies that could increase safety culture and monitoring: liability, financial responsibility (a requirement that a firm's assets exceed a threshold), government oversight, mandatory private insurance, and risk-based drilling fees. We find that

[1] Numerous definitions, often closely related, are available in the literature. For example, James Reason has defined safety culture as "the product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety programmes" (Weick and Sutcliffe 2001). Some authors use "a culture of safety" to mean that the culture is centered on safety as the main priority. Others use "safety culture" to denote that every organization has a culture of safety that sits on a spectrum from poor to strong. Some authors use "high-reliability organization" (HRO) to refer to organizations with exceptionally strong safety cultures that effectively minimize accidents. For purposes of this paper, we use "strong safety culture" to indicate the qualities of an HRO.

although each policy has a positive effect on safety culture, there are important differences—in particular, the latter three provide external monitoring that could reduce principal-agency problems. Furthermore, interactions among these policies mean that they should be jointly determined. Importantly, raising or eliminating the liability cap without raising the financial responsibility requirement would be insufficient for promoting safety culture at small firms because they might declare bankruptcy in the event of a large spill and avoid paying the costs.

Section 5 concludes with our policy recommendations for promoting stronger safety culture in offshore drilling. The two policy objectives are for firms to internalize the social costs of a spill when they choose safety culture, and to increase third-party monitoring. Our preferred approach would be to set a liability cap for each well equal to the worst-case social costs of a spill, and to require insurance up to the cap. We note that even in this liability regime, the public may not be able to recover all social costs, and additional policies, such as stronger government oversight, would be justified. If mandatory private insurance is not feasible, raising the cap and the financial responsibility requirement would also have a significant effect on safety culture, particularly if this approach is combined with stronger government oversight. In either case, imposing risk-based drilling fees (for example, via license fees or insurance premiums) would also create an incentive for firms to adopt a stronger safety culture.

Before proceeding, we note a caveat to the analysis. There are numerous ongoing investigations of the causes of the *Deepwater Horizon* spill, and there is no definitive assessment of whether an inadequate safety culture increased the likelihood of the spill or whether a stronger safety culture would significantly reduce the likelihood of future accidents. Furthermore, despite the growing management literature on high-reliability industries, there is no consensus about the characteristics that define a strong safety culture for deepwater drilling. Consequently, our objective is not to identify specific policies that would have prevented the *Deepwater Horizon* spill or to make recommendations on specific changes to safety culture that would prevent a major spill. Instead, we assess whether policies for promoting safety culture are economically justified and we analyze a range of policy changes, including the major ones currently under discussion. Although this analysis is necessarily qualitative, to the extent possible, we attempt to assess the likely significance of each policy.

2. Literature Review and Theory of Safety Culture

We present an overview of the safety culture literature and give a few examples of policies that indicate a strong safety culture in industries other than oil and gas production. We

then outline a theoretical structure for understanding why a firm selects a particular level of safety culture, and the economic justification for government policy intervention.

2.1 Literature on Safety Culture in High-Risk Industries

2.1.1 Background and Terminology

Safety culture can be understood within the context of *corporate culture*, defined as "the ways work and authority are organized, the ways people are rewarded and controlled, as well as organizational features such as customs, taboos, company slogans, heroes and social rituals" (Brickley et al. 2007, 315). Safety culture refers to the features of a firm's culture that specifically affect safety, both that of individual workers and that of processes that relate to the release of dangerous or environmentally harmful materials (sometimes called process safety; Baker et al. 2007). After the nuclear explosion at Chernobyl in 1986, an entire body of literature developed on the importance of a strong safety culture in high-risk industries. Specifically, that work focused on the underlying causes of catastrophic accidents and ways to avoid them.

Organizations that operate relatively error-free in high-risk industries over a long period of time are termed high reliability organizations (HROs). Several researchers have identified characteristics of HROs through a combination of empirical studies, case studies, and application of theoretical frameworks to specific examples. Weick and Sutcliffe (2001) compiled a comprehensive list of qualities that HROs exhibit, including preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise. Weick and Sutcliffe provide examples of HROs from the railroad and mining industries. Hopkins (2008) focuses on three of the attributes listed above, citing constant worry about failure, reluctance to draw quick conclusions, and sensitivity to the experience of frontline operators as the major components of safety culture. Roberts and Bea (2001) expand on these elements and assert that HROs also aggressively seek out information, design their reward and incentive systems to recognize costs and benefits of failure versus reliability, and consistently foster communication among employees about the organization's mission and where they fit in.

Commonly agreed-upon characteristics of low-reliability organizations, or organizations prone to catastrophe, are cost cutting, lack of training, poor communication, poor supervision, and fatigue (DHSG 2010a). Some studies also cite disaggregation of responsibility and inflexible decisionmaking as contributing factors to disasters. A strong safety culture requires a balance between centralization and decentralization of decisionmaking, such that a "delegated capacity

for local detection must be held simultaneously with a centralized capacity that maintains the organization's larger awareness of its vulnerability and serves to coordinate responses and learning that occur at the local level" (Weick and Sutcliffe 2001, 170). Weick and Sutcliffe (2001) find that an HRO must have flexible decisionmaking that allows for decisions to come from the top-level managers during stable times and further down during emergencies. Hopkins (2008) argues that complete decentralization does not allow operations managers to learn from incidents that top management might have stored away for future institutional reference.

2.1.2 Why Aren't All Firms HROs?

The preceding discussion raises the question as to why all firms are not HROs. Hopkins (2008, 83) suggests that organizations do not always behave in their best interest because "organizations themselves don't act—individuals within them do," an observation that makes failure to invest in safety more understandable.

In many cases, employees do not have the proper incentives to behave in manners consistent with an HRO. Executives may be pressured to perform quickly and cheaply and may perceive safety as less important.

Information flow between individuals, particularly up and down the hierarchy, has also prevented firms from engaging in HRO behaviors. According to Hopkins (2008, 114), "Research shows that, prior to every major accident, information was available somewhere in the organization pointing to the fact that trouble was brewing, but this information failed to make its way upwards to people with the capacity and inclination to take effective action." Top managers need to convey to all employees the importance of reporting all information, both positive and negative (Hopkins 2008). Thus, the literature suggests that some firms may not be HROs because upper management does not provide the correct incentives. Section 2.2 discusses reasons why that might occur.

2.1.3 The Importance of Incentive Schemes

Roberts and Bea (2001, 74) note that HROs:

> Seek to establish reward and incentive systems that balance the costs of potentially unsafe but short-run profitable strategies with the benefits of safe and long-run profitable strategies. They make it politically and economically possible for people to make decisions that are both short-run safe and long-run profitable. This is important to ensure that the focus of the organization is fixed on accident avoidance. When organizations focus on today's profits without consideration of tomorrow's problems, the likelihood of accidents increases.

Hopkins (2008) asserts that managers are driven not only by financial incentives but also by praise and criticism. Whether such corporate or social norms counteract or reinforce economic incentives is an empirical issue. It is widely acknowledged within the management literature that to instill a particular culture, performance evaluations and rewards must reinforce that culture. Hence, if cost cutting is more important than safety in a manager's evaluation and reward structure, it would not be surprising to see safety taking second place to cost cutting.

2.1.4 Measurement of Safety Culture

Quantitative comparisons of safety cultures between firms, occupational groups, and even industries can be made using the safety attitudes questionnaire developed by Bryan Sexton, Eric Thomas, and Bob Helmreich. Originally designed for the health care industry, the questionnaire has been used to contrast the safety cultures of airlines and intensive-care units (Sexton et al. 2000). The approach has also been applied to other high-risk industries, like nuclear power generation and, most recently, offshore oil drilling.

A similar questionnaire was used in an analysis by Mearns et al. (2003) to ascertain whether there was a correlation between safety culture and accidents.[2] Safety culture scales measure employees' satisfaction with safety activities, involvement with safety planning, and safety communication, in addition to attitudinal questions about safety and the frequency of unsafe behavior. The paper reports an association between proficient safety management practices and low levels of official, OSHA-reported accidents and respondent-reported accidents. The authors note the challenges of interpreting the results as the causal effect of safety culture on accidents.

2.1.5 Examples of Strong Safety Culture in High-Risk Industries

A nuclear power plant is one example of a hazardous worksite where awareness of risk is central to avoiding catastrophes. For example, the Diablo Canyon nuclear power plant exhibits qualities of an HRO by mandating that employees spend one week of every four in training.

[2] Thirteen separately operated oil rigs were included in the study. Each rig was assessed based on its safety culture, safety management practices, and safety performance. Surveys were delivered and filled out by hand. Respondents answered questions using a five-point scale to indicate their agreement or satisfaction with a particular safety-related statement. Part 2 of the survey was a safety management questionnaire, which addressed safety management practices on each oil rig. Responses were collected in the same manner, and a coding scheme converted qualitative survey answers into quantitative data.

Frequent training prevents employees from becoming complacent and reinforces the idea that the organization strives to learn what it does not know (Roberts and Bea 2001).

Aviation is another high-risk industry in which some organizations operate with high reliability. An often-cited example is the 1989 United Airlines flight that experienced an unprecedented emergency when a secondary engine exploded, cutting off the aircraft's hydraulic power. The cockpit crew made an emergency landing in Sioux City, where a DC-10 had never landed before. Despite a malfunction in a crucial piece of firefighting equipment, more than half of the passengers on board survived because the emergency ground personnel had recently practiced how to safely land a DC-10. This is an example of an HRO training its employees to recognize and respond to irregularities, but confounding factors undermine the conclusion that this is a perfect example of an HRO. Because an instructor pilot who happened to be on board played a pivotal role in landing the disabled aircraft, it is difficult to discern to what extent the outcome was due to luck or a strong safety culture.

Many airlines behave as high-reliability organizations, as evidenced by the expensive precautions they take to minimize risk (Roberts and Bea 2001). It is a subject of debate whether this is because airlines internally value a strong safety culture or are just complying with legal requirements. Laws mandate that there be two qualified pilots in the cockpit of a large commercial aircraft, two air traffic controllers monitoring the same skies, and multiple people directing the plane to its gate. These and other legal provisions force firms to adopt some HRO-type behaviors, which they may or may not have adopted otherwise. Fraas et al. (2010, 11) find that the Federal Aviation Administration's "site-specific and general environmental and safety management systems aim to strengthen safety cultures and accountability within firms, but these systems require periodic independent audits to evaluate their substance, their implementation, and their effectiveness in improving safety results."

Aircraft carriers operate in extremely dangerous conditions with little margin for error. To avoid disasters, U.S. Navy aircraft carriers build redundancy into their operations, such that there are more than 20 communications devices on board to ensure that the landing-signal officer is always connected to a commander in the control tower. Because the Navy "spend[s] money to create redundancy, there is no question in anyone's mind that the organization believes it can't know everything and must take the possibility of accidents seriously" (Roberts and Bea 2001, 73–74), and thus a strong safety culture emerges.

2.1.6 Examples of Weak Safety Culture

In theory, numerous disasters could have been avoided had organizations incorporated HRO tactics into their operations. For example, in 2006 an airplane crashed after taking off from the wrong runway in Lexington, Kentucky, because of confusion about taxi patterns due to construction. "A small group of aircraft maintenance workers told the investigators that they also had experienced confusion when taxiing to conduct engine tests—they worried that an accident could happen, but did not know how to effectively notify people who could make a difference" (Leveson 2010, 352). This example demonstrates the importance of information flows.

Another avoidable incident occurred in 1986 when the space shuttle *Challenger* fell apart within the first two minutes of its flight. Hopkins (2007, 11) finds that "the decision to launch the Challenger space shuttle was made against the advice of the expert engineers." Hopkins believes that had NASA employed flexible decisionmaking, which is crucial to HROs, the accident would have been avoided.

Weick and Sutcliffe (2001) use the example of the Union Pacific–Southern Pacific railroad merger to illustrate potential repercussions of a weak safety culture. Union Pacific experienced several accidents, some fatal, directly after the merger, when its safety culture was in flux. At that time, errors were underreported or ignored until they were almost irreversible; top management was composed of people with homogeneous backgrounds who wanted to simplify operations; and any employee who relied on expertise to make decisions without explicit permission from supervisors was deemed insubordinate (Weick and Sutcliffe 2001). Thus Union Pacific failed to follow many of the essential HRO practices.

Redundancy is cited as critical to a safety culture, but it is not always effective at preventing accidents. Occasionally, organizations incorporate HRO recommendations into their operations but still experience accidents. For example, in April 1999, a military communications satellite, Titan IV B-3, was launched into an incorrect, unusable orbit. The loss cost approximately $1.2 billion. Leveson (2010, 400) points out that in this instance "there were a large number of redundancies in each part of the process to prevent the loss, but they were not effective. Sometimes (as in this case), built-in redundancy itself causes complacency and overconfidence and is a critical factor in the accident process."

Similarly, in Miami in 1984, a Lockheed L-1011 lost oil pressure in all three engines simultaneously because two mechanics failed to install O-rings on the new engine oil plugs. As in the case of the *Challenger* space shuttle, "the failure of the primary O-ring led to the failure of

the secondary O-ring. Redundancy does not provide protection against underlying design errors, only random failures" (Marais et al. 2004, 11).

Marais et al. (2004, 9) further argue that the simultaneously centralized and decentralized decisionmaking recommended for HROs "can lead to major accidents in complex socio-technical systems." For instance, before a ferry disaster at Zeebrugge, Belgium, "those making decisions about vessel design, harbor design, cargo management, passenger management, traffic scheduling, and vessel operation were unaware of the impact of their decisions on the others and the overall impact on the process," even though they were all making their decisions properly according to HRO theory (Marais et al. 2004, 9). These examples suggest that becoming an HRO is more difficult than simply adopting each individual policy and procedure that the literature advocates.

2.1.7 Safety Culture at BP

Concerns about the safety culture at BP preceded the *Deepwater Horizon* spill. Numerous studies analyze the explosion at BP's Texas City oil refinery in 2005. The U.S. Chemical Safety Board (CSB) released a landmark report in 2007 concluding that corporate culture caused the incident. The report asserts that senior executives did not adequately address major hazard risk or process safety performance. External audits conducted by GHSER (BP's Health, Safety and Environmental Management System Framework) and Telos (a provider of risk management and insurance broking services) in 2003–2005 concluded that "Texas City had serious deficiencies in identifying and controlling major risks" (U.S. CSB 2007, 184). An internal audit by BP in 2004 concurred that "business unit managers' risk management processes did not understand or control major hazards" across the corporation (U.S CSB 2007, 184). Furthermore senior executives did not provide effective safety culture leadership or oversight. Examples included "managers not following or ensuring enforcement of policies and procedures, responding ineffectively to a series of reports detailing critical process safety problems, and focusing on budget cutting goals that compromised safety" (U.S. CSB 2007, 187). In addition, BP managers "did not formally review the safety implications of policy changes such as cost-cutting strategy prior to making changes" (U.S. CSB 2007, 194).

Above, we noted the importance of providing incentive schemes that encourage safety and long term profitability. At BP's Texas City refinery, each employee received a bonus based on the overall performance of the refinery (U.S. CSB 2007). Fifty percent of the bonus was determined by "cost leadership," or cost cutting, and only 10 percent was determined by safety—calculated as OSHA-reported injuries, which are a measure of personal safety, not process safety.

The incentives were powerful: refinery managers could receive significant bonuses, up to 40 percent of their salaries. Such incentives can create incentives to hide accidents. The Telos Group found that managers at Texas City would avoid reporting a frontline injury, sometimes by having the employee return to work immediately in a different capacity. The report includes an employee anecdote stating, "minor steam burn resulting in first aid visit; management encouraged self-treatment to avoid OSHA recordable injury" (Hopkins 2008, 86). Managers also had a high rate of turnover and were judged on their profitability. The short-term mentality combined with improper reward structures created a culture that did not value safety highly (Hopkins 2008).

Hopkins (2008) adds that BP officials took for granted that they were being properly informed of audits' results, did not heed warnings from their subordinates, and relied heavily on the observations of others rather than inspecting operations firsthand. External audits completed in 2002 and 2004 of Texas City produced strong, negative conclusions about BP's safety culture, which were not reported to the chief executive (CE) of the refining and marketing businesses (Hopkins 2008). The CE stated in his deposition, "there were no audits which were coming to me, for instance, or, indeed, as I understand it, to [my immediate subordinate] which would have indicated the state of that plant" (Hopkins 2008, 111). In addition, BP received several warnings about danger at Texas City, including one from the health, safety and environment manager at Texas City a month before the explosion, who said "I would like for us to make these incidents our No. 1 priority …. I truly believe that we are on the verge of something bigger happening and that we must make critical decisions tomorrow morning over getting the workforce's attention around safety" (Hopkins 2008, 71). Two investigations of Texas City concluded that the management team was "not connecting to the workforce in a meaningful way" and "management was generally unaware of local practices" (Hopkins 2008, 116). The CE did make a visit to Texas City in 2004 but did not inspect the plant, and spoke solely with management, not frontline workers. The management team he spoke with informed him that effective programs were being put in place, and he left with a positive impression of the safety efforts at Texas City. The CE assumed that management's reporting was accurate and comprehensive and did not engage with the frontline workers. Essentially, BP was not an HRO because initiatives were not driven from the top (Hopkins 2008, 147).

Communication between levels of management also appears to have affected BP's safety culture. While Lord Browne was BP's CEO (1995–2007), managers recalled, "only good news flowed upwards … no one dared say the wrong thing or challenge the boss" (Hopkins 2008, 108). Tony Hayward, who succeeded Browne, added, "we have a leadership style that is too

directive and doesn't listen sufficiently well. The top of the organization doesn't listen sufficiently to what the bottom is saying" (Hopkins 2008, 109).

After the Texas City incident, BP attempted to shift to an HRO culture. In July 2010, Robert Dudley (who became CEO in October 2010) said that "Tony [Hayward] started a cultural change three years ago, around a focus on safe and reliable operations. It is a fundamentally different company today than it was three years ago … we've now had this *[Deepwater Horizon]* incident: we need to accelerate that change in the culture inside the company" (Crooks 2010, 1). A 2009 financial risk management report stated that, "following the health & safety crisis, the company underwent a significant shift in its corporate culture which resulted in an integrated approach to safety within the organization" (RiskMetrics 2009, 5). Analysts expressed concern that this shift was not permanent: the 2010 report finds "our analysis of BP's reported H & S [health and safety] statistics 2005-2009 indicates an improving trend from 2005-2009, which is most likely a function of BP management's increased attention to EHS [environment, health and safety] …. However, from 2009, performance deteriorated" (RiskMetrics 2010, 2).

Some reports have attributed the *Deepwater Horizon* spill in part to a weak safety culture. For example, the Deepwater Horizon Study Group (DHSG 2010a) finds that fatigue, poor communication, and lack of training characterized many BP employees in previous accidents, such as the Texas City explosion in 2005, and states suspicion that those characteristics also applied to the workers aboard the *Deepwater Horizon* oil rig.[3] Interviews conducted prior to the spill reveal that employees aboard the rig "felt comfortable raising safety concerns and ideas for safety improvement to managers on the rig, but felt that they could not raise concerns at the Divisional or the Corporate level without reprisal" (Leveson 2010, 352).

Following *Deepwater Horizon*, BP's new management apparently recognized that previous changes were inadequate to ensure a safety culture. According to a BP press release, Dudley began to implement corporate safety changes even before he replaced Hayward. A new "Safety & Operational Risk" function will oversee and audit the company's operations. The new group will have its own expert staff "embedded in BP operating units" and will report directly to

[3]Lots of finger-pointing has occurred since the *Deepwater Horizon* oil spill. For example, Jack Hackett, the CEO of Anadarko (BP's partner on the Macondo well), even said, "the mounting evidence clearly demonstrates that this tragedy was preventable and the direct result of BP's reckless decisions and actions—BP's behavior and actions likely represent gross negligence or willful misconduct" (DHSG 2010, 10).

the CEO (BP 2010). BP will also restructure its upstream division into exploration, development, and production and will review incentives for safety and risk management.

2.1.8 Summary of the Safety Culture Literature

Before presenting a theoretical structure for analyzing government policies and safety, we list a few specific policies and procedures that researchers have suggested indicate a strong safety culture in other industries. These safety culture indicators may or may not be applicable to deepwater drilling, but they help ground the theoretical discussion that follows.

The literature emphasizes that safety culture must be advocated by upper management. Consider a few specific policies and procedures that are adopted at firms with a strong safety culture:

- redundancy;
- compensation schemes, including bonuses, that emphasize safety performance;
- hiring appropriately trained individuals and providing continual on-the-job training; and
- regular analysis of how changes affect safety (i.e., management of change).

Redundancy should be built into emergency preparation and day-to-day operations. A firm would have a stronger safety culture by requiring more than one qualified person to assess operations and having a variety of people at different management levels sign off on all operational changes. This would also guarantee a smooth information flow between senior executives, managers, and frontline workers.

Compensation schemes play a central role in promoting a strong safety culture. Consider a firm whose managers' compensation depends exclusively on the operating profits of their business units. Each manager will try to reduce costs even if doing so increases the number of accidents within the unit (as long as the accidents do not result in a larger increase in costs). In the case of Texas City, the Baker Panel recommended "making a significant portion of total compensation of refining line managers and supervisors contingent on satisfactorily meeting process safety performance indicators and goals"; a similar recommendation applied to nonmanagerial workers (Baker 2007, 251). Such changes should be implemented carefully in order to minimize the perverse incentives for reporting accidents that were noted above.

Hiring well-trained workers and providing on-the-job training is also consistent with a strong safety culture. Both actions are likely to increase the costs of the firm, but they represent a prioritization of safety over short-term costs.

Many decisions made by employees affect safety, although the effects of these decisions are not readily apparent. Analyzing the effects of such decisions is costly to the firm, in terms of time and money. The willingness to pay the costs and undertake the analysis represents a prioritization of safety over costs, and is thus indicative of an HRO.

2.2 Theoretical Framework for Evaluating Government Policy and Safety Culture

Researchers have described the characteristics of firms with strong safety cultures but have not attempted to explain why some firms adopt a strong safety culture and others do not. More importantly for our purposes, despite some discussion about the disincentives for adopting a strong safety culture (for example, doing so is costly), they have not addressed directly the role for government policy. We therefore turn to the literature on corporate criminal behavior and the design of optimal sanctions to control illegal activities as the basis for our evaluation of potential government policies.[4]

We begin by assuming that a firm engaged in deepwater drilling maximizes profits. For the moment, we assume there are no conflicts of interest between shareholders, managers, and other employees at the firm (i.e., there are no agency costs), so that the incentives within the firm are perfectly aligned. Consequently, decisions made by employees are always in the best interest of the firm's profits. We also assume that the owners of the firm care only about profits and not about their personal reputations or the environmental consequences of their firm's behavior. These assumptions are strong but will be relaxed later in the discussion.

For convenience, we conceive of a firm choosing safety culture along a continuum. A particular level of safety culture represents the adoption of certain policies and procedures, such as those discussed above. One of the aims of this section is to characterize the factors that affect the desired level of safety culture.

A profit-maximizing firm weighs the expected benefits of adopting a stronger safety culture against the expected costs. An example of a benefit is that a stronger safety culture reduces the likelihood of a catastrophe and the ensuing lawsuits; an example of a cost is the

[4] Corporate crime can be modeled just like the decision to engage in any illegal activity or to avoid activities that are designed to prevent harmful activity (Cohen and Simpson 1997). Indeed, because of U.S. law and the nature of corporate criminal liability, virtually any oil spill in the U.S. subjects the responsible party to potential criminal liability—essentially at the discretion of government prosecutors. The underlying economic theory of why individuals commit unlawful activities is generally attributed to Becker (1968) and was expanded by Cohen (1992) to incorporate corporate environmental crimes.

higher wages that must be paid to workers who have more training. The following sections discuss at length the economic and policy factors that affect these costs and benefits. In short, *individuals and firms choose the major elements of safety culture in response to economic, legal and other regulatory pressures*.

We adopt the standard perspective in welfare economics that government intervention may be justified if the private market does not lead to the socially desirable outcome (here, the socially optimal level of safety culture). That is, only in that case could government policy lead to an economically efficient outcome (the framework focuses on economic efficiency and does not consider distributional consequences of government policies). In the context of deepwater drilling, some benefits of adopting a strong safety culture may not be internalized by the firm. For example, society may not be compensated fully for environmental degradation (Krupnick et al. 2011). In this example, the social benefit of increasing safety culture exceeds the private benefit, in which case the *firm will adopt a weaker safety culture than society would like*. This constitutes the first justification for government intervention. It follows directly that policies that align the incentives of the public with those of the firm—that is, policies that internalize the externalities—would likely improve economic efficiency.

Thus far, we have assumed away any conflicts within the firm, or the possibility that individuals within the firm care about anything other than profits. We now broaden the discussion by relaxing these assumptions.

More specifically, we have assumed that the firm's policies are actually carried out by its employees—something that is less and less likely as the firm expands and the cost of monitoring the actions of managers and employees increases. Firms engaged in deepwater oil and gas production certainly have such concerns—not only with employees but also with the many subcontractors they hire for exploration and production. This "principal-agent" relationship between owners and managers or between firms and subcontractors causes a divergence of interests that may result in more (or fewer) precautions to prevent a catastrophic event than the owner of the firm would prefer.[5] Because of this divergence of interests, the firm's owners will decide what *ex ante* training programs, internal monitoring policies, and so forth to put in place, and what *ex post* rewards and punishments, such as monetary compensation, promotions or firings, and nonpecuniary benefits of the job, to give its managers and employees.

[5] Alexander and Cohen (1996) model this divergence between owners and managers of the firm in the context of corporate crime and estimate the extent to which crime is likely to be the outcome of this divergence of interests.

To illustrate, assume for simplicity that there is only one owner and one manager of the firm. The owner (principal) hires the manager (agent), who has the expectation of earning a reasonable wage. Suppose further that there are two ways to achieve a given level of profit: one that involves designing and enforcing a safety culture and one that does not.[6] Society desires a safety culture because of the lower probability of a catastrophic spill, but suppose, for the moment, that such a spill would not affect the firm's profits (i.e., the costs of the spill are not internalized). The safety culture requires more work on the part of the manager, whereas the absence of a safety culture results in the same profits but requires significantly less time and work. Thus, the manager can increase "leisure time" and work fewer hours (or otherwise increase perks on the job) while maintaining the owner's profits.

For comparison, suppose that firms are held liable for accidents attributed to not having an adequate safety culture (i.e., the costs of such accidents are fully internalized by the owner), such that the social and private benefits of safety culture are the same. In this case, the owner would clearly prefer the safety culture, and there is a divergence of interests between owner and manager. In the extreme, where the owner cannot observe the manager's actions and the manager is not held personally liable for unsafe activities, the outcome is clear: the manager will shirk even though the owner wants a strong safety culture. Although this simplification ignores some other possible constraints on the manager's action, such as moral inhibition, the point is that as long as the owner cannot perfectly monitor the daily actions of the manager, there is a risk that the manager will not adopt a safety culture because the costs outweigh the benefits.

Given the above scenario, we would expect the owner of the firm to put mechanisms in place to align his own incentives with those of his manager. These mechanisms might involve costly monitoring devices, such as internal audits, extra layers of management approval for certain actions, or random third-party inspections. The owner might also include monetary incentives or promotion to a manager whose unit achieves certain levels of performance and demotions or dismissal of a manager whose unit does not. Of course, if the owner wants to encourage unsafe behavior, the opposite incentives might be put in place. Ultimately, although the owner may not be directly involved in day-to-day decisions by the manager, his decisions on the size and intensity of internal compliance programs, compensation and performance evaluation processes, strategic plans, and so forth may be thought of as choosing a "probability"

[6] In the principal-agent discussion, we refer to safety culture as an either-or decision—either the firm has one or it does not. The model can be generalized to allow safety culture to be chosen from a continuum.

that the manager (agent) pursues an unsafe culture. Because such policies are costly, the owner may choose a probability of safety culture that is less than the socially desirable level.

To summarize the preceding discussion of principal-agent theory, even if social and private benefits (i.e., to the owner) of safety culture are equal, the firm may not adopt a safety culture because of agency costs. This is consistent with Hopkins' (2008) argument, noted above, that employees may not always act in the firm's best interests. Similarly, the level of safety culture may be less than socially optimal if the social and private benefits to the agent are equal, but the owner benefits less from safety culture than does the agent. *Agency problems thus create a second potential justification for government policy*.

Note that information plays an important role in the principal-agent theory, because it is the owner's inability to observe the manager's actions that increases the owner's costs of incentivizing the manager to adopt a safety culture. Below we consider the implications of other aspects of information that affect safety culture, including whether the owner knows how to instill a strong safety culture.

The final consideration is that individuals may care about other things besides a firm's profits. The corporate crime literature discusses quality of life, reputation, self-respect, moral inhibitions, and aversion to jail time and fines. As noted above, Hopkins (2008) finds that praise and criticism, and not just financial compensation, affect a manager's decisions. Once these other factors are considered, a firm may adopt a higher safety culture than society desires—if, for example, the firm's owner has an extremely strong preference for environmental quality. Furthermore, individuals and firms differ in many of these aspects. Because the costs and benefits of a safety culture may vary both by firm and by individual, *the level of safety culture may vary across firms within an industry and it may vary across business units within a firm*.

In summary, (1) day-to-day decisions about whether to implement a safety culture are the consequence of individual choices; (2) individual choices are affected by economic and policy incentives; and (3) the interests of owners, managers, and employees may not be aligned. In this setting, there are two potential justifications for government policy: (a) the firm may not fully internalize the social benefits of adopting a strong safety culture; and (b) agency problems may cause the firm to adopt a weaker safety culture than if the agency problems did not exist. Section 4 evaluates policies that would affect safety culture. Before beginning that discussion, however, we discuss in greater detail the economic incentives for safety culture.

3. Economic Incentives for Safety Culture

Several factors put pressure on a firm to adopt a stronger or weaker safety culture.

3.1 Does the Market Punish a Poor Safety Record?

Consumers and investors are often mentioned as two forces that might have an important influence on firms that have a poor safety record. If consumers thought that a firm's safety record posed a risk to them directly through product quality or safety concerns, this would no doubt be priced into the firm's product and would have a significant effect on a firm's behavior.

In the case of oil production, however, production risks do not translate into lower-quality oil. Instead, it is possible that because many consumers care about the environment, some may decide to purchase products based on their perception of the company's safety or environmental record. They may want to send a message to a firm with a weak safety record, or they may derive some nonmonetary value from punishing such firms. In other words, consumers might be willing to pay a higher price or switch to a lower-quality or less convenient brand. Survey research finds that some U.S. consumers are willing to pay such a premium.[7]

There is also anecdotal evidence in the United States (and in Europe) that consumers have boycotted petroleum companies, including Shell (following the *Brent Spar* incident), Exxon (following the *Exxon Valdez* accident), and BP (following the *Deepwater Horizon* spill) (Tye 1989). Although the effect of these boycotts is generally temporary and of limited geographic and/or demographic scope, they can affect short-term profits. For example, "A consumer boycott of Shell products, organized by Greenpeace and the Green Party, hit particularly hard in Germany, where sales dropped by 30%" (Neale 1997, 99). At least in the case of the *Brent Spar* incident, consumer boycotts were apparently significant enough to be a major contributing factor leading to a change in corporate policy (Neale 1997). Indeed, after the *Deepwater Horizon* incident, anecdotal evidence suggests there were significant and painful boycotts by consumers against branded BP oil—something that appears to have hurt small business owners as much as BP (Neuman 2010). Clearly, this is more relevant for vertically integrated companies, like BP,

[7] For example, a 2008 survey of the U.S. public found that approximately 50% of respondents indicated they would probably pay up to 15% more for environmentally friendly laundry detergent, computer printer paper, automobiles, or wood furniture. See "The GfK Roper Yale Survey on Environmental Issues," July 2008, http://environment.research.yale.edu/documents/downloads/a-g/GfK-Roper-Yale-Survey.pdf.

than for deepwater drilling companies that do not have branded products and do not participate in retail markets.

Reputation can provide incentives for adopting a strong safety culture. Information that a firm has been sanctioned for violating environmental laws may be of interest to shareholders or lenders if the monetary sanction reduces the expected value of the firm and thus its share price or bond rating. It may also give lenders and insurers pause about risking more capital on that particular firm.[8] Other costs to having a weak safety culture might include debarment from future government contracts and targeted enforcement by regulatory agencies.

Several studies looking at bad environmental news, such as oil or chemical spills or the announcement of civil or criminal enforcement actions, have demonstrated a negative stock price effect. Because stock prices are generally thought to represent the market's best estimate of future profitability, if the stock price reduction exceeds the expected cost of penalties and cleanup, this could be attributed to a "reputation" penalty. However, most studies fail to find any reputational penalty from environmental violations: stock prices appear to decline roughly by the same amount as the value of the direct cost to the firm, including cleanup costs, tort liability, government-imposed sanctions, etc. (Jones and Robin 2001; Karpoff et al. 2005). For example, Jones et al. (1994) studied the effect of the *Exxon Valdez* spill on Exxon's stock price and estimated a cost to shareholders of $4.7 billion to $11.3 billion—within the range of estimates of the ultimate cost to Exxon of the spill itself.

3.2 Lack of Appropriate Information

For markets to work efficiently, decisionmakers must have adequate information. There are several ways that imperfect information prevents the establishment of appropriate compensation schemes and other elements of a strong safety culture. First, even if it would be profitable for the firm to adopt a strong safety culture, upper managers may not know what policies to put in place. For example, in the Texas City accident, by focusing on worker injuries rather than problems at the system level, managers may not use the appropriate safety metrics (U.S. CSB 2007). Since the *Deepwater Horizon* spill, there has been a lot of interest in developing safety metrics that can be used to predict the possibility of a future accident (Cooke et al. 2011).

[8] Sharfman and Fernando (2008) find that firms with lower environmental risk have a lower cost of capital.

This argument could be pushed further to say that there is no need for government intervention. Suppose it is profitable to adopt a strong safety culture, but some firms do not know how to adopt it. Furthermore, assume the market is competitive, such that high-cost firms will eventually exit the industry. In that case, market pressures will cause the firms with a weak safety culture to exit, and in the long run the likelihood of a major accident should be very low because all firms that remain in the industry will have a strong safety culture.

There are two problems with this argument, however. First, a large number of major accidents may occur before market pressures drive out the firms with poor safety culture. Because of the high external costs of such accidents, this is clearly not a desirable outcome from the public's perspective. Second, government intervention may be needed precisely because some firms do not know how to adopt a strong safety culture. The government could raise the cost of failing to adopt a strong safety culture, which would hasten the exit of firms that do not know how to implement it, or the government could increase the incentive for them to learn. This type of policy is discussed in more detail below.

Another type of information problem is that firm managers might simply not have adequate information about the expected cost of not adopting a strong safety culture. In particular, firm managers might not have adequate information about the probability of a spill or its potential magnitude. Before the *Deepwater Horizon* spill, the risk model used by industry and government indicated that the most likely size of a large spill at the Macondo well was 4,600 barrels and no more than 26,000 barrels over the entire 40-year life of production activity on six leases, including the Macondo well—a fraction of the nearly 5 million barrels of oil actually spilled (Scarlett et al. 2011). Thus, to the extent that the expected cost of not adopting a safety culture is underestimated, firms are likely to underinvest in a safety culture.

3.3 Conflicts of Interest between Shareholders and Managers

A particularly salient information problem is that shareholders or managers may not have sufficient information to monitor employees' safety-related decisions. As discussed in Section 2.2, there is an inherent conflict of interest between shareholders and top management of a company. This conflict is most apparent in large, publicly traded companies, but it is also evident in any organization where top managers are not the owners of the firm. Of particular interest for our paper, shareholders may have a greater interest in safety and environment when a manager's compensation is linked to short-term profits (such as performance bonuses). The manager's decisions increase short term profits by reducing safety while decreasing long-run profits by exposing the firm to liability from a catastrophic spill. Managers may simply shirk on their

responsibility to provide an adequate safety culture because doing so takes significant effort and it is difficult for shareholders to monitor their behavior. The corporate governance literature focuses on mechanisms designed to overcome these conflicts of interest.

A review of the corporate governance literature noted:

> The fundamental insight from the field of corporate governance is that there are potential problems associated with the separation of ownership and control that is inherent in the modern corporate form of organization. Corporate governance, then, encompasses the set of institutional and market mechanisms that induce self-interested managers (the controllers) to maximize the value of the residual cash flows of the firm on behalf of its shareholders (the owners). (Denis 2001, 192)

The corporate governance literature generally considers four mechanisms by which managerial effort can be aligned more closely with shareholders (Jensen 1993): (1) legal and regulatory mechanisms; (2) internal control mechanisms; (3) external control mechanisms; and (4) product market competition. None of these mechanisms is perfect, as each comes with its own costs. Although government actions might affect the external control and product market mechanisms, the most direct way in which the government affects governance is through the first two mechanisms.

Numerous laws and regulations at both the state and federal levels are designed to align the interests of shareholders and managers—that is, to protect shareholders. For example, although a board of directors has many protections from shareholder lawsuits, the board may be vulnerable to shareholder derivative lawsuits if there is a serious conflict of interest or if they did not take due care in arriving at a decision that has a major effect on corporate performance. The standards for such lawsuits are very high, however, and it might take gross negligence or willfully ignoring signs of mismanagement, for example, on the part of a board, to become personally liable for shareholder losses due to a catastrophic spill. Many of the laws and regulations dealing with internal controls refer to transparency and the provision of adequate information so that investors can properly estimate the firm's future profitability. Thus, if a board knew about a serious material risk to the firm (e.g., safety standards that were significantly below industry standards) and failed to inform investors, it could be in violation of securities laws.

The literature on internal controls has considered the makeup of the board of directors, executive compensation, and the role of large institutional investors. Managers are more likely to be aligned with shareholders when the board has a significant number of independent, or outside, directors (Denis 2001)—that is, directors who are not employees of the firm and do not have

personal or business ties to its managers. In well-designed governance structures, only outside directors can be members of the board's compensation and audit committees.

Traditional executive compensation schemes may reduce incentives for a strong safety culture. Past research has concluded that managers are more likely to act in shareholders' interests if doing so results in greater compensation. Managerial compensation generally includes a significant performance-based component, which often depend on short-term profit goals. Even though a top manager might lose his or her job in the event of a catastrophic spill, the downside risk is generally not very large relative to the upside potential for significant earnings based on short-term profitability. Attempts have been made to increase the time period over which stock options are granted and/or vested in order to lengthen the time horizon of top managers. However, there is general agreement that the board of directors has an important role in monitoring the long-term strategic focus of managers to ensure that their incentives are aligned better with the interests of shareholders. Thus, for example, it is thought that firms with board-level environment or safety committees and managerial compensation tied to observable measures of environmental protection or safety culture may exhibit stronger environmental performance or safety culture.[9]

Empirical evidence suggests that corporate crime is more likely to be committed by firms whose managers and shareholders are not fully aligned (Alexander and Cohen 1999) and—especially for environmental crimes—by firms that are relatively weak financially (Alexander and Cohen 1996). Similar findings come from Kassinis and Vafeas (2001), who report that corporate boards can be an important factor in determining corporate environmental performance. Findings like these might help target government monitoring and enforcement efforts—focusing them on firms that are at highest risk of a catastrophic spill. They might also be another justification for financial responsibility requirements (see Section 4): firms that are relatively weak are not only less able to cover the costs of a spill, they are also more likely to have spills.

The government does not often take a direct role in specifying internal controls, but laws such as Sarbanes-Oxley require disclosure of internal controls and any factors that might prevent the firm from accurately reporting financial results. It appears that Sarbanes-Oxley had a positive

[9] The empirical evidence on this, however, has not yet been fully established. For example, Berrone and Gomez-Mejia (2009) failed to find such an association in their study of 469 U.S. firms.

effect on firms that had previously been below industry standards for shareholder disclosures, suggesting that such requirements might give shareholders information not otherwise disclosed by top management. For example, Chhaochharia and Grinstein (2007) found that firms not already in compliance with Sarbanes-Oxley requirements saw their value rise relative to competitors that were already in or near compliance when the law was passed. They suggest that the market expected the law to improve the performance of those firms. They also state, however, that this trend did not hold true for smaller firms, which implies that some provisions of Sarbanes-Oxley will be detrimental to small firms—and in fact, there is some evidence that firms have been reluctant to go public because of the cost of complying with Sarbanes-Oxley.

What is the evidence that shareholders care more than managers about safety and reducing the risk of a catastrophic spill? That corporate offenders are less likely to have managers aligned with shareholders (Alexander and Cohen 1999) is one piece of evidence: if crime "paid" for shareholders, we would likely see more offenses in firms whose top management was closely aligned with shareholders. Why would shareholders accept this higher risk from some firms? One reason might simply be lack of information—and indeed, in the case of deepwater drilling, investors are unlikely to know more about the risks of a catastrophic spill than either government or industry experts. Of course, the corollary is that now that the risks are better known, investors will take this into account. However, this still assumes that investors have adequate information about the relative risks of each firm in the industry. Nonfinancial rating firms do provide some of this information to investors, with analyses that focus on nonfinancial risks and opportunities. We previously mentioned one example, RiskMetrics, whose analysts had closely followed safety culture at BP and other oil and gas companies. Such information, especially with respect to drilling safety culture, may now be followed more carefully by mainstream investors.

3.4 Conflicts of Interest between Firm and Subcontractor

Public discussion about the relative liability of BP and its subcontractors raises the question of whether incentives are properly aligned between the firm (lease operator) and the subcontractors (such as the drilling contractor). For example, BP may have had stronger safety culture incentives than the drilling subcontractor because BP was more concerned about consumer backlash in its product markets (see Section 3.1). On the other hand, if the subcontractor has more workers on the rig than does the lease operator, the subcontractor may have stronger safety culture incentives. In either case, misaligned incentives could cause investment in safety culture that from the public's perspective is insufficient. This concern

motivates recent proposals for the government to mandate interfacing documents and safety and environmental management systems (see Section 4.3).

Although the literature does not provide clear evidence of conflicts of interest between lease operators and subcontractors in deepwater drilling, this may not be a significant problem in practice. First, if the lease operator has a much stronger incentive for safety culture than the subcontractor, the operator could actively monitor; if monitoring proves too expensive, the firm could undertake the activity itself. Note that this is more likely for larger firms, which might find it less costly to perform more of the drilling-related tasks in-house.

Second, liability law makes it unlikely for incentives to become significantly misaligned. As discussed further in the next section, the operator is liable for the costs of the spill, but it can sue the subcontractors to recover at least some of those costs. The liability regime does not imply that the incentives of the two firms are perfectly aligned, because the firm would have to establish that the subcontractor was negligent, which may prove difficult in practice. Nonetheless, the subcontractor faces potential lawsuits if it causes an accident by underinvesting in safety culture.

Reputational effects may play an important role in keeping incentives aligned. The operator may observe the subcontractor's safety culture directly from interacting repeatedly on different well operations (Corts and Singh, 2004). The operator could rely upon its own experience or industry-wide reputation to choose subcontractors. Furthermore, reputation and repeated interactions could create strong safety culture incentives at subcontractors, because the firm would lose future business if it contributes to an accident.

4. Analysis of Policies That Affect Safety Culture

Sections 4.1–4.5 discuss the effects on safety culture of five government policies: liability, financial responsibility, mandatory insurance, government oversight, and risk-based drilling fees. Section 4.6 discusses interactions between the policies, Section 4.7 summarizes the main features of these policies, and Section 4.8 lists the main findings from the preceding discussion. Our policy recommendations are reserved for Section 5.

The following discussion focuses on the effect of the policies on safety culture. We do not consider the broader policy question of whether to allow drilling at all and instead assume that decision has already been made. Also, we do not consider compensation issues related to liability. Setting a liability cap below worst-case social damages means that either victims of a

spill will not be compensated or the public will pay via higher taxes (Krupnick et al. 2011). This is a central issue to oil spill policy, but it is beyond the scope of this paper.

4.1 Liability

While damage to equipment and loss of valuable hydrocarbons are costs of spills borne by firms themselves, whether the associated environmental and economic costs are also borne by firms depends on the legal regime. An important method by which firms are made to internalize the environmental and economic costs associated with a spill—and therefore are given incentives to invest in preventing or reducing damages—is tort liability. In the event of a spill, public and private claimants can sue firms that spill ("responsible parties") and seek recovery of economic or natural resources damages. These suits may sometimes be brought under (common) tort law or under federal or state statutes. In addition to litigation to recover damages, state and federal government agencies might bring administrative, civil or criminal charges against a responsible party and seek to impose a fine or other nonmonetary sanction (such as debarment or probation).

The possibility of such legal actions creates an incentive for a responsible party to adopt a stronger safety culture to reduce the probability and severity of a spill. The greater is the liability exposure, the greater the extent to which firms internalize costs, and the greater the incentive for a strong safety culture. Section 2.2 concluded that policies should be calibrated to internalize the social cost of a spill. Therefore, for the purpose of promoting the socially desirable level of safety culture, a firm's potential liability under the law should be equal to the expected social harm of the worst-case spill (see finding 1, in Section 4.6). We note that liability includes administrative, civil and criminal sanctions.[10]

In practice, three factors limit the amount a responsible party would pay after a spill, which limits the safety culture incentive that liability creates. The first is that legal costs may prevent some of the harmed individuals from suing. The Oil Pollution Act of 1990 (OPA 90)[11] is

[10] The firm's total liability should not exceed the expected social harm as this could induce more than the socially optimal level of safety culture resulting in firms taking costly precautions beyond what society deems appropriate See Cohen (1987) for an analysis of the optimal government penalty for preventing oil spills. While this penalty is generally higher than the social harm as it must take into account the probability of detection, in the case of a catastrophic spill where detection is certain, the penalty should just equal the social harm. From an efficiency standpoint, this analysis is no different under criminal law – although other goals such as punishment or incapacitation might come into play under criminal law; see Cohen (1999).

[11] 33 U.S.C. §2701 et seq.

the primary statute governing liability for spills, although it explicitly does not preempt state law (or other federal laws).[12] As a result, plaintiffs can file suits seeking recovery of spill damages either in federal district court under OPA 90 or in state court under either common law or applicable state statutory law.[13] However, petroleum exploration, production, and transportation are complex industries, with a large number of firms, complex contractual relationships, and advanced technology understood only by experts. These factors can make litigation over damages claims very complex and costly.

To reduce this complexity, oil spill liability law generally uses *channeling* and *strict liability*.[14] Both mechanisms have strong foundations in the economic theory of enforcement literature (see, e.g., Cohen 1999).

Channeling is the identification, before litigation, of a particular party that will be the defendant in an action to recover spill-related damages. Since drilling operations typically involve several partners and contractors, it might be difficult in the absence of channeling provisions to identify which party to sue in the event of a spill. OPA 90 makes the holder of the drilling permit the responsible party for spills from offshore platforms.

In addition to simplifying litigation, channeling creates incentives for a responsible party to select and monitor partners and subcontractors with care, since it is ultimately responsible for damage claims. Channeling does not prevent the responsible party from recovering damages from other parties, such as lease partners or contractors.

Strict liability plays an important role in reducing legal costs. In suits seeking compensation for spill-related damages under OPA 90 and some state statutes, plaintiffs need not show that the defendant was negligent. Plaintiffs must show that they suffered some damage (economic damage, physical injury, or natural resources damage) and that this damage was caused by a spill by the responsible party. Whether that firm is "at fault" or took care to prevent

[12] Because of this nonpreemption clause, OPA 90 sets a liability floor, not a ceiling. States can deviate upward but not downward: they can implement higher liability caps (or none at all) or higher financial responsibility requirements, but cannot go lower.

[13] The reasons why a plaintiff might choose one venue over another are complex and largely beyond the scope of this analysis, but they include recovery beyond the liability limits in OPA 90 and access to the channeling and strict liability provisions of federal law (discussed below).

[14] OPA 90 and some state laws, such as Louisiana's Oil Spill Prevention and Response Act, feature channeling and strict liability provisions, but these features are not available in state common law actions.

the spill is not relevant. Strict liability therefore has the advantage of greatly simplifying litigation and the cost to the government in particular. Generally speaking, legal scholars argue that strict liability is appropriate where it is easy to identify in advance which party can most readily avoid damages[15]; in the case of spills, this is almost certainly the responsible party.[16]

Together, channeling and strict liability can simplify spill-related litigation and reduce legal costs. This increases firms' expected liability as reduced costs for plaintiffs make more suits possible and influence their settlement terms. Litigation ensuing from large spills remains highly complex, however, in part because of the number of victims (and therefore plaintiffs). Class-action lawsuits reduce the cost of litigation but are still very expensive and may take a long time. This complexity and the associated costs and burden on the judicial system have driven efforts, such as the $20 billion Gulf Coast Claims Facility, to satisfy damages claims without litigation. In addition, litigation under state common law does not benefit from either channeling or strict liability; plaintiffs must name a defendant and, generally, show negligence in order to recover.

Besides legal costs, there is a second limitation to a responsible party's expected liability: statutory liability caps. For example, for offshore facilities like *Deepwater Horizon*, OPA 90 imposes a liability cap for spill damages at $75 million. OPA also limits liability in the case of natural disaster, war, or certain actions taken by third parties.[17]

OPA 90's liability caps are not as firm in practice as a cursory reading of the statute would indicate, however (Richardson 2010). First, they are qualified by the statute itself: OPA 90 caps do not apply to cleanup costs and are waived in cases of gross negligence or a violation of applicable regulations.[18] The latter exception seems quite broad; many spills are likely to involve some violation, and if a violation, no matter how trivial, is discovered, the cap is removed.

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[15] See, for example, Gilles (1992). Farnsworth (2007) has an excellent discussion of this issue for the general reader.

[16] Strict liability also creates incentives to search for better safety technologies than a negligence standard because a negligence standard would only impose penalties if current standards of care are not adopted. On the other hand, if under strict liability the potential penalty from a large spill is so great that a small firm would declare bankruptcy, strict liability might cause such a firm to take *less* care than under a negligence standard. See Shavell (1980); Cohen (1987, 1992,2010). As we discuss in section 4.2, sufficient financial responsibility requirements should prevent this from occurring.

[17] OPA 90, 33 U.S.C. §2703(a).

[18] OPA 90, 33 U.S.C. §2704(c).

Second, OPA 90 does not preempt state or other federal law.[19] Table 1 summarizes state laws regarding oil spill liability. To the extent that these laws do not include damages caps, a case brought under them (or under common law) is not subject to OPA 90 caps. In the Gulf of Mexico, Florida, Mississippi, Alabama, and Texas either do not have specific statutes governing oil spill liability, or their statutes do not set caps on liability. However, suits to recover spill damages in these states' courts may not benefit from the channeling and strict liability provisions available under federal law, making litigation more costly and recovery more difficult. Plaintiffs therefore face a difficult choice.

Table 1. Major Provisions of State Oil Spill Liability Laws in the Gulf of Mexico[20]

	Liability for spill damages		
State	*Strict*	*Cap*	*Notes*
Florida	Y	N	Removal costs capped by statute; damages not capped
Alabama	N	N	Common law negligence regime
Mississip	N	N	Strict liability for removal costs, negligence regime for damages
Louisiana	Y	Y	Cap at same level as OPA 90
Texas	Y	N	

Drilling firms' exposure to damages liability to private plaintiffs[21] is much greater under most states' laws than it is under OPA 90. In fact, two states—Texas and Florida—allow uncapped strict liability for spill damages. Louisiana does, however, cap liability. The Louisiana Oil Spill Prevention and Response Act[22] mirrors OPA 90 in many respects, including its liability caps. As a result, damages to Louisiana residents and Louisiana natural resources *are* subject to the liability caps in the two statutes. Private plaintiffs will find it difficult or impossible to evade the effect of the caps. To do so, they may have to show gross negligence or a regulatory violation. Because so many drilling operations take place near Louisiana, the state's cap may significantly lower the costs a responsible party would pay after a spill.

[19] Ibid. at §2718(a).

[20] See Louisiana Oil Spill Prevention and Response Act, La. Rev. Stat. 30:2451 et seq.; Waldron (2010).

[21] Despite the OPA 90 damages caps, the federal government can recover damages and cleanup costs from responsible parties via a variety of other legal methods, including suit under other statutes, civil penalties, or settlement under threat of criminal prosecution.

[22] La. Rev. Stat. 30:2451 et seq.

Outside Louisiana, OPA 90 caps are not binding. Besides the possibility of lawsuits in state courts, the government can use the threat of criminal or civil penalties to compel a settlement regardless of OPA 90 caps, a legal strategy used in the *Exxon Valdez* spill. BP's decision to fund claims for compensation of victims, in lieu of litigation, up to levels far beyond the OPA 90 cap suggests that the firm believes the cap would not significantly limit its liability, though this move may also be influenced by political and public relations considerations (see Section 3.1).

On the other hand, liability caps do affect where plaintiffs sue and may block plaintiffs' access to the favorable strict liability and channeling provisions available in an OPA 90 suit. In states like Louisiana, where common law actions for spill damages are replaced by state statutes with their own damages caps, recovery by private plaintiffs beyond the caps may be difficult or impossible. Liability caps may also restrict avenues available to plaintiffs and/or raise litigation costs, reducing the number of cases firms must defend and the amounts they must pay in settlements. Some types of damages may also be recoverable only under federal maritime law (as modified by OPA 90), and not under state law. Drilling firms' liability exposure from these kinds of claims would be firmly limited by the OPA 90 cap.

We conclude that although the federal liability cap is far below worst-case damages from drilling in the Gulf of Mexico, the liability caps in OPA 90 are not generally binding because of other provisions in state and federal law. However, the caps do likely reduce the aggregate expected damages payments from a spill to some degree (unless they are waived, as BP has said it has done), with corresponding effects on safety incentives (see finding 2).

The third limitation of liability is that the public may not be able to recover the full social cost of the spill. Certain types of lawsuits are precluded due to the difficulty of establishing proximate cause, for example, recovering public health costs or payment for mental anguish to economic victims of a spill. In the case of the Gulf Coast Claims Facility, claims are limited to certain economic costs. Therefore, firms do not appear to fully internalize social costs when choosing safety culture; we note that this would be the case even if liability caps were removed entirely as this limitation is inherent in the tort liability system itself, not in liability caps or any specific policy (see Krupnick et al. 2011).

4.2 Financial Responsibility

Up to this point, we have assumed that responsible parties pay any damages awards made by courts, and that exposure to the full risk of liability will influence safety decisions. But in

reality, firms' resources are not unlimited. The ability to declare bankruptcy limits a firm's exposure to risk. Specifically, a responsible party that is too small to adequately compensate victims of a worst-case spill lacks incentives to make sufficient investments in safety: there is no reason to prevent spills that cause damages that exceed its ability to pay. The remaining costs of the spill would then fall on spill victims or the public at large. In fact, this consideration suggests that firms have an incentive to be small, to avoid the costs that a larger firm would incur by adopting a stronger safety culture. This problem—in legal terms, that of the judgment-proof tortfeasor—is not unique to oil spills, but it is particularly salient given their large costs. Thus the possibility of bankruptcy implies that, in the absence of insurance, liability from a spill creates an incentive for safety culture that is limited by the value of the firm's assets (see finding 3).

A partial solution to this problem is requiring a demonstration of financial responsibility (FR) (Boyd 2001). The basic idea is simple: to engage in activities that expose outside parties to risks, a firm must demonstrate that it has sufficient resources—either its own (self-insurance) or third-party insurance coverage—to compensate those parties in the event of an accident.

OPA 90 establishes FR for petroleum firms. For offshore facilities, the statute requires that firms make a $35 million demonstration, subject to increase by the President up to a maximum of $150 million.[23] Regulations of the Minerals Management Service (MMS, now the Bureau of Ocean Energy Management, Regulation and Enforcement, BOEMRE) include guidelines for the level of FR necessary, based on the estimated worst-case discharge from offshore facilities. The highest level of FR demonstration—the statutory maximum of $150 million—is required for facilities whose worst-case discharge volume exceeds 105,000 barrels.[24] A firm's FR demonstration is equal to the highest level required by any one of its wells.[25]

In principle, the FR requirement for a given activity should be sufficiently high to cover the costs of the worst-case spill associated with that activity. If requirements are lower, the judgment-proof spiller problem is mitigated but not eliminated. Offshore drilling firms capable of demonstrating only $35 million to $150 million of FR are unable to cover damages associated

[23] 40 U.S.C. §2716(c). Note that firms with more than one facility need show financial responsibility for only the facility with the highest requirement. A firm with 10 offshore drilling platforms, for example, must demonstrate only $35 million, not $350 million.

[24] See U.S. Department of Interior, Minerals Management Service, *Oil Spill Financial Responsibility for Offshore Facilities*, 63 FR 42714.

[25] Ibid.

with spills that exceed these levels. These firms therefore lack liability-driven incentives to invest in preventing such spills. Limiting FR in OPA 90 to $35 million to $150 million is broadly consistent with capping liability at $75 million, however.[26]

But, as discussed above, the actual liability for a firm drilling in the Gulf of Mexico is potentially far greater than the liability cap in OPA 90. The result is that current FR requirements are far lower than both the expected damages associated with a worst-case spill and the expected *liability* associated with such a spill. In this sense, it is fortunate that BP and not a smaller firm was the responsible party for the *Deepwater Horizon* spill.[27] Many smaller drilling firms would have been unable to cover the multibillion-dollar liability and would have gone bankrupt. Such firms would therefore have had reduced *ex ante* incentives to prevent large spills and would have left victims uncompensated if such a spill did occur—exactly the problems that FR requirements would avoid if they were set at the appropriate level (see finding 4).

Firms too small to meet the FR requirement are not permitted to drill. Consequently, an increase in FR requirements could result in greater market share for major oil companies if smaller firms exit because they cannot demonstrate FR directly or because they cannot remain profitable while paying premiums for insurance that would do so. For example, 16 of the 32 firms drilling in deep water in the Gulf of Mexico in 2009 had market values below $30 billion (Muehlenbachs et al. 2011), which is likely to be the low end of the external costs of the *Deepwater Horizon* spill. The resulting decrease in competition could lead to (slightly) higher prices in oil markets and lower licensing fees. We view this cost as unlikely to be as great as the cost to society of the risk that a small firm causes a spill whose damages far exceed the value of the firm's assets, but a conclusive answer is not possible without empirical study (see finding 5).

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[26] For vessels over 300 tons, OPA 90 links financial responsibility requirements to liability caps (40 U.S.C. §2716(a)). It is not clear why the statute does not do so for offshore facilities. Because the liability cap for such facilities is fixed at $75 million but the financial responsibility requirement can be anywhere in the $35 million to 150 million range, the requirements could be insufficient. The default $35 million cap seems especially problematic: it fails to deal with the problem that FR is designed to address. A firm with, say, the means to cover $50 million in damages would be permitted to operate a facility but unable to cover even capped liability. If financial responsibility were raised to $150 million, firms would have to demonstrate double what they would have to pay based on the cap; this is probably good for the public, however, because firms are very likely to have liabilities beyond the cap.

[27] Note, however, that two other firms—Anadarko and MOEX—are part owners, and therefore co-responsible parties, in the Macondo well. These firms have not waived liability caps, but they are significantly smaller than BP. It is as yet unclear whether their lack of resources will ultimately limit recovery.

4.3 Government Oversight

This section and the next discuss government oversight and mandatory insurance. There are two important differences between these policies and liability. First, both include third-party monitoring prior to a spill. Second, whereas liability affects safety culture by imposing costs on a firm after a spill, these policies affect safety culture by affecting costs before a spill.

4.3.1 Monitoring

There are several reasons monitoring could be desirable. First, if the results of monitoring are made public, monitoring could increase information available to stock market investors, who in turn could place greater pressure on firms to adopt stronger safety cultures (see Section 3.3).

Second, information disclosed in monitoring could inform regulators and the public about the efficacy of a policy regime, prior to a spill. Because major spills are so rare, it is not possible to evaluate policies aimed at reducing risk of a major spill by observing their effect on the probability or severity of a spill. This consideration is particularly important because even if liability and FR requirements cause social costs to be internalized fully, firms may not adopt the socially optimal level of safety culture because of agency problems within the firm (see Section 3). Monitoring and disclosure could reveal whether this is occurring.

The third benefit of monitoring is that a qualified third-party monitor could be an important check on industry practices. Industry might go many years without another major spill, in which case complacency could lead to a gradual weakening of safety culture. Third-party monitors could make this less likely. Note that these benefits pertain to both government oversight and insurance, but there are important differences that are discussed below.

4.3.2 Safety and Environmental Management Systems

Government oversight can take many forms. The distinction between prescriptive- and performance-based regulation is discussed in Scarlett et al. (2011). We define stronger regulatory oversight as more intense monitoring combined with the threat of civil fines or criminal prosecution, which should lead to additional precautions and a lower *ex ante* expected probability of catastrophe.

Stronger oversight has direct and indirect effects on safety culture. Via fines or prosecution, it directly raises the cost of failing to adopt a strong safety culture. Indirectly, if government discloses results of its monitoring, investors could learn about the company's weak efforts and exert pressure.

One example of a government oversight policy that could directly affect safety culture is a safety and environmental management system (SEMS). In October 2010, BOEMRE issued a rule that requires firms to use a SEMS. The SEMS required by BOEMRE is the same as the recommended practice of the American Petroleum Institute, API RP 75. Many firms operating in the Gulf of Mexico, including BP, already use SEMS or something similar to it.

As specified in the regulation, a SEMS contains 12 features, many of them discussed in Section 2; they include management of change, training, investigation of incidents, and auditing safety and environmental management programs. Although agreement among safety experts is not perfect, we consider a firm's adoption of a SEMS as indicating an increase in safety culture.

We do not evaluate the effect of a SEMS on the risk of a major accident and assume that, when properly adopted, it reduces the probability or severity. Instead, we focus on the effect on safety culture of a *government-mandated* SEMS. Prior to the regulation some firms may not have used a SEMS because of a lack of information or insufficient incentives; we discuss both possibilities in turn. Some firms may not have known how to implement a SEMS or about the benefits of the approach. We do not consider this relevant to drilling in the Gulf of Mexico, however, particularly for large firms that operate in other regions of the world, such as Norway and the United Kingdom, where a SEMS (or an equivalent) is required. Lack of information could be an issue for smaller firms, but we do not have evidence in either direction.

We distinguish between government-mandated SEMS and the actual adoption of SEMS and a stronger safety culture. In theory, a firm could comply with a government-mandated SEMS on paper without significantly changing its safety culture, particularly if the legal requirements of a SEMS are vague.

Thus, requiring a SEMS could cause firms to adopt a stronger safety culture, but not necessarily. Consider a simple model of a SEMS that costs c to adopt. The benefit, b, of the SEMS is a lower expected cost of a catastrophe, which depends on the liability cap and other factors. Before *Deepwater Horizon*, as firms weighed costs and benefits, some firms presumably decided that the costs outweighed the benefits and did not adopt a SEMS. Post *Deepwater Horizon*, with a government-mandated SEMS, the firm can choose to adopt a stronger safety culture or it can pay a cost, f, to satisfy the regulatory requirements. In other words, it is possible to fool the government into thinking that the firm has adopted a SEMS. But stronger government oversight raises f because it is more difficult to satisfy the SEMS requirements without adopting a safety culture. Examples of stronger oversight include hiring better-trained monitors, using third-party monitors, or adopting more specific requirements for the SEMS. Therefore, the

change in safety culture depends on *b, c,* and *f*: if $b > c + f$, the firm adopts a stronger safety culture. Mandating SEMS could have no effect on safety culture if *f* is relatively small, but stronger government oversight of the SEMS would raise the likelihood that the firm adopts a stronger safety culture. Thus, changes in government oversight beyond mandating a SEMS are necessary; specifically, the benefit of adopting the SEMS must exceed the cost of evading it (see finding 6).

4.4 Mandatory Insurance

Currently, there is no insurance requirement under OPA 90: insurance is one means of satisfying the FR requirement but is not required. Many large drilling firms self-insure through captive insurers. In principle, the FR requirement could be replaced by mandating third-party insurance.

Although proof of FR may serve a similar role as insurance in ensuring that victims are compensated, neither by itself may provide adequate incentives for firms to take the socially desirable level of safety culture. First, as we have discussed, principal-agency problems within the firm might reduce the internal incentives for individuals within the firm to act in the firm's best interest. Second, the fact that a firm has purchased insurance creates a new problem: the firm has an incentive to shirk because it is now financially covered in the case of an oil spill. To overcome this moral hazard problem, insurers might institute risk-based pricing so that firms with identifiably higher risk exposures pay higher rates (creating an incentive to reduce risk). Numerous other mechanisms are available, including coinsurance, deductibles, and direct monitoring of firm behavior. The level of monitoring and the overall effect of insurance on safety culture depends on the liability cap, as discussed in Section 4.6. Third-party monitoring thus constitutes an additional benefit of requiring insurance, which should be compared to government monitoring.

4.4.1 Comparison of Government and Insurance Monitoring

As with government oversight, a third-party insurance monitor can assist in overcoming some of the principal-agency conflicts inherent in the owner-manager relationship. Third-party monitoring by insurance companies may be redundant if government monitoring and enforcement are effective.

For two reasons, however, third-party insurance can provide a mechanism for monitoring beyond that of the government or the firm itself. First, because of government's lower pay scales, the private insurance industry could attract better-qualified monitors. Second, exposure to

liability creates a strong incentive for the insurance company to monitor well, which is not present with government monitoring. There is evidence that the insurance industry does play this role in the oil drilling industry (Booz Allen and Hamilton 2010), and that government monitoring efforts have been less than adequate. For example, Scarlett et al. (2011) note that MMS's budget limitations and low pay scales compromised effective oversight. They also cite MMS's own admission that despite inspection and enforcement efforts, it "could find no discernible improvements in safety performance trends" and had "limited methods to verify and document industry compliance with the regulatory performance standards."

On the other hand, if the liability caps are low, this monitoring incentive may not be very strong for private insurance. An additional advantage of government monitoring is that the results of the monitoring can be made public, which may be more difficult to require in a private insurance regime.

Whether the government or the insurance industry ultimately is a more effective monitor of drilling activity is an empirical question that is beyond the scope of our analysis. The former depends on vigilant government enforcement; the latter relies upon market forces, which should be adequate if the potential liability is sufficiently high. Whichever approach is ultimately chosen, it is clear that unless the government significantly increases its own oversight capacity and monitoring activities, a requirement for third-party insurance is likely to result in more effective monitoring than government oversight.

4.4.2 Potential Challenges to Mandating Private Insurance

There are two reasons why a third-party insurance requirement might not work. First, monitoring is expensive, and it is difficult to observe a firm's efforts to reduce the risk of a spill. The cost of monitoring could be too high for both insurance companies and drilling companies to remain profitable.

The second reason why requiring third-party insurance might not be a viable solution is that insurance markets may be unable to raise adequate capital to insure against the potential liability. Indeed, we note that the industry argued this point in congressional hearings shortly after the *Deepwater Horizon* spill, when Congress was considering raising the liability cap. Robert Hartwig of the Insurance Information Institute testified on June 9, 2010, that it would be impossible for energy insurers or reinsurers to raise $10 billion of coverage. He cited several reasons, including the difficulty of underwriting for unlikely, but extremely severe events that are difficult to predict. Nevertheless, the insurance industry has a history of adapting to new liability caps and attracting the necessary capital to provide a market where demand exists.

Current industry concerns that increasing liability exposure will make firms uninsurable seem unfounded based on prior experience[28] and on a recent proposal by Munich Re to provide insurance of $10 billion to $20 billion on a rig-by-rig basis (just three months after the industry testified it would impossible to insure at that level).[29] However, we note that the levels of insurance that would be required for deepwater drilling under our recommended liability cap and financial responsibility requirements are likely to exceed even this amount; further study of this issue is warranted.

4.5 Risk-Based Fees

The central economic problem regarding safety is that managers (and perhaps shareholders) may not choose the socially desirable level of safety culture because its social benefit is not fully internalized. Raising the liability cap and FR requirement would help, but as noted above, there may still be damages that are not recoverable.

An insurance pool, currently under consideration as a means of preventing small firms from exiting under mandatory insurance, could actually exacerbate the problem (Bergin 2010). Suppose, as in some proposals, that an insurance pool is constructed in which a firm pays a premium in proportion to the number of wells it has. This premium structure creates a classic moral hazard problem in which, compared with the status quo, there is a stronger incentive to (1) adopt a weaker safety culture and (2) drill wells that the firm knows, *ex ante,* are riskier.

Another way to raise the benefit of adopting a strong safety culture would simultaneously address the perverse incentives created by an insurance pool. Imposing *risk-based drilling fees* would reduce the profits of a firm that does not have a strong safety culture. A regulator, insurance company, or industry organization would rate the level of safety at each well. Under an insurance pool, the responsible party would pay a premium that is proportional to the number of wells and the safety score at each operation. The premium could depend on the subcontractors, which would encourage the operators to employ subcontractors that also have strong safety cultures. This would resolve potential conflicts of interest between firm and subcontractor (Section 3.4).

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[28] Boyd (2001) provides evidence of similar unfounded concerns raised by the insurance industry during debates over OPA 1990 and CERCLA reauthorization.

[29] See Munich Re press release, September 12, 2010, http://www.munichre.com/en/media_relations/press_releases/2010/2010_09_12_press_release.aspx.

Three issues would have to be addressed in a scheme with risk-based fees: measurement, transparency, and reporting. Ideally, the fee would be based on the *ex ante* probability and severity of a spill from each well. Estimating this probability is no small task, and it would have to be studied intensively. At the outset, it seems reasonable to set the fee based on (1) the firm's past safety record; (2) observable characteristics of the well (depth, pressure, etc.); and (3) the adoption of certain safety culture policies (such as compensation schemes or promotion criteria that reward safety). The fee would be updated when more information is available—for example, using subsequent data on a firm's safety record to change the weighting of the components or add new components. Although estimating the *ex ante* probability of a spill is extremely difficult, the same problem arises with third-party insurance and government oversight. Thus, the risk measurement problem is not unique to using risk-based fees.

An important question is whether the results of the safety rating would be made public. This would provide some of the benefits of third-party monitoring. Concerns over releasing trade secrets would have to be addressed in that case.

Clearly, firms would have an incentive to misreport—for example, by hiding accidents. Again, this is not different from monitoring under mandatory third-party insurance or stronger government oversight (or if a firm links compensation to safety outcomes). One way to address this problem is to impose fines or jail time for misreporting. Alternatively, a firm could be given time to address any problems it reports. If the problem is addressed to the satisfaction of the regulator or auditor, the safety score would not change. This would remove at least some of the disincentive to report truthfully.

A final note regarding risk-based fees is that the approach could easily be used for other institutions, such as fees for drilling permits or for membership in the Marine Well Containment Corporation (MWCC). Rather than requiring large firms to pay a fixed fee to support MWCC, fees could be based on each firm's number of wells and the safety score at each.

In summary, we find that risk-based fees would increase the incentive for a stronger safety culture and could provide the benefits of monitoring. The approach could be used in combination other policies, including an insurance pool or MWCC (see finding 7).

4.6 Policy Interactions

Two interactions between policies must be considered. The first is the relationship between liability and FR, and the second is the relationship between liability and insurance.

4.6.1 Interaction between Liability and Financial Responsibility

Suppose that, for a given firm, there is a risk of, at most, one major spill (Section 5 discusses the implications of relaxing this assumption). If there were no possibility of bankruptcy, raising the liability cap would increase the firm's safety culture because it would increase the financial risk of a spill. However, as discussed above, if the value of a firm's assets is less than the liability cap, raising the cap would not affect its safety culture unless the FR requirement were simultaneously raised; the firm would have to acquire additional assets (or purchase insurance) to continue drilling.

Similarly, raising the FR requirement while maintaining the liability cap may not affect safety culture. Firms would have to hold more assets to drill, but the benefit of adopting a stronger safety culture would be unchanged because firms are not exposed to any additional risk (see finding 8).

4.6.2 Interaction between Liability and Mandatory Insurance

A mandatory insurance requirement complements liability in a similar manner as FR. If liability is capped and there is no FR requirement (or it is lower than the cap), small firms would have little incentive to adopt a strong safety culture because they could lose only the value of their assets. In this case, the incentive for safety culture could be increased by requiring firms to have insurance up to the liability cap. For larger firms (for which bankruptcy is less likely), the incentive for safety culture of raising the liability cap and requiring third-party insurance is more difficult to characterize. In principle, the moral hazard problem created by insurance could result in a weaker safety culture; further study of this question is warranted.

As Section 4.4 discusses, the insurance company would have to monitor to ensure that the firm's safety culture and other decisions did not expose the insurance company to excessive risk. This relationship between liability and insurance is really a special case of the relationship between liability and FR, since third-party insurance is one option available for firms to demonstrate FR—though, as described above, insurance can provide a monitoring function that FR alone cannot (see finding 9).

The level of monitoring depends on the liability cap and other factors, however. A low liability cap could provide only a small incentive for private insurance monitoring. We note that government monitoring is not linked to the liability cap in this way.

4.7 Summary of Policies

Table 2 summarizes the features of five policy changes that would increase safety culture incentives. The first column shows whether the policy affects a drilling firm's costs before or after a spill. The second column shows whether the policy reduces the likelihood that a firm declares bankruptcy without covering the full costs of the spill—if this is the case, the policy has a smaller effect on safety culture at small firms. The next column shows how the policy affects monitoring, followed by its potential to create a moral hazard problem. The final column notes the interactions with other policies. See the previous sections for explanations of each entry.

Table 2. Summary of Safety Culture Policies

	Does the policy ...				
Policy proposal	*affect firm's costs before or after spill?*	*prevent small firms from avoiding spill costs?*	*increase monitoring?*	*create moral hazard?*	*interact with other policies?*
Raise or eliminate liability caps	After	No	No	No	Yes (see finding 8 and 9)
Raise FR requirements		Yes	No	No	Yes (see finding 8)
Require third-party insurance	Before and after	Yes	Yes	Yes	Yes (see finding 9)
Implement more stringent government regulation	Before		Yes	No	
Introduce risk-based fees	Before		Yes	No	

4.8 Summary of Findings

The following list includes our findings on policy and safety culture:

1. Tort liability and OPA 90 require firms to pay for cleanup costs and economic and natural resource damages. When firms make decisions related to safety culture, their

cost benefit analysis for adopting a stronger safety culture should reflect the expected social harm from a spill.

2. Caps on spill liability in federal law are below worst-case damages from drilling in the Gulf of Mexico, although the liability caps in OPA 90 are not generally binding because of other provisions in state and federal law. Caps do limit firms' liability, directly for some types of damage, and indirectly by restricting avenues available to plaintiffs and raising plaintiffs' litigation costs, which reduces the number of cases firms must defend and the amounts they must pay in settlements.
3. Liability raises the benefit of adopting a strong safety culture, as long as the expected damages payout, plus other possible costs (e.g., legal costs), is no greater than the firm's assets.
4. Current FR requirements are well below expected damages from a worst-case spill and therefore are insufficient to prevent firms from engaging in activities whose risks they cannot bear. The safety incentives generated by liability for small firms are limited, in many cases dramatically.
5. Significant increases in liability caps and financial responsibility requirements may force some small firms out of the Gulf because they will be unable to afford liability insurance. Competition may decline, (slightly) raising oil prices and reducing lease fees. These effects are likely outweighed by small firms' failure to fully internalize social costs.
6. Without adequate monitoring and enforcement, firms may be able to satisfy the regulatory requirements without changing their safety culture. In that case, the adoption of a safety culture would depend not on the regulatory requirement, but rather on other policy and economic forces that affect safety culture.
7. Risk-based fees directly raise the benefit of adopting a strong safety culture and could be implemented in such a way that includes third-party monitoring.
8. Raising the liability cap without changing the financial responsibility requirement would not affect safety culture at a firm whose asset value is less than the cap. For such a firm, both the liability cap and the financial responsibility requirement would have to be raised to increase the incentive for a strong safety culture.

9. Increasing the liability cap and mandating insurance up to the new cap would increase the incentive for safety culture, similarly to jointly raising the liability cap and the financial responsibility requirement.
10. Mandatory third-party insurance (as opposed to self-insurance or the use of captive insurers) may be an effective substitute for government monitoring.

5. Policy Recommendations

5.1 Liability Caps

Capping liability for damages resulting from oil spills tempers drilling firms' incentives for strong safety culture (see finding 1, Section 4.8). Eliminating liability caps would force drilling firms to fully internalize the costs of drilling and fulfill the compensatory goals of liability policy.

Eliminating liability caps may not be politically feasible or consistent with other policies (e.g., a mandatory insurance requirement if markets are unable to insure against unlimited liability). But if we assume there will be a liability cap, then the level at which it is set remains an important policy choice. The current federal (OPA 90) liability cap is $75 million, a figure woefully out of proportion to the estimated $20 billion to $60 billion in third-party damages from the *Deepwater Horizon* spill. Given this new information about the possible size of an oil spill in the Gulf of Mexico, perhaps the simplest option is to raise liability caps to somewhere in this $20 billion to $60 billion range. This would treat the *Deepwater Horizon* spill as a worst-case scenario. Although administratively expedient, this approach has several problems.

First, it is not known whether the *Deepwater Horizon* spill is really a worst-case event. The industry says that advances in well containment and lessons learned make a similar spill unlikely or impossible, but this is little comfort: the industry apparently believed that a spill like *Deepwater Horizon* was impossible—until it happened. A new spill could occur under different conditions with different causes and could create even greater environmental and economic harm. There are, of course, physical limits to the plausible size of a spill, but there is little evidence that the *Deepwater Horizon* spill (and therefore the damages associated with it) reached those limits. In short, a liability cap based on *Deepwater Horizon* damages might be too *low* to give firms adequate safety incentives.

On the other hand, there is strong evidence that the Macondo well was particularly dangerous: it was a high-pressure well in deep water. The worst-case damages from other wells

might be far less. Setting a uniform cap based on the *Deepwater Horizon* damages would therefore provide little extra benefit[30] for less dangerous wells.

A one-size-fits-all cap calibrated to *Deepwater Horizon* damages, therefore, is likely to be a relatively poor solution. A more considered alternative is to set liability caps individually for each well. In each case, the cap would correspond to the estimated damages associated with a worst-case spill. Such an approach would generate the same incentives to invest in safety as unlimited liability (since firms would not invest beyond the level required to prevent or contain a worst case spill even if liability were unlimited). Furthermore, these incentives would be tailored to the conditions of a given well. For particularly dangerous wells, such as those in very deep water accessing high-pressure reservoirs, damages estimates might be even higher than the *Deepwater Horizon* damages. But for many wells—those in shallower water, for example—the cap would likely be much lower.

In practice, such a tailored damages cap could operate in a number of ways. Perhaps most simply, experts could determine criteria that contribute to risk, such as depth and reservoir pressure. At the extreme of simplicity, this might result in one cap for shallow-water operations and another for those in deep water.

A more finely tailored approach is possible, however. Firms already must make estimates of worst-case-discharge volumes, provide detailed response plans, and anticipate the environmental impacts of a spill as part of the BOEMRE permitting process. Key components of an expert estimate of damages from a worst-case spill are therefore already available. It should be possible to make such a calculation for each well and generate individual liability caps. It is worth noting that this approach is similar to the process a third-party insurer might use to determine the level of coverage available to a drilling firm (and the level of associated premiums). Whatever the source of the relevant information, tailored caps would maintain safety incentives and may be easier to implement than a uniform cap or eliminating the cap.

We note that the liability cap should include all payments to victims, compensation for natural resource damages, and any administrative, civil or criminal sanctions. A final caveat concerns civil and criminal sanctions. In practice, the public may not be able to fully recover social damages from the firm, for example, because of legal costs. Additional

[30] In terms of incentives to invest in safety, a liability cap beyond expected worst-case damages would still serve to compensate victims in the event that damages exceed estimates.

government policy intervention is justified in this case; increasing oversight or allowing criminal sanctions are two examples of policies that would address this consideration. On the other hand, if social damages are fully internalized from payments to victims, imposing additional sanctions could lead to over deterrence.[31]

5.2 Financial Responsibility

The same general arguments regarding the rationale for raising liability caps apply to FR requirements. If caps are eliminated, FR requirements should be raised to at least the level of expected worst-case damages from a spill. Lower FR requirements would expose the public to risk that a small firm that causes a large spill would declare bankruptcy to avoid paying the damages costs. If liability caps remain, FR requirements should be no lower than liability limits, for the same reason.

The links between liability caps and FR requirements superficially suggest that the two be equal. However, there are some grounds for suggesting that FR requirements be set *higher* than liability caps. First, some costs are excluded from the statutory caps on third-party liability. The most obvious excluded cost is spill removal, which is explicitly left uncapped in OPA 90. Also, penalties other than third-party liability are a prominent feature of U.S. law: the Clean Water Act provides for civil penalties, and criminal liability (including financial settlements made under threat of such liability) is a powerful tool available to federal and state governments seeking compensation for natural resources damages. A firm whose financial resources are exhausted by third-party damages would be unable to pay these costs, and a firm that expected to be constrained in this way would not take the additional precautions that these forms of liability would otherwise promote.

Second, OPA 90 currently requires only one demonstration of FR for any firm, regardless of the number of wells for which it is the responsible party. FR law therefore assumes that only one spill will affect a firm at any given time. Although the chances of simultaneous spills are low, they are not zero. Furthermore, a self-insuring firm's ability to compensate spill victims does not recover immediately after a spill. Therefore, a second spill, even if it occurs some time

[31] From an optimal deterrence standpoint, the total costs paid by the responsible party should equal the social damages caused by the spill. While over-deterrence is theoretically plausible, the evidence for under-deterrence discussed throughout the paper appears stronger, particularly in light of the findings in Krupnick et al. (2011) suggesting that externalities are not fully internalized under existing liability laws and standards of proof.

after the first, may still exceed a firm's ability to compensate. A FR requirement greater than that needed to cover a worst-case spill would provide a cushion for these costs. How much greater this level should be is a difficult question that depends on estimates of spill damage and removal costs, the likelihood of events that might cause multiple spills,[32] and the risk aversion of the public.

We therefore recommend that FR requirements be set at least as high as liability caps, with some consideration given to yet higher requirements.

5.3 Insurance

Firms drilling in deepwater should be required to purchase third-party insurance to cover all cleanup and containment costs as well as economic and natural resource damages. Similar to the FR requirement, the level of insurance should be at least as high as the liability cap, and probably greater. The recommendation that third-party insurance be required—as opposed to allowing self-insurance or captive insurance—is based on an assumption that government monitoring will not be stringent enough to ensure an adequate level of safety. If government monitoring is deemed adequate, allowing self-insurance or captive insurance might be appropriate. In addition, as we noted above, there is concern in the industry that capital markets will not be adequate to supply third-party insurance to cover a worst-case scenario. Thus, if no third-party insurance product is available, firms wishing to drill in deep water should be required to provide proof of FR to the government.

5.4 Risk-Based Fees

Risk-based fees provide direct incentives for safety culture and can also be designed to provide monitoring that increases the amount of information available to the public. Introducing an insurance pool without risk-based fees could create a significant moral hazard problem in which the insured firms undertake riskier projects than they would in the absence of insurance. Risk-based fees can be used in conjunction with certain other policies, including membership in the Marine Well Containment Corporation.

[32] Natural disasters and terrorism are examples. The former and (likely) the latter, however, are explicitly excluded from strict liability under OPA 90. If such an event were to cause multiple spills, firms would not be liable, and costs—at least under federal law—would be borne by the public.

5.5 Summary of Policy Recommendations

This paper has examined the role of government in ensuring safety culture at oil drilling firms. It presumes that society has already determined that under "good" safety practices, the benefits of deepwater drilling outweigh its risks. Liability laws can provide an economic incentive for firms to adopt and maintain a strong safety culture. Increased government regulation, monitoring, and enforcement can reduce the likelihood and magnitude of future spills, but we believe that this would be inadequate without significant changes to liability law, financial responsibility requirements, and insurance. Therefore, we provide recommendations on the policies that should be used, in addition to stronger government oversight.

All the policies discussed in Section 4 have a positive effect on safety culture. But that does not mean that they can be chosen independently of one another, as the discussion of policy interactions in Section 4.6 has demonstrated. Therefore, we provide several alternative sets of policies that would each have a significant effect on safety culture.

Our preferred approach is to raise the liability cap to the level of the social damages expected from the estimated worst-case discharge from a given well. Firms must already estimate such a worst-case discharge in the permitting process. This information, combined with expert damages analysis, would generate a risk-based damages cap for each well. In combination with setting the liability cap for each well equal to the worst-case social costs of a spill, firms drilling in deep water should be required to purchase third-party insurance to cover all cleanup and containment costs and all economic and natural resource damages arising from a spill. Third-party insurance not only ensures that victims will be compensated but has the added benefit of third-party monitoring in the absence of effective government enforcement capacity.

As discussed above, third-party insurance may not be feasible in such a liability regime. If third-party insurance is not feasible, firms wishing to drill in deep water should be required to provide proof of financial responsibility to the government at a level no smaller than the maximum liability of a firm's wells. Setting the requirement greater than this maximum would ensure that the firm can cover costs not included in the liability cap and the costs if a second major spill occurs.

Finally, we reiterate that risk-based drilling fees should be used as part of an insurance pool to reduce moral hazard. They could be used in other contexts as well, such as the Marine Well Containment Corporation, leasing, and permitting.

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