Evaluating the Applicability of Performance-Based Regulations to High-Hazard Industries

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1 Introduction

The National Academies of Science (NAS) has convened a board for discussing performance-based regulation (PBR) to manage risk in high-hazard industries, specifically the transportation of hazardous materials. The study is conducted for the Pipeline and Hazardous Materials Safety Administration (PHMSA), an agency under the Department of Transportation responsible for developing and enforcing regulations for pipeline and hazardous-materials transportation (e.g., oil, natural gas, and chemicals via pipelines, airplanes, rail lines, and vehicles). Its overall mission is to reduce the risk of deaths, injuries, environmental and property damage, and transportation disruptions (PHMSA, 2016a).

The current regulation of high-hazardous materials transportation relies primarily on prescriptive standards specifying exactly how the regulated entity must act (Coglianese, forthcoming: 4; Menzies, 2016). Presently, PHMSA is responsible for the oversight of more than 2.5 million miles of pipeline, the transportation of thousands of hazardous materials, and more than 3,000 operators of variable size and capacity (PHMSA, n.d.-b; PHMSA, n.d.-c). Since 1996, more than $7.6 billion in damages, 3,000 injuries, and 400 deaths have resulted from failures in pipelines or hazardous-materials transportation (PHMSA, n.d.-a; PHMSA, 2016b). Effective regulation is crucial because of the high economic, environmental, and social costs associated with noncompliance.

In 2003, PHMSA's Office of Pipeline Safety implemented a performance-based standard that required pipeline operators to develop integrity-management plans in high-consequence areas based on a guidance developed by the American Society of Mechanical Engineers (National Archives and Records Administration, 2003; American Society of Mechanical Engineers, 2004). In recent years, however, PHMSA has been scrutinized by Congress and has been the subject of an investigation by the U.S. Office of the Inspector General, both of which have criticized the efficacy of the agency's regulations and oversight procedures specifically with respect to its pipeline-safety program (Menzies, 2016; Office of the Inspector General, 2010). Consequently, the

NAS has initiated a review of the applicability of performance-based regulations to high-hazard industries.

Performance-based regulation (PBR) *"[…] specifies required outcome but leaves the means of achieving that outcome to the discretion of the regulated entity"* (Coglianese, forthcoming: 4). Proponents of PBR argue that it has the potential to increase performance and reduce costs of compliance by providing firms with flexibility in means of complying with the regulation and encouraging them to be innovative (Coglianese, forthcoming: 1; May, 2003: 388). Thus, PBR may result in greater effectiveness, on the part of the firm, in reaching specific regulation objectives.

Unfortunately, such claims and arguments are largely theoretical and lack systematic empirical evidence of their effectiveness under various regulatory settings, or how performance standards are developed and managed in practice (e.g., energy, building, banking, occupational health and safety) (Coglianese, forthcoming: 2; Coglianese, Nash, & Olmstead, 2003: 708). Several challenges have limited empirical evaluations of PBR, including a lack of clear terminology, sparse data, and significant costs to carrying out randomized experiments (Coglianese, forthcoming: 3). On this basis, the overall purpose of the NAS board is to "examine the advantages and disadvantages of performance-based safety regulation and identify constraints on U.S. regulators from pursuing this approach" (NAS, n.d.).

The purpose of this paper is to contribute to the work of the NAS board by offering theoretical and empirical insights on the following questions:

1. Under what conditions is a performance-based standard the appropriate regulatory instrument?
2. What particular challenges are expected to arise in implementing performance-based regulation?
3. What types of regulations are our peer (comparable) nations applying to the regulation of high-hazard industries?

2 Defining Performance-Based Regulation

Before summarizing what lessons can be learned from the published literature, we define the three types of regulatory instruments that are relevant to this analysis and discuss the conventional wisdom on their relative benefits and challenges. The three types are: 1. prescriptive regulations, 2. performance-based regulations, and 3. management-based regulations.

For prescriptive regulation, the regulator prescribes standards and the process to which the entity must adhere in order to meet the standard (Coglianese, forthcoming: 6). For example, under the United States' current regulations of the transportation of high-hazard materials, each material has specific standards for labeling, packing requirements, quantity limitations, and operational procedures that must be followed in order for operators to legally transport it (PHMSA, n.d.-d: 12). Prescriptive regulations are often criticized by firms for their rigidity and complexity, which some argue prohibits innovation (Coglianese, forthcoming: 6). As a result, their efficacy is thought to be undermined when applied to industries in which firms are heterogeneous, technology is rapidly changing, and tasks are uncertain (Gunningham, 2007: 5-7; Bennear, 2015: 11, 14; Coglianese, 2010: 166-170). Thus, the conventional wisdom is that prescriptive regulations may lead to suboptimal outcomes when applied to these industries (Coglianese, forthcoming: 6; Gilad, 2011: 423; Bennear, 2015: 11, 14; Coglianese, 2010: 166-170; Gunningham, 2007: 5-7).

In contrast, under PBR, regulators specify a standard for firms but do not require firms to follow specific procedures to meet the standard. According to May (2003: 387), *"[…] it is useful to consider performance-based approaches to regulation as a reaction to the perceptions of overly rigid rules and inflexible enforcement. […] critics argue that these regulatory shortcomings impose unnecessary burdens and limit innovation."* PBR, when compared to prescriptive regulations, may provide greater flexibility in means of regulatory compliance and encourages innovation, both of which can lead to greater effectiveness in reaching specific regulatory objectives (May, 2003: 388; OTA, 1995: 91, 195). There are potential drawbacks, however; (i) performance-based standards can be administratively expensive to set; (ii) PBR requires substantial analytical capacity to enforce, and (iii) PBR introduces uncertainty into social, environmental,

and economic outcomes because of complex technologies and uncertain causal relationships between standards and outcomes (May, 2003: 388; OTA, 1995: 89, 91).

Management-based regulation (MBR) is an additional alternative that "[...] neither explicitly imposes the means, nor the ends. Rather, what is required is that each regulated entity review its production processes and develop a set of goals and procedures that will [achieve the regulation objectives, red.]." (Bennear, 2007: 329). MBR is a broad regime that allows for substantial variation. It ranges from requirements of regulated entities to issue a policy statement on their strategies for achieving the regulatory goals to more sophisticated requirements that firms "engage in a review of their production processes, identify alternative production techniques or input mixes that would achieve the public goal, and evaluate the feasibility of these alternatives" (Bennear, 2007: 329). Typically, these management plans are subject to approval by the regulatory agency or a third-party auditor. Despite these conceptual distinctions, in practice, PBR and MBR are often conflated.

3 What Does the Theoretical Literature Suggest about the Appropriateness of Different Regulations to PHMSA's Operations

Prior research suggests that several characteristics of the activities regulated by PHMSA make prescriptive regulation an ineffective tool. For example, PHMSA's Office of Pipeline Safety is tasked with the oversight of more than 3,000 pipeline operators. As of 2014, approximately two-thirds of regulated pipeline operators in the United States operated less than 10 miles of pipeline, 16 percent operated between 10 and 100 miles of pipeline, and just under 13 percent operated more than 100 miles of pipeline (Stafford, 2014: 2). Furthermore, there is substantial variability in materials being transported, and the risks associated with transporting those materials can vary by location (Menzies, 2016; Bennear, 2015: 18). These facts speak to the heterogeneity of the regulated firms, as well as the heterogeneity in precautions required to ensure that their operations are safe (Bennear, 2015: 18). Finally, and perhaps most importantly, PHMSA's regulations aim to reduce risk to humans as well as the environment - an outcome that is not easily measured by government entities. Because each firm operates a unique system in a unique

environment, prescriptive regulations may require operators to engage in safety processes that are not appropriate for their circumstances (Bennear, 2015: 18). Therefore, MBR, which requires firms to engage in planning processes that identify risks and strategies to reduce risk (in the context of their unique environment), is touted as an effective alternative. The rationale is frequently cited in the published literature regarding high-hazard industries (Gunningham, 2007: 5-7; Grant, Moreira, & Henley, 2006: 3; Bennear, 2015: 14; Paterson, 2011: 2).

To date, few empirical analyses have evaluated the effectiveness of these regulatory approaches (Vectra Group Limited, 2003: 18, 53; Gunningham, 2007: 10; Bennear, 2015: 15-16). In our search for evidence on its use in a high-hazard industry resembling PHMSA, we discovered that regulations of offshore oil and gas drilling in United Kingdom, Australia, and Norway are the most heavily studied examples. That said, very little academic research has addressed the effectiveness of regulation, and only one peer-reviewed empirical analysis could be found; Stafford (2013). In addition, there is no consensus in the literature on the definition of performance-based regulation; academics frequently conflated performance-based regulation with management-based regulation (Grant, Moreira, & Henley, 2006: 1; Orth, 2011; Chinander, Kleindorfer, & Kunreuther, 1998). We characterize the previously mentioned UK, Australia, and Norway regulations as management-based because they require firms to engage in planning processes and to implement management practices that aim to achieve a specific outcome. In this case, the desired outcome is reduced risk of accidents (Coglianese, 2010: 160-166). The key characteristic differentiating MBR from PBR is compelling regulated entities to engage in planning toward a certain outcome rather than actually requiring attainment of a specific outcome (Coglianese, 2010: 160-166). Because this is the most robustly studied and closely-aligned example of the application of a non-prescriptive-based regulation to high-hazard industries, we chose to include this body of literature in our analysis.

4 Our Approach

Our knowledge of high-hazard industry and the specifics of its regulation is limited, and, therefore, we have been careful not to make any unwarranted assumptions about the behavior and interests of firms. While this limits us from specifying appropriate regulations, contracts, and performance measures, our contribution lies in summarizing the relevant, extant evidence on developing and managing PBR and MBR. We hope that the evidence presented and the considerations of this paper will provide the NAS board with relevant sources of literature and spur discussions concerning the consistency between theoretical arguments and practical experience from managing non-prescriptive regulation systems. We assume NAS members will have more direct knowledge of the regulated industries.

The merits of any regulatory regime depend on how its design and implementation interacts with the particular circumstances of the regulatory context. For example, May explains a crisis with performance-based standards in building regulation in New Zealand, as "the fault of the particulars of the regulatory regime that was employed more than it is the consequence of performance-based regulations per se" (May, 2003: 397). Therefore, rather than examining whether PBR or MBR is generally more efficient than current prescriptive regulation, we have sought to determine what can influence the appropriateness of these regulatory regimes and what PHMSA should take into account when developing and implementing regulation based on performance or management.

Evidence Used and Limitations to Generalizability

To address the research questions, we have reviewed academic literature from the fields of law, public administration, contract management, and performance management to identify theoretical arguments and assumptions concerning the advantages and disadvantages of prescriptive standards, MBR, and PBR, and conditions affecting the adequacy of these. To provide evidence of the theoretical claims, we have examined empirical studies of regulation of high-hazard industries, buildings, environmental management, and management of job training programs and

social welfare programs. Appendix B provides some notes on our search for and selection of relevant literature. Given the limited studies of high-hazard industries, we have been compelled to include studies from various policy fields. Such studies may seem distant from high-hazard industries, but they offer an empirical basis for understanding how governmental principals use performance metrics to monitor agents who provide complex public services. We assume that challenges with the implementation and management of performance measurement systems show a similar pattern across policy fields although their particular appearance and implications might differ.

Studies on job training and social welfare programs have benefited from the passage of the Government Performance Results Act (GPRA) of 1993 and its modernization under the Obama Administration in 2010 which requires state agencies to set goals, measure outcomes, and report outcomes to Congress (Moynihan & Kroll, 2015: 314). Agencies were directed to evaluate the effectiveness of programs - in place of simply measuring program outputs. Evaluating the causal effect of programs on achieving results is only feasible with good data. For this reason, we look to the literature on workforce training programs, specifically the Job Training and Partnership Act (JTPA) for which a national JTPA study (NJS) was undertaken to evaluate the provision of employment and training programs for economically disadvantaged adults. The study generated a longitudinal, micro-level dataset from which researchers can draw inferences not only on the effectiveness of the programs themselves, but also on the effects of using performance standards to achieve program goals (Heckman, Heinrich, & Smith, 2011: 3).

In contrast to the large-N quantitative approach in studies of job training programs, most studies of high-hazard industry, building, and environmental regulation have largely been intensive (qualitative and quantitative) analyses of a single case or a small number of cases. Such studies can aid in understanding causal relationships between principals and agents, but, regardless of case selection techniques, they cannot overcome "the inherent unreliability of generalizing from small-N samples" (Seawright & Gerring, 2008: 295). On the other hand, the regulators of these fields share a common goal of risk minimization as well as the challenges of heterogeneous

industries, complex production procedures, and changes in technology, all of which make these results relevant to the high-hazard industry.

5 Current Applications of Management-Based Regulation to High-Hazard Industry: The Cases of the UK, Norway, and Australia

This section describes applications and examples of management-based regulation in the UK, Norway and Australia, from which we will draw insights throughout the report. All three countries implemented a management-based regulatory regime in response to major accidents (Bennear, 2015: 9). For example, in July 1988, an explosion occurred off the UK's Continental Shelf (Grant, Moreira, & Henley, 2006: 4). The accident, henceforth referred to as the Piper Alpha, is the deadliest accident in the history of offshore oil and gas drilling, resulting in the death of 167 individuals (Bennear, 2015: 9). In response, the UK conducted an internal investigation of the incident and its regulations, yielding the Cullen Report (Bennear, 2015: 9). The report was highly critical of the prescriptive regulatory system in place at the time of Piper Alpha's occurrence (Grant, Moreira, & Henley, 2006: 4; Bennear, 2015: 9). Specifically, it argued that prescriptive regulations (i) imposed solutions instead of setting objectives and (ii) led to a "checklist" approach to safety inspection in which compliance with the rules was valued over overall safety - and, as a result, such regulations are an ineffective tool for promoting the safety of the entire operation (Bennear, 2015: 9; Grant, Moreira, & Henley, 2006: 4; Kaasen, 1991: 10). Critically, the Cullen Report made the case for an alternative to the current prescriptive regulatory approach; the resulting "Safety Case" approach was goal-oriented and intended to place the burden of proof on firms to demonstrate that they can operate safely (Bennear, 2015: 9; Grant, Moreira, & Henley, 2006: 5; Paterson, 2011: 5). Review, approval, and monitoring of Safety Cases was placed under the jurisdiction of the UK Health and Safety Executive (UKHSE).

Under the Safety Case regime, firms are required to produce a Safety Case for each offshore installation (Grant, Moreira, & Henley, 2006: 5). Within this Safety Case, firms must demonstrate that an "adequate" Safety Management System has been implemented and that potential risks and hazards have been identified and mitigated through the use of the "appropriate controls"

(Grant, Moreira, & Henley, 2006: 5; Bennear, 2015: 9-10; Paterson, 2011: 5). Specifically, firms must demonstrate that the risks associated with operation have been minimized such that they are "as low as reasonably practicable" (Grant, Moreira, & Henley, 2006: 6; Paterson, 2011: 6) by completing a quantitative risk assessment (Bennear, 2015: 9; Kaasen, 1991: 7; Grant, Moreira, & Henley, 2006: 8; Paterson, 2011: 5). Approval of the installation's Safety Case is required for operation, and the Safety Case must be updated every five years (Bennear, 2015: 10; Grant, Moreira, & Henley, 2006: 8). Inspections use the Safety Case to evaluate compliance instead of a 'checklist' imposed under the former prescriptive regulatory system (Bennear, 2015: 10). Operators can be subject to punitive measures if their operations are found to violate the Safety Case (Paterson, 2011: 6). As of 2005, all Safety Cases must include a summary of how the workforce on each installation has been involved in the development and revision of the Safety Case in order to ensure that all individuals working on the installation are familiar with the Safety Case (Paterson, 2011: 6-7). Finally, although the formal Safety Case is updated only every five years, the document is still intended to be continuously updated and improved as operations change over time (Bennear, 2015: 10).

In response to the Piper Alpha incident, Australia replaced most of its prescriptive regime with the Safety Case approach in the offshore oil and gas industry. Today, Australia still utilizes the Safety Case approach but also has some remaining prescriptive regulations in place. Oversight of the offshore oil and gas drilling industry has been provided by the National Offshore Petroleum Safety Authority since 2005 (Grant, Moreira, & Henley, 2006: 16).

Norway also moved toward MBR after a high-profile accident: the 1980 failure of the Alexander Kielland (Bennear, 2015: 10-11). Similar to the Safety Case regime, firms in Norway develop and implement a safety plan for each installation, which includes a comprehensive risk assessment and clearly identified risk-management strategies (Bennear, 2015: 11). The critical difference between the Norwegian regulatory system and that of the United Kingdom and Australia is that formal approval of the safety plan is not required in order to operate (Bennear, 2015:

11). Consistent with a corporatist political system, the government and firms cooperatively address potential issues with the safety plan itself while it is being drafted. If any violations of the protocols outlined within the plan are identified during routine inspections, (Bennear, 2015: 11) firms could still be subject to sanction, but they are typically avoided as a result of this cooperative approach (Bennear, 2015: 11).

Next, we summarize the literature on the application of performance-based and management-based regulation and discuss the conditions that affect the appropriateness of these regulatory models. Then, we address the lessons that can be learned from our review of the published literature. Finally, we recommend topics for future research by the National Academies of Science as they assess whether PBR and MBR are viable alternatives to the prescriptive regulatory model.

Challenges and Lessons Learned from the Literature on Performance- and Management-Based Regulations

Challenge 1: Clarifying the Performance Standards

Lessons Learned: Clarity of the performance standard or level of detail required in order to demonstrate compliance with a management-based regulation is essential to successful implementation. When performance standards are not clearly defined, regulators under a PBR regime cannot enforce standards uniformly nor efficiently (May, 2003: 397). Poor clarity with respect to the structure, level of detail, and appropriate methods for demonstrating compliance under a management-based regime can increase transaction costs for regulated entities (Haines, 2009: 10-11).

Challenge 2: Detecting and Managing Dysfunctional Behavior

Lessons Learned: There is evidence to suggest that both PBR and MBR may lead to dysfunctional behavior. Preventing gaming and ensuring that measurements validly and reliably capture all relevant outcomes across different firms require a critical assessment and continuous refinement of measurements. Demonstrating the existence of dysfunctional behavior (e.g., cream skimming, manipulation with data, and misallocation of resources) is difficult because it is not directly observable. To address this, the regulator needs to evaluate metrics and monitor regulated entities on alternative metrics in addition to those included in the regulation to reveal dysfunctional behavior (Behn & Kant, 1999: 480).

Challenge 3: Ensuring that the Regulator has the Required Administrative Capacity

Lessons Learned: "When the requisite professional expertise is lacking, there may be little choice but to revert to a largely prescriptive regime" (May, 2011: 382). PBR should involve an enhancement of the analytic capacity of the regulator. Improvements to performance standards and contracts require the regulator to have knowledge and expertise. Feedback from enforcing agencies therefore needs to be supported by organizational procedures that support an inter-agency learning environment.

Challenge 4: Ensuring that the Regulated Entity has the Required Administrative Capacity

Lessons Learned: Successful implementation of PBR and MBR depends on the capacity of the regulated entity. Smaller firms or new market actors who have had less time to develop expertise may prefer a prescriptive approach. In order to allow for small firms to continue to flourish, providing non-binding prescriptive standards can help to lower their cost of compliance (Gilad: 2011, 434). When implementing a new regulatory regime, implementation in a phased approach may help to allow for both firms and regulators to learn about the challenges associated implementation and lower transaction costs for both as a result (Gunningham, 2007: 16).

Challenge 5: Verifying Performance through the Use of Standards

Lessons Learned: In an effort to measure the reduction of risk under performance- and management-based regulatory regimes, regulators often rely on proxies like the amount of effort dedicated to the managing operations, professional judgment, or predictive models that can provide an estimate of risk but are difficult to validate (Bennear, 2006: 73-74; May, 2011: 375, 381). These measures are imperfect reflections of actual risk reduction and should be interpreted with caution as a result (Bennear, 2006: 73-74).

6 Challenges Associated with Implementation of Performance- and Management-Based Regulations

We present five challenges in the implementation of both performance- and management-based regulations. The challenges are: 1. clarifying the performance standards, 2. detecting and managing dysfunctional behavior, 3. ensuring that the regulator has the required administrative capacity, 4. ensuring that the regulated entity has the required administrative capacity, and 5. verifying performance through the use of standards. We summarize the theoretical arguments in support of these challenges, evidence of the undesired consequences that can result from these challenges, and lessons that can be learned from the evidence presented. Above is a brief summary of the challenges and lessons learned.

Challenge 1: Clarifying the Performance Standard

Theoretical Hypothesis

Specification of clear performance standards and standards of proof lowers the uncertainty associated with using new practices and thereby lowers the potential financial losses for firms in engaging in innovation. Thus, PBR may not actually encourage development of innovative technology and procedures when standards are ambiguous (Coglianese, Nash, & Olmstead, 2003: 708). Clear and simple standards provide certainty of how rules will be enforced and whether innovative solutions will be approved (Gann, Wang, and Hawkins, 1998: 293; Deighton-Smith, 2008: 98). However, as May (2011: 382) has identified, "[m]ost of the criticisms that have been raised about the performance-based approach revolve around the uncertainties that are fostered by vague performance goals or standards, and the inability to adequately quantify or otherwise measure performance." It may further create uncertainty for the regulated entities if enforcing agencies are provided with large discretion because it may produce inconsistencies in the enforcement of vague standards.

Performance standards must set clear expectations, but clarity and specificity can come at a cost to the flexibility of the regulation. New scientific knowledge and technology can deliver large productivity gains to industries, but rules that do not accommodate changing technology

and new processes can squash innovation (Heinrich & Marschke, 2010: 191). New scientific knowledge and innovative solutions may therefore give rise to a re-evaluation and adjustment of performance standards (OTA, 1995: 91). PBR runs the risk of resembling a prescriptive regime if performance standards only capture intermediate outcomes that are specific to the current set of industry procedures (Coglianese, forthcoming: 20-21).

Empirical Evidence

Building Regulations in New Zealand - Unclear Performance Standards Led to Inconsistent Implementation by the Regulator (May, 2003): In the early 1990s New Zealand adopted PBR in the regulation of building safety. It provided firms with substantial flexibility which led to significant innovation in alternative building methods (Buchanan et al., 2006: 6). Yet, enforcement failed and led to a crisis of widespread rotting of particular houses. May found that the formulation of performance standards in the building code was insufficiently precise to guide an accurate assessment of whether alternative building methods were complying which lead to weak regulatory oversight and vast inconsistencies between enforcing agencies (May, 2003: 388). In the aftermath, the government introduced reforms that called "for a general tightening of the regulatory regime with emphasis on greater specification of performance standards and stronger monitoring of building inspection practices." (May, 2003: 396). This higher level of proof for approval of novel methods "created an environment where innovative solutions [were] significantly more difficult to introduce" (Buchanan et al., 2006: 2). This case suggests that PBR has the potential for encouraging innovation but that, in the case of New Zealand, it was achieved at the cost of insufficient accountability of the regulated entities (May, 2003: 382, 397). Despite the crisis, governmental inquiries endorsed the performance-based approach and did not recommend returning to the stringency of prescriptive standards (May, 2003: 395).

Australian Safety Case Regime - Unclear Standards for Safety Case Frustrates Firms (Haines, 2009: 10-11; Vectra Group Limited, 2003: 27): In 1998, Australia's Safety Case regime was expanded to include all major hazard facilities, which are defined as plants, refineries, and storage sites where large quantities of hazardous materials are stored, handled, or processed (Haines,

2009: 5; Safe Work Australia, n.d.; Gunningham, 2007: 8). While the Safety Case regime was already well underway in the offshore oil and gas industry, its implementation in other sectors proved to be a challenge for firms (Haines, 2009: 10). When firms were required to submit their first Safety Cases in 2002, many site managers expressed concern and frustration over the lack of clarity in the Safety Case regulations (Haines, 2009: 10). Specifically, site managers did not know what information needed to be provided in order to create a compliant Safety Case, and they cited this as the reason why their cases had not been approved (Haines, 2009: 10). As a result, many site managers expressed that they had wasted valuable time and resources in the development of their Safety Cases (Haines, 2009: 10). This lack of clarity and resulting trial-and-error approach to the development of Safety Cases was noted as the reason why at least one firm relocated to another country and was attributed to the difficulties firms had in achieving compliance (Haines, 2009: 10-11). This sentiment was echoed in a literature review commissioned by the United Kingdom's Health and Safety Executive, in which researchers found that as of 2003, regulated entities still has considerable amounts of confusion about the level of detail required as well as how to demonstrate the risk had been minimized such that it was as low as practicably possible (Vectra Group Limited, 2003: 27).

In sum, PBR and MBR are claimed to be less burdensome to regulated entities (May, 2003: 388; Gunningham, 2007: 6;) because these techniques "supposedly simplifies regulatory requirement (by replacing detailed prescriptive requirements with simple outcome standards)" (Deighton-Smith, 2008: 98). However, the result is often the reverse because the technical performance standards under both performance- and management-based regulatory regimes are less clear to understand and less straightforward to comply with than prescriptive regulation.

Lessons Learned: Clarifying the Performance Standard

Clarity of the performance standard or level of detail required in order to demonstrate compliance with a management-based regulation is essential successful implementation.

1) When performance standards are not clearly defined, regulators under a PBR regime are challenged in enforcing standards uniformly and sufficiently (May, 2003: 397).
2) Poor clarity with respect to the structure, level of detail, and appropriate methods for demonstrating compliance under a management-based regime can increase transaction costs for regulated entities (Haines, 2009: 10-11).

Challenge 2: Detecting and Managing Dysfunctional Behavior

Theoretical Hypothesis

"The more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor." (Campbell, 2011 [1974]: 34). This suggests that a strong emphasis on monitoring and compliance with performance goals can enhance the risk of unintended dysfunctional behavior or deliberate gaming and manipulation of performance standards (van Thiel & Leeuw, 2002: 273). Typically, principals begin with an imperfect understanding of agents' means for achieving contract goals and how agents respond to an incentive structure (information asymmetry between the regulated and regulator), which is thought to increase the potential dysfunctional consequences because it leads to an incomplete contact (Bergen, Dutta, & Walker, 1992: 3; Eisenhardt, 1985: 136). Once performance measurements are implemented - meaning that they are incorporated into management systems and tied to certain extrinsic rewards - the correlation with regulation objectives might decrease (Courty & Marschke, 2007: 912) due to the efforts of firms to "explore *all* strategies to raising it" (Heinrich & Marschke, 2010: 197).

We find the distinction between unintended and deliberate dysfunctional behavior important (van Thiel & Leeuw, 2002: 273). It recognizes that allocation of resources that is non-optimal on a societal level can be caused by performance targets that direct "emphasis [toward] measures of success rather than [on] the underlying objective" (Smith, 1995: 290). We also find it relevant to assess whether or not dysfunctional behavior has a direct impact on regulatory objectives (*Appendix A*). A compelling example of dysfunctional behavior without any direct impact is provided by Aviv (2014), who tells the story of middle school teachers in Atlanta who - in the face of strict and overambitious performance targets - decide to manipulate students' scores on standardized tests to avoid penalties that they deemed to be unfair. Based on teachers' statements, the manipulation does not seem to influence the quality of their teaching or the learning outcomes of students. Yet, it did undermine the validity of performance data (test scores) and led to an unwarranted rewarding of the school.

It is useful to look at the classification of dysfunctional behaviors by Courtry and Marschke (2011: 203):

(1) Accounting manipulation: the deliberate misrepresentation of data in order to increase measured performance, not to the detriment of outcomes; "cooking the books."
(2) Gaming responses: deliberate actions by the agent to cheat the regulation system which increase measured performance but negatively affect outcomes
(3) Marginal misallocation of resources: decisions that positively impact performance but are still not optimal; "cream skimming."

Empirical Evidence

Job Training Programs - Accounting Manipulation: Much of the literature has focused on the agent's ability to use discretion over the timing and reporting of outcomes in order to meet performance standards (Courtry & Marschke, 2011: 211). Barnow and Smith (2004: 247) find a tendency among job training organizations to terminate "[...] participants at a time that would maximize measured performance rather than when services are no longer provided." By terminating participants only after they have been employed - regardless of whether they are provided

training services during that time - maximizes the number of successful cases (Barnow & Smith, 2004: 271). Courty and Marschke (2004: 33) found this raised the employment rate at termination by 11 percentage points.

If the regulator is aware of misreporting, it can inflate its expectations in proportion to the amount of misreporting. If the regulator, however, is unaware of or cannot characterize the exaggerated performance, an accounting manipulation causes large losses in information that PBR intends to supply to the regulator (Courtry & Marschke, 2011: 212). PBR potentially rewards agents who invest in accounting manipulations. To the extent that agencies are dedicating time and resources to accounting manipulations, this can be harmful to outcomes.

Job Training Programs - Marginal Misallocation of Resources: Marginal misallocation typically arises because performance measures are not completely capturing the ultimate goal. An example: When job training agencies were held accountable for levels of unemployment and earning after job training and incentives are intensified, Cragg (1997: 149) found that program operators would engage in cheat by enrolling those with high expected earnings or low unemployment rates (a form of cream skimming). The agencies were orienting toward the measurements and behaved rationally to maximize their performance. The issue is that these measurements were only partially correlated with performance objectives. Yet, Cragg also finds that the quality of job training programs is enhanced, implying that agencies were both gaming the system while improving their efforts to obtain highest possible performance (Cragg, 1997: 162).

Job Training Programs - Gaming: In the face of declining budgets, program managers apparently tried to preserve their client load while maintaining low costs by offering cheaper but less cost-effective services (Courty & Marschke, 2003: 41). As a result, managers cut service quality to keep program costs low and maintain service quantity. All things equal, this negatively impacts the quality of services.

Offshore Oil and Gas Industry - Poor Understanding of Risk Leads to Misallocation of Resources (UKHSE, 2007): There are examples of the performance paradox in the offshore oil and

gas industry as well. Beginning in 2004, the UKHSE, the regulatory body responsible for the oversight of Safety Cases, conducted an audit of offshore installations (Bennear, 2015: 16; UKHSE, 2007; 6). Over the course of the next three years, inspections of 100 offshore facilities on the UK's Continental Shelf were conducted (Bennear, 2015: 16; UKHSE, 2007; 6). These inspections focused on 17 performance elements which taken together were intended to provide a representation of the quality of the plant maintenance management system. These "Safety Critical Elements," defined as parts of an offshore installation that work to prevent, control, or mitigate major accident hazards, as well as an element that focused on the general state of the plant. The results of the inspections were scored using a traffic-light system in order to rate the quality of these elements (UKHSE, 2007; 6). Their findings were published in a document called the Key Programme 3 Asset Integrity Program (Bennear, 2015: 16). Through this investigation, UKHSE discovered that more than 50 percent of inspected facilities' were receiving only a "poor" rating on the performance element regarding the general state of the plant (UKHSE, 2007: 7, 14; Bennear, 2015; 17). Critically, this report also noted that "[c]ompanies often justified the lower level of integrity with the claim that the plant, fabric, and systems were non-safety-critical. This illustrates a lack of understanding in many parts of the industry that degraded non-safety-critical plant and utility systems can impact on safety critical elements in the event of a major accident reducing their performance" (UKHSE, 2007: 7).

Regulators determined that operators lacked processes that allowed for organizational learning to occur. Specifically, their audits were being used primarily to ensure compliance, as opposed to using audits to identify good and bad performance, develop best practices, and learn from experiences within and between firms (UKHSE, 2007: 8, 29). In addition, financial constraints were dampening the role of the engineers who are responsible for analysis of data on the installation itself, which directly undermines the operator's ability to make decisions about risks and safety (UKHSE, 2007: 8, 28). Finally, the UKHSE determined that senior leaders poorly understood the relationship between the risks associated with the lack of maintenance of non-safety-critical equipment and the safety of the operation on the whole, resulting in a failure to

prioritize investments in health- and safety-related equipment maintenance and upgrades (UKHSE, 2007: 8, 27; Paterson, 2011: 7). While this is clearly not an example of intentional gaming, it demonstrates how the goals of private industry, profit maximization, and provision of safety for the well-being of workers and society can produce unintended consequences (Paterson, 2011: 7).

Chemical Plants - Creative Accounting to Avoid Regulation (Chinander, Kleindorfer, and Kunreuther, 1997: 7): Evidence of intentional gaming can be found in examples of management-based regulation in the chemical industry. Chinander, Kleindorfer, and Kunreuther (1997) sought to analyze how firms of variable size viewed and reacted to the implementation the U.S. Clean Air Act amendments. These amendments required firms that utilized certain hazardous chemicals to create risk-management plans for each facility that handled these materials (Chinander, Kleindorfer, and Kunreuther, 1997: 2). Within each risk-management plan, firms were required to include procedures such as training, risk assessment, emergency planning, and incidents documentation, and then communicate the results of these plans to relevant internal and external stakeholders (Chinander, Kleindorfer, and Kunreuther, 1997: 2). Through interviews of both small and large firms impacted by the legislation, they found that several small firms were engaging in gaming behaviors in order to avoid being subject to the new regulations (Chinander, Kleindorfer, and Kunreuther, 1997: 6). For example, one firm began to store extra barrels of a regulated chemical in a warehouse thereby limiting the total amount of that chemical on-site such that it was below the threshold for regulation (Chinander, Kleindorfer, and Kunreuther, 1997: 7). This action arguably increased the risk associated with this operation because storing materials at an offsite warehouse makes it more difficult to control or contain an accident or a leak (Chinander, Kleindorfer, and Kunreuther, 1997: 7).

Lessons Learned: Detecting and Managing Dysfunctional Behavior

The evidence supports the hypothesis that both PBR and MBR may lead to dysfunctional behavior. Preventing gaming and ensuring that measurements are validly and reliably capturing all relevant outcomes across different firms require a critical assessment and continuous refinement of measurements. Demonstrating the existence of dysfunctional behavior (e.g., cream skimming, manipulation with data, and gaming) is difficult, because it is not directly observable. To address this, the regulator needs to evaluate metrics and monitor regulated entities on alternative metrics in addition to those included in the regulation to reveal dysfunctional behavior (Behn & Kant, 1999: 480). Such adjustments and experimentations require analytical capacity of the regulator, which is the focus of the next section.

Challenge 3: Ensuring Technical and Analytical Capacity of the Regulator

Theoretical Hypothesis

The administrative capacities developed for a prescriptive regime may not be suited to MBR or PBR approaches. When the enforcing governmental agencies have sufficient analytical and knowledge capacity to assess risk-management strategies under MBR or engage in incremental refinement of measurements and performance contracts under PBR, regulation is more likely to be effective (Behn & Kant, 1999: 480–481). The lesson from evidence on dysfunctional behavior is that PBR and MBR require long-term implementation processes involving assessment and adjustment of regulation standards to better reflect ultimate goals and the means of regulated entities. Specifically, it is necessary to engage in an ongoing learning process where outcomes of gradual adjustments provide lessons to implement new adjustments. Implementing performance-management systems is a process of ongoing monitoring and continuous revision (Courty & Marschke, 2007: 912). Engaging in such learning processes requires substantial analytic capacity and competency of the agency (Behn & Kant, 1999: 480-481; Coglianese, forthcoming: 20-22; Heinrich & Choi, 2007).

The development of performance or prescriptive standards is challenged by uncertainties in predicting and monitoring the economic, environmental, and social costs of novel methods and technologies. This requires extensive data which can be costly and analytically challenging to gather (OTA, 1995: 89). Limited administrative resources and data gaps make it difficult to set performance standards that are societal optimal (OTA, 1995: 91). "Collecting the data necessary to set an appropriate performance-based standard can be very resource-intensive for an agency. Congress or an agency could reduce demands on government by encouraging or requiring the targeted entities to provide necessary data." (OTA, 1995: 90). Yet, shifting the burden of proof to the regulated entity still presumes that the regulator has the capacity to assess evidence that alternative technologies or transportation practices satisfy safety criteria. Further, placing burden of proof on the entity may decrease the incentive to develop alternative, innovative solutions.

Empirical Evidence

Leaky Buildings in New Zealand - Unclear Standards and Inadequate Training of Enforcing Agencies (May, 2003): In assessing failures of performance-based building regulation in New Zealand (described under challenge 1), May found that the failure could, among other issues, be ascribed to a lack of sufficient specification of performance standards (requirements), including how local authorities should certify new building materials and approaches, and inadequate training and certification of third-party certifiers. Such unclear standards and lack of professionalism created gaps and inconsistencies in the regulation enforcement. Further, it delayed the identification and management of the violation (May, 2003: 395). We have emphasized this case because it shows that specification of performance standards is difficult and should be supported by learning processes of trial-and-error involving feedback from enforcing agencies to make gradual adjustments. This requires a willingness of regulators to allocate resources for this purpose which correspond with the argument that enforcement of PBR may be costly to government (May, 2003: 388; Coglianese, Nash, & Olmstead, 2003).

Social Welfare Program - Continuous Adjustments to Performance Contract with Moderate Results: The Wisconsin Works program introduced performance-based contracting and private-

sector management of social welfare programs. Heinrich and Choi (2008: 419) found that difficulties in controlling for unexpected and uncontrollable factors (changing economic circumstances, legislative mandates, etc.) combined with information asymmetry led to several incomplete contracts that involved unambitious goals and allowed program managers to strategically game metrics to maximize rewards (Heinrich & Choi, 2008: 419, 427). Yet, the Wisconsin Works case shows that fixed contract periods supported program managers in consummating a learning process by translating lessons from failures into new contracts at regular intervals. Although deficiencies in contract-management capacity limited its success, the authors "[...] found promising signs that organizational learning [was] taking place [...]" to handle the challenges in contracting (Heinrich & Choi, 2008: 428).

United Kingdom Safety Case Regime - Shortage of Skilled Laborers and Financial Constraints Inhibit HSE's Ability to Review Safety Cases (UKHSE, 2007;* Grant, Moreira, & Henley, 2006: 9*): Under the United Kingdom's Safety Case regime, the capacity of the Health and Safety Executive (UKHSE) played a critical role in the implementation of these regulations (Grant, Moreira, & Henley, 2006: 9). When the regime was first implemented, significant investments were required on the part of the UKHSE in order to review these Safety Cases (Grant, Moreira, & Henley, 2006: 9). By 1993, a Safety Case had been submitted for each of the 350 installations that were operating at that point in time, and the UKHSE had allotted just two years to review these Safety Cases (Grant, Moreira, & Henley, 2006: 9). To meet this deadline, the UKHSE required a significant increase in staff who were qualified to review Safety Cases (Grant, Moreira, & Henley, 2006: 9). Contributing further to this increase in demand in staff is the fact that the UKHSE was competing with industry for a finite number of qualified and experienced individuals (Grant, Moreira, & Henley, 2006: 9). Finally, because the UKHSE is a government agency, it also faced budget constraints. Each of these factors contributed to the struggle that the UKHSE experienced in reviewing the Safety Cases submitted by firms (Grant, Moreira, & Henley, 2006: 9). This lack of internal capacity is an issue that the UKHSE has continued to struggle

with over time (Grant, Moreira, & Henley, 2006: 9). That said, adverse effects of lack of administrative capacity within the UKHSE are not just limited to delays in the Safety Case review process. Perhaps most critically, the previously mentioned dysfunctional consequences also developed under the oversight of the UKHSE (Paterson, 2011: 9). Arguably, there is a greater need for regulatory capacity associated with the implementation of a management-based regime like the United Kingdom's Safety Case (Paterson, 2011: 9).

PHMSA - Capacity Already Limited within Agency (Office of Inspector General, 2014: 2): Based on a 2014 report the Office of Inspector General for the Department of Transportation, we are skeptical that agencies under PHMSA are currently holding the necessary capabilities to support a learning process of continuous adjustments of the performance regulation system. The report found that "PHMSA's guidelines, policies, and procedures for State pipeline safety programs – such as inspector staffing, training, scheduling, and inspection forms – lack elements to ensure State inspections cover all Federal requirements and pipeline operators maintain safety standards." (Office of Inspector General, 2014: 2). Further, learning feedback from agencies on the functioning of regulatory standards does not currently seem to be prioritized: "PHMSA's policies and procedures for conducting State inspections do not require its evaluators to review the adequacy of States' inspection procedures, and the Agency does not have procedures to inform States of updated inspection forms." (Office of Inspector General, 2014: 2). If PHMSA is to adopt alternative regulatory approaches, it must also deal with the difficulty in retaining qualified staff (also experienced by the UKHSE) when such staff will be able to earn a premium by transferring to the private sector.

Lessons Learned: Ensuring Technical and Analytical Capacity of the Regulator

"When the requisite professional expertise is lacking, there may be little choice but to revert to a largely prescriptive regime" (May, 2011: 382). Implementing performance-based regulation should involve an enhancement of the analytic capacity of the regulator. Improvements to performance standards and contracts require the regulator to have knowledge and expertise. Feedback from enforcing agencies therefore needs to be supported by organizational procedures that support an inter-agency learning environment.

Challenge 4: Technical and Analytical Capacity of Regulated Entities

Theoretical Hypothesis

To achieve the potential of PBR and MBR, it is vital that the regulated entities have sufficient capabilities to effectively implement the requirements (Deighton-Smith, 2008: 95). Small firms are disadvantaged in a non-prescriptive regulatory environment due to their limited financial resources, time, competency, and manpower (Vickers et al., 2005: 2-3). It has been argued that under significant cross-sectional heterogeneity (differences among regulated entities), PBR and MBR should be preferred because these regulation regimes can accommodate the differences within a given industry by leaving it up to individual firms to take the measures needed to meet with the specified outcomes or level of performance (Coglianese, forthcoming: 13). Yet, the complexity and analytic sophistication associated with completing and demonstrating compliance with PBR and MBR can be a significant constraint to small- and mid-sized firms (Gunningham, 2007: 18). The literature recommends that when small firms are subjected to non-prescriptive-based regulation, non-binding standards should be provided in order to reduce the costs of compliance (Gilad, 2011: 434). New entrants to a marketplace may face similar capacity constraints as smaller firms.

Empirical Evidence

Chemical Plants - Small Firms Lack Labor and Capital Resources Necessary for Compliance (Chinander, Kleindorfer, and Kunreuther, 1997: 7): The capacity of the regulated entity can

also have significant implications for the success of management-based regulations. For example, Chinander, Kleindorfer, and Kunreuther (1997: 7) found that small firms lacked the labor and capital resources to produce and implement the risk-management plan required under these management-based regulations. As a result, these small firms viewed the risk- management planning process as just another required activity that needed to be conducted in order to be compliant with regulations instead of viewing it as a risk-reduction tool, and they frequently engaged in gaming behavior to avoid being regulated (Chinander, Kleindorfer, and Kunreuther, 1997: 6-8).

United Kingdom Safety Case Regime - High Cost of QRA (Grant, Moreira, & Henley, 2006: 8): The implementation of the Safety Case regime also required investments on the part of the regulated entity. For example, one of the fundamental components of the Safety Case is the quantitative risk assessment (QRA), which is used to demonstrate if hazards have been mitigated such that risk associated with operation is as low as reasonably practicable (Grant, Moreira, & Henley, 2006). While the use of a QRA for this purpose originated under the Norwegian management-based regime, the United Kingdom's decision to require firms to engage in this assessment significantly increased the demand and usage of QRA (Ramsay, 1994; 1). This change in demand prompted the rapid development of QRA technologies (Ramsay, 1994: 1, 2; Grant, Moreira, & Henley, 2006: 8). These technological advances are an obvious boon for the regulator who is concerned with safety, but the investment required by firms to access these technologies was significant for multiple reasons. First, many firms did not have staff that were prepared or qualified to conduct a QRA. As a result, many firms were required to contract out the completion of their QRA to consultants, who retained the rights to the model and charged firms for each subsequent change that needed to be made (Grant, Moreira, & Henley, 2006: 8). Consequently, cost associated with the production of a firm's first Safety Cases was estimated to be on the order of 1 million pounds (Grant, Moreira, & Henley, 2006: 8). Second, once these Safety Cases had been created, firms had to begin the process of actually implementing them. As of 2006, an estimated

5 billion pounds has been spent by firms on improving offshore safety (Grant, Moreira, & Henley, 2006: 8). These investments have the potential to be relatively costly for smaller operators and could pose a barrier to entry for new firms.

Lessons Learned: Technical and Analytical Capacity of the Regulated Entity

Successful implementation of PBR and MBR is dependent on the capacity of the regulated entity. In order to allow for small firms to continue to flourish, providing non-binding prescriptive standards can help to lower their cost of compliance (Gilad: 2011, 434). When implementing a new regulatory regime, implementation in a phased approach may help to allow both firms and regulators to learn about the challenges associated implementation and lower transaction costs for both as a result (Gunningham, 2007: 16).

Challenge 5: Verifiability of Performance

Theoretical Hypothesis

Managing performance systems of job training programs benefits from a constant flow of performance data in terms of unemployment rates. A challenge in implementing alternatives to prescriptive regulation in high-hazard industries is that performance cannot always be directly measured and verified, for instance, if performance is defined by rare and catastrophic events. In this case, regulators and regulated entities must rely on predictive models (May, 2011: 375). However, since the incremental learning process required to verify the predictive model relies on performance feedback, it is difficult to detect whether the performance measure (predictive model output) is correlated with performance itself (minimizing risk). As a result, it is difficult to adjust the predictive model to increase its validity (Coglianese, Nash, & Olmstead, 2003: 712). An example of this would be a regulator assessing the performance of a novel technology against the performance requirements without having access to data from formal testing and therefore relying on uncertain predictive models.

Within high-hazard industries, reduction of risk is rarely the performance target that enforcement actions are based upon (Bennear, 2006: 73-74). This is because there is a tradeoff between accuracy and measurability (Bennear, 2006: 73-74). Bennear accurately describes this trade-off in the context of environmental regulations in which highly accurate metrics (risk) are rarely used to monitor performance because they are very difficult to measure, while more inaccurate measures of performance like inputs and chemical releases are utilized because they are easily measureable (Bennear, 2006: 73-74). As a result, regulators are forced to choose between imperfect measures that act as proxies for risk or invest in more accurate measures that reflect the actual risk of failure. (Bennear, 2006: 73-74) In the case of management-based regulations, regulators typically attempt to continuously monitor the amount of effort that regulated entities put into their operations through the use of tools like inspections (Bennear, 2006: 73-74). While this may be the best approach to take when faced with the regulation of something that is not easily measurable, like risk, it is a reliable measure only if additional management effort actually correlates with a reduction in risk (Bennear, 2006: 74). In the case of high-hazard industries, this is not necessarily the case. In general, these findings suggest that the verifiability of performance may be a challenge under both performance- and management-based regulatory environments.

Empirical Evidence

Pipeline Safety in the US - Inspections not Correlated with Better Performance (Stafford, 2014: 7): In general, the regulation of risk is a difficult exercise because the reduction of risk is not an inherently measurable activity (Gunningham, 2007: 6; Bennear, 2006: 73-74). As a result, regulators in the United Kingdom, Australia, and Norway rely on inspections of installations (among other things) in order to ensure that operators are in compliance with the protocols outlined in their Safety Cases (Bennear, 2006: 73-74; Bennear, 2015: 15-16). Reliance on inspections of installations is problematic because there is little evidence available that supports the idea that inspections and subsequent enforcement actions actually improve safety (Stafford, 2014: 7). For example, Stafford (2014) empirically analyzed the effectiveness of inspections and regulatory enforcement actions as a tool for enhancing the environmental and safety performance

of natural gas pipeline and hazardous liquid pipeline operators in the United States. Focusing on 344 firms operating more than 100 miles of pipeline in the United States, Stafford sought to determine if increases in federal pipeline inspections, enforcement actions, and fines enhance pipeline safety (Stafford, 2014: 3, 7). The results suggest that inspections and fines are negatively correlated with good performance (Stafford, 2014: 7). While there are some limitations associated with this analysis, in general, it does not provide compelling evidence for inspections being an instrumental tool for enhancing performance in high-hazard industries (Stafford, 2014: 7).

Lessons Learned: Verifiability of Performance

In an effort to measure the reduction of risk under performance- and management-based regulatory regimes, regulators often rely on proxies like the amount of effort dedicated to the managing operations, professional judgment, or predictive models that can provide an estimate of risk but are difficult to validate (Bennear, 2006: 73-74; May, 2011: 375, 381). These measures are imperfect reflections of actual risk reduction and should be interpreted with caution as a result (Bennear, 2006: 73-74).

7 Current Conventional Wisdom from High-Hazard Industries

Thus far, this analysis has focused on the potential challenges and unintended consequences that can result from the application of management-based regulation to high-hazard industries. Much of the appeal of performance-based regulation arises from a series of beliefs about its effectiveness that are not evidence-based in a classic social science sense of the term, which we therefore refer to as conventional wisdoms. In the following section, we consider how these conventional wisdoms match up with what evidence does exist.

Evidence of Adaptation in Response to Known Shortcomings

In general, regulators have responded to the previously mentioned challenges largely by changing the structure of the regulations. For example, after completing an extensive review of the efficacy of the Safety Case regulations, in 2005, the United Kingdom repealed and replaced

the original Safety Case regulations which had been in place since 1992 in order to enhance their efficacy (Paterson, 2011: 7; Grant, Moreira, & Henley, 2006: 10). In general, the UK Health and Safety Executive (UKHSE) maintained that the 1992 regulations had been effective at first, but that their returns had been diminishing progressively over time (Paterson, 2011: 7; Grant, Moreira, & Henley, 2006: 10). The 2005 update of the Safety Case regulations sought to address this and other several shortcomings of the 1992 regulations. Specifically, in order to combat the problem of diminishing returns, the UKHSE added a new element to the Safety Case document which required operators to summarize how the workforce was being involved in the development and review of the Safety Case (Paterson, 2011: 7-8). To reduce the burdens associated with QRA, the UKHSE weakened the regulations such that QRA was required only when both the complexity of the system and the risk associated with failure were high (Paterson, 2011: 7-8). This was intended to allow regulated entities to move toward contracting QRA back in and encourage operators to add value to existing QRAs (Paterson, 2011: 7-8). Finally, the 2005 regulations moved Safety Cases from a three-year to a five-year resubmission process, effectively lowering the administrative burdens associated with Safety Cases for both the UKHSE and firms (Paterson, 2011: 7-8; Grant, Moreira, & Henley, 2006: 10). Similar examples of incremental changes to the management-based regulations applied to the offshore oil and gas industry have been observed in Australia and Norway (Grant, Moreira, & Henley, 2006: 13, 17).

Operators have also responded to criticisms of their performance under the management-based regulatory regime. For example, the UKHSE conducted a follow-up review of offshore operators in 2009 (UKHSE, 2009: 3; Bennear, 2015: 17). In this review, the UKHSE found that progress had been made: workforce involvement and understanding of risks had improved, a culture of safety was beginning to form, and leadership had an improved understanding of risk and was beginning to invest more in safety (UKHSE, 2009: 4, 14-19). These are considerable improvements and generally are indicative of the industry's responsiveness to regulators. That said, these findings must be interpreted with some caution. Although the UKHSE relied on a

variety of data sources, including surveys, interviews, industry-reported data, and historic inspection data, the findings were validated by inspecting only five installations (UKHSE, 2009: 8-9; Steinzor, 2011: 14).

Are Management-Based Regulations More Effective?

What is the general consensus about the applicability of management-based regulations to high-hazard industries? To date, the conventional wisdom is that management-based regulations - like the Safety Case - can have a positive impact on safety (Gunningham, 2007: 10). That said, a consensus has yet to be reached among the academic community, largely for want of sufficient evidence. Some researchers arrive at the conclusion that the management-based regulatory approach has been instrumental to enhancing safety in high-hazard industries (Gunningham, 2007: 10; Grant, Moreira, & Henley, 2006: 31). Other academics conclude that management-based regulations have had modest beneficial impacts on the safety of the offshore oil and gas industry despite these previously mentioned challenges (Bennear, 2015: 18; Paterson, 2011: 9; Vectra Group Limited, 2003: 50). Others maintain that these regulatory systems do little more than promote "paper-compliance" (Gunningham, 2007: 10). Again, it is critical to interpret this evidence with some caution because this is an empirical question and to date no empirical analyses have addressed this topic.

While it is not yet clear whether management-based regulations have led to better outcomes in high-hazard industries, they have had tangible benefits within the realm of environmental regulation. In Bennear's analysis of state pollution-prevention programs, firms were required to adopt a management-based regulatory regime (Bennear, 2007: 1). Under these management-based regulations, plants were required to identify alternative production techniques that would reduce the use and emission of toxic chemicals and evaluate the technical and economic feasibility of each of these alternatives (Bennear, 2007: 4). This regulation varied among states with respect to the frequency of the reporting required (from once a year to once every four years) and whether third-party review and approval was required (Bennear, 2007: 4). Bennear was able to

capitalize on a natural experiment for this empirical analysis because just 14 states adopted management-based regulations in the early 1990s while others remained consistent (Bennear, 2007: 1). While operating under a management-based regulatory regime, firms reduced toxic chemical release by approximately 28 percent compared to pre-regulatory conditions. They also were more likely to take actions that effectively prevent pollution (Bennear, 2007: 19). Although the results suggest that MBR has led to a reduction in toxic chemical releases, one caveat is that the effectiveness of MBR is measured against a situation with no regulation and not against alternative regulatory approaches (Bennear, 2007: 19, 20).

Has the Introduction of Management-Based Regulations Fostered a Safety Culture?

So far, we have primarily discussed how PBR and MBR might influence safety-related investments and behaviors of firms and regulators. Another key determinant of safety performance, in addition to processes and rules that are in place, is 'safety culture' (Gunningham, 2007: 7). One of the cited benefits of management-based regulations is that they force the regulated entity to dedicate time and resources to the consideration of safety above and beyond what would be considered the economically optimal level, and in doing this, involve the workforce and stimulate a greater awareness of safety within the firm (Gunningham, 2007: 7; Vectra Group Limited, 2003: 23-24; Bennear, 2015: 13-14; Coglianese, 2010: 172-173). The proposed by-product of this process is a culture of safety in which in accordance with the U.S. Occupational Safety and Health Administration's definition: "[...] everyone feels responsible for safety and pursues it on a daily basis; employees go beyond 'the call of duty' to identify unsafe conditions and behaviors, and intervene to correct them" (OSHA, n.d.; Gunningham, 2007: 7). While the time we dedicated to the examination of this topic was limited, in our review of the published literature we encountered little discussion of safety culture. The evidence we did encounter presented an inconclusive picture of safety culture within the offshore oil and gas industry. For example, Vectra Group Limited did not find conclusive evidence that the UK's Safety Case regulation impacted safety culture, Haines found evidence that management-based regulation had positive impacts on safety

culture, and yet another study cited by Gunningham found that safety culture was inadequate under a management-based regulatory regime (Vectra Group Limited, 2003: 23-24; Haines, 2006: 10; Gunningham, 2007: 10-11). A clear caution here is that measuring culture reliably is inherently difficult, complicating the ability to identify the type of causal relationship between regulatory changes and culture that are assumed.

8 Conclusion

One major question that was considered in the introduction to this paper was to what extent can the evidence from other sectors like job training, building codes, and environmental management be applied to high-hazard industries? Evidence was drawn from a variety of sources due to the lack of empirical evidence regarding the application of PBR and MBR to high-hazard industries. While this allowed us to complete a more robust evaluation of the potential challenges and lessons learned from performance- and management-based regulatory regimes, it limits our ability to generalize findings to high-hazard industries (Bennear, 2015: 17-18). As a result, the findings of this paper must be interpreted with some caution. Based on the evidence reviewed in this paper, we are unable to conclude whether or not benefits have been reaped from the use of performance- and management-based regulations. We recommend that the NAS and PHMSA engage in the following activities in order to further explore if the adoption of a performance- or management-based regulatory regime in the United States would lead to beneficial outcomes.

9 Recommendations

A) Harmonize Data Collection Procedures to Facilitate Empirical Research on Management-Based Regulations

Despite the fact that the United Kingdom, Australia, and Norway have had management-based regulations in place for more than 20 years, few empirical analyses have been completed on their effectiveness (Bennear, 2015: 15). Currently, each country has different reporting requirements and formats for the data collected from offshore oil and gas firms. As a result, it is

difficult to draw comparison between these countries (Bennear, 2015: 16). One way to help facilitate the creation of empirical analyses on this topic would be to harmonize the data collected by these countries.

B) Combine Regulatory Regimes to Exploit Comparative Advantages and to Make an Incremental Transition toward Non-Prescriptive Regulation

A potential source of lessons might be environmental regulation, where performance-based standards have most commonly been used in combination with design standards ("best available practice") (OTA, 1995: 84, 88). Such approach allows regulated entities to either apply the design standards or achieve equivalent performance using alternative (and possibly more-effective) means. Given the differences among regulated entities in terms of innovation capacity and pipeline miles, the combination of standards provides flexibility to engage in innovation only when it is expected to result in greater effectiveness to the individual firm. Prescriptive standards could be maintained for methods and technologies known to produce desired outcomes, while alternative standards could be introduced for situations where innovation potential calls for flexibility, and outcomes can be measured (Deighton-Smith, 2008: 93). Such combination could limit the requirement to invest in analytical capacity for both the regulated and the regulator, which in this report has been found to pose substantial costs (May, 2011: 378). This approach of hybrid regulation regimes could further be applied in the transition toward PBR or MBR to give firms and governmental agencies a possibility to become familiar with the alternative regime before complete implementation.

C) Establish a Pilot Program to Encourage Experimentation

Given the limited empirical investigation of the functioning of both PBR and MBR in high-hazard industries, we recommend that the NAS explore the possibilities of establishing pilot programs for experimentation and knowledge generation. The general movement toward PBR and MBR in many OECD countries has been criticized as a "tendency to see these regulations as necessarily more 'modern' and superior to prescriptive regulation" (Deighton-Smith, 2008: 89,

99). This has ultimately led to the indiscriminate adoption of PBR and MBR under various circumstances that might not all support the particular regulation structures (Deighton-Smith, 2008: 94). Therefore, it would be unwise for the PHMSA to simply adopt the regulatory structures found in the UK, Australia, and Norway because the main finding of this report is that a consensus cannot yet be reached on whether their impacts have been beneficial.

As a consultant who undertakes Regulatory Impact Assessments, Deighton-Smith, (2008: 99) argues that there are significant analytical challenges with determining *ex ante* whether MBR or PBR is likely to lead to more superior regulatory performance than traditional prescriptive standards. We are therefore arguing that this calls for an approach of incrementalism where the regulatory structure is developed through gradual changes with a focus on the specific characteristics of the regulatory objectives and entities at hand (Lindblom, 1959). Such incremental steps are especially important in uncertain (untested) and complex policy contexts where reformers are unsure of causal effects between problems and solutions. It is important that regulators recognize that the adoption of fundamental alternative regulation regimes such as MBR and PBR will most likely result in a nonlinear and frustrating process of both successes and failures. Therefore, we are recommending that neither PBR nor MBR are broadly implemented until pilot programs have been pursued to generate evidence from the particular regulatory settings in high-hazard industries in the United States. This would minimize the costs of generating knowledge.

As this paper has shown, PBR and MBR are broad regulatory regimes allowing for substantial variation. Pilot programs should incorporate this variation and involve participation from representative groups of regulated entities to develop reliable evidence. This would generate knowledge of how the regulatory- and sector-specific characteristics influence the effectiveness. Specifically, pilot programs could provide evidence as to whether MBR and PBR are more cost-effective than prescriptive regulations, taking into account both the cost of compliance and costs associated with developing and monitoring such alternative regulation standards.

In establishing these pilot programs, the NAS and PHMSA could benefit from looking toward the Innovation Center under U.S. Centers for Medicare & Medicaid Services. The Innovation Center was established "for the purpose of testing innovative payment and service delivery models (for health care providers) to reduce program expenditures [...] while preserving or enhancing the quality of care" (CMS, 2015). The approach of the Innovation Center focuses on; (i) conducting rigorous evaluation of each payment and service delivery model with an explicit plan of action to ensure that lessons learned are contributing to an establishment of best practices and adopted in new models; (ii) engaging a broad range of stakeholders (e.g., care providers and clinical and analytical experts) to share ideas and inform model development (CMS, 2015). We are convinced that PHMSA could benefit from the approach and experience of the Innovation Center by providing an evidence-based process to assess the outcomes of regulatory experimentation.

As it works to implement this pilot program, NAS should consider taking action to foster a cooperative relationship between PHMSA and regulated entities. The introduction of an alternative regulatory regime in high-hazard industries will create uncertainties to both the regulator and regulated entities that become mutually dependent in achieving the regulatory objectives and cost reductions to the regulated entities. Given the information asymmetry, the regulator would benefit from the knowledge and experience of the regulated entity that would in turn benefit from its influence on regulation policies and less uncertainty of changes to policies (Behn & Kant, 1999: 482).

Disclaimer

This report was generated for the educational benefit of its student authors, and the main purpose of the project was to learn managerial techniques. The opinions and suggestions in this report do not represent the views of the University of Wisconsin–Madison or its faculty.

Bibliography

American Society of Mechanical Engineers. (2004). Gas Transmission and Distribution Piping Systems. Retrieved from https://law.resource.org/pub/us/cfr/ibr/002/asme.b31.8.2003.pdf

Aviv, Rachel. (2014). Wrong Answer. *The New Yorker.* Retrieved 2016-04-05 from http://www.newyorker.com/magazine/2014/07/21/wrong-answer

Barnow, Burt S., & Smith, Jeffrey A. (2004). Performance Management of U.S. Job Training Programs: Lessons from the Job Training Partnership Act. *Public Finance & Management*, *4*(3): 247–287.

Behn, Robert D., & Kant, Peter A. (1999). Strategies for Avoiding the Pitfalls of Performance Contracting. *Public Productivity & Management Review*, *22*(4): 470–489.

Bennear, Lori. S. (2006). Evaluating Management-Based Regulation: A Valuable Tool in the Regulatory Toolbox? In C. Coglianese & J. Nash (Eds.), Leveraging the Private Sector Management-Based Strategies for Improving Environmental Performance. Resources for the Future: Washington, DC.

Bennear, Lori S. (2007). Are Management-Based Regulations Effective? Evidence from state pollution prevention programs. *Journal of Policy Analysis and Management*, *26*(2): 327–348.

Bennear, Lori S. (2015). Offshore Oil and Gas Drilling: A Review of Regulatory Regimes in the United States, United Kingdom, and Norway. *Review of Environmental Economics and Policy, 9*(1), 2-22.

Bergen, Mark, Dutta, Shantanu, & Walker Jr, Orville C. (1992). Agency Relationships in Marketing: A Review of the Implications and Applications of Agency and Related Theories, *Journal of Marketing*, *56*(3): 1–24.

Buchanan, A. H., Deam, B. L., Fragiacomo, M., Gibson, Tony, & Morris, Hugh. (2006). Fifteen Years of Performance-Based Design in New Zealand. *9th World Conference on Timber Engineering*.

Campbell, Donald T. (2011) [1976]. Assessing the Impact of Planned Social Change. *Journal of MultiDisciplinary Evaluation*, *7*(15): 3–43.

Centers for Medicare & Medicaid Services (CMS). (2015). About the CMS Innovation Center. Retrieved 2016-04-24 from https://innovation.cms.gov/about/index.html

Chinander, Karen., Kleindorfer, Paul, & Kunreuther, Howard (1998). Compliance Strategies and Regulatory Effectiveness of Performance-Based Regulation of Chemical Accident Risks. *Risk Analysis, 18*(2), 135-143.

Coglianese, Cary. (Forthcoming). Performance-Based Regulation: Concepts and Challenges. In F. Bignami & D. Zaring (eds.): *Comparative Law and Regulation: Understanding the Global Regulation Process*. Northampton, MA: Edward Elgar.

Coglianese, Cary. (2010). Management-based Regulation: Implications for Public Policy. In OECD (Eds.): *Risk and Regulatory Policy: Improving the Governance of Risk*. OECD Publishing: Paris, France. Retrieved from http://www.oecd.org/publications/risk-and-regulatory-policy-9789264082939-en.htm.

Coglianese, Cary, Nash, Jennifer, & Olmstead, Todd. (2003). Performance-Based Regulation: Prospects and Limitations in Health, Safety, and Environmental Protection. *Administrative Law Review*, *55*(4): 705–729.

Courty, Pascal, & Marschke, Gerald. (2003). Performance Funding in Federal Agencies: A Case Study of a Federal Job Training Program. *Public Budgeting and Finance 23*(3): 22–48.

Courty, Pascal, & Marschke, Gerald. (2004). An Empirical Investigation of Dysfunctional Responses to Explicit Performance Incentives. *Journal of Labor Economics 22*(1): 23–56.

Courty, Pascal, & Marschke, Gerald. (2007). Making government accountable: Lessons from a federal job training program. *Public Administration Review*, *67*(5): 904–916.

Courty, Pascal & Marschke, Gerald. (2011). Measuring Government Performance: An Overview of Dysfunctional Responses. In James J. Heckman, Carolyn J. Heinrich, Courty, Pascal, Marschke, Gerald, Smith, Jeffrey (eds.): *The Performance of Performance Standards*. Kalamazoo, MI: W.E: Upjohn Institute for Employment Research. http://dx.doi.org/10.17848/9780880993982

Cragg, Michael. (1997). Performance Incentives in the Public Sector: Evidence from the Job Training Partnership Act. *Journal of Law*, *13*(1): 147–168.

Deighton-Smith, Rex. (2008). Process and Performance-Based Regulation: Challenges for regulatory governance and regulatory reform. In P. Carroll, R. Deighton-Smith, H. Silver, & C. Walker (eds.), *Minding the Gap: Appraising the promise and performance of regulatory reform in Australia* (pp. 89–104). Australia, Canberra: ANU E Press.

Eisenhardt, Kathleen M. (1985). Control: Organizational and Economic Approaches. *Management Science*, *31*(2): 134–149.

Gann, David M., Wang, Yusi, & Hawkins, Richard. (1998). Do Regulations Encourage Innovation? The case of energy efficiency in housing. *Building Research & Information*, *3218*(April 2015): 37–41.

Grant, Rob, Morera, Will, & Henley, David G. (2006). Potential for Performance-Based Regulation in the Canadian Offshore Oil and Gas Industry. *Alberta Law Review, 44*(1), 1-32.

Gilad, Sharon. (2011). Process-Oriented Regulation: Conceptualization and Assessment. In D. Levi-Faur (eds.), Handbook on the Politics of Regulation. Cheltenham, UK: Edward Elgar.

Gunningham, Neil. (2007). Designing OSH standards: Process, safety case and best practice. *Policy and Practice in Health and Safety, 5*(2), 3-24.

Haines, Fiona. (2009). Regulatory Failures and Regulatory Solutions: A Characteristic Analysis of the Aftermath of Disaster. *Law & Social Inquiry, 34*(1), 31-60.

Heckman, James J., Heinrich, Carolyn J., & Smith, Jeffrey. (2011). Performance Standards and the Potential to Improve Government Performance. In James J. Heckman, Carolyn J. Heinrich, Pascal Courty, Gerald Marschke, Jeffrey Smith (eds.): *The Performance of Performance Standards*. Kalamazoo, MI: W.E: Upjohn Institute for Employment Research. http://dx.doi.org/10.17848/9780880993982

Heinrich, Carolyn J., & Choi, Youseok. (2007). Performance-Based Contracting in Social Welfare Programs. *The American Review of Public Administration*, *37*(4): 409–435.

Heinrich, Carolyn J., & Marschke, Gerald. (2010). Incentives and Their Dynamics in Public Sector Performance Management Systems. *Journal of Public Analysis and Management*, *29*(1): 183–208.

Kaasen, Knut. (1991). Post Piper Alpha: Some Reflections on Offshore Safety Regimes from a Norwegian Perspective. *Journal of Energy & Natural Resources Law, 9*(4), 281-289.

Lindblom, Charles. E. (1959). The Science of "Muddling Through." *Public Administration Review*, *19*(2), 79–88. http://doi.org.ezproxy.library.wisc.edu/10.2307/973677

May, Peter J. (2003). Performance-Based Regulation and Regulatory Regimes: The Saga of Leaky Buildings. *Law and Policy*, *25*(4): 381–401.

May, Peter J. (2011). Performance-Based Regulation. In D. Levi-Faur (ed.), *Handbook on the Politics of Regulation* (pp. 373–384). Cheltenham, UK: Edward Elgar.

Menzies, Thomas. (2016). Interview conducted 02-26-2016 with Thomas Menzies, Study Director on the Transportation Research Board, The National Academies of Sciences.

Moynihan, Donald P., & Kroll, Alexander. (2015). Performance Management Routines that Work? An Early Assessment of the GPRA Modernization Act. *Public Administration Review*, *76*(2): 314–323.

National Archives and Records Administration. (2003). 49 CFR Part 192 Pipeline Safety: Pipeline Integrity Management in High Consequence Areas (Gas Transmission Pipelines); Final Rule. Retrieved from https://primis.phmsa.dot.gov/gasimp/docs/GasTransmissionIMRule.pdf

The National Academies of Science (NAS). (No date). Project Information: Performance-Based Safety Regulation. Retrieved from http://www8.national-academies.org/cp/projectview.aspx?key=49767

Occupational Safety & Health Administration (OSHA). (No date). *Creating a Safety Culture*. Retrieved from https://www.osha.gov/SLTC/etools/safetyhealth/mod4_factsheets_culture.html

Office of Inspector General. (2014). *PHMSA's State Pipeline Safety Program Lacks Effective Management and Oversight*. Retrieved 2016-02-28 from https://www.oig.dot.gov/sites/default/files/PHMSA%20State%20Pipline%20Safety%20Program%20Audit%5E5-7-14.pdf

Office of Technology Assessment (OTA), U.S. Congress. (1995), *Environmental Policy Tools: A User's Guide*. OTA-ENV-634. Washington, DC: U.S. Government Printing Office, September 1995.

Orth, Derek. (2011). Administering America's Offshore Oil Fields: How fewer performance-based regulations can produce better results. *Journal of Environmental Law and Litigation, 26*(2), 509-534.

Paterson, John. (2011). The Significance of Regulatory Orientation in Occupational Health and Safety Offshore. (Learning from Disaster: Lessons for the Future from the Gulf of Mexico). *Boston College Environmental Affairs Law Review, 38*(2), 369-389.

Pipeline and Hazardous Materials Safety Administration (PHMSA). (No date a). *All Incidents*. Retrieved from https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages

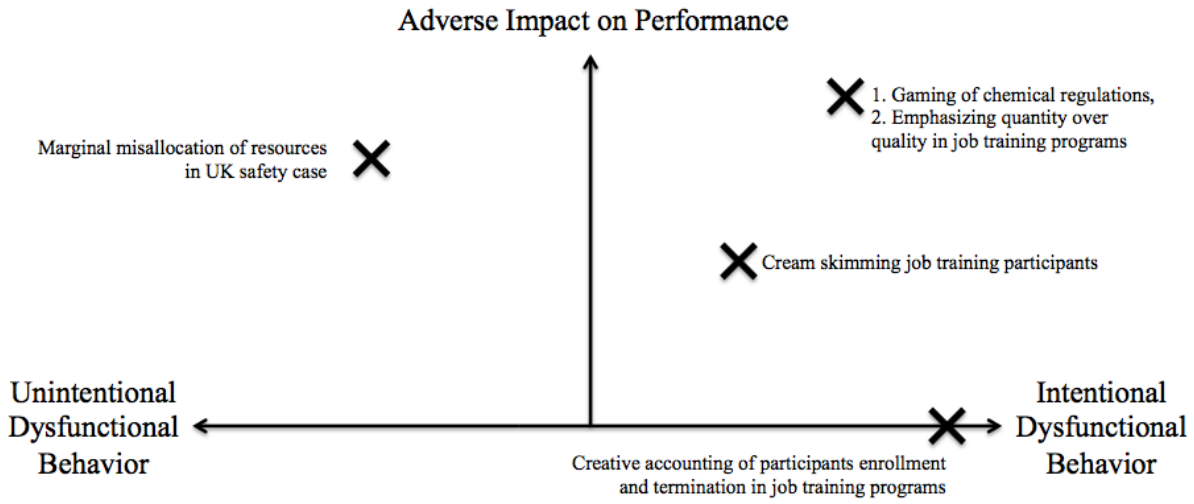
Pipeline and Hazardous Materials Safety Administration (PHMSA). (No date b). Pipeline Basics. Retrieved from http://primis.phmsa.dot.gov/comm/PipelineBasics.htm?nocache=7580

Pipeline and Hazardous Materials Safety Administration (PHMSA). (No date c). Hazardous Materials Table. Retrieved from http://www.phmsa.dot.gov/pv_obj_cache/pv_obj_id_7482D0DD9A1114E18A77788F3DAC7522F4F11500/filename/Alpha_Hazmat_Table.pdf

Pipeline and Hazardous Materials Safety Administration (PHMSA). (No date d). How to Use the HMR. Retrieved from http://www.phmsa.dot.gov/pv_obj_cache/pv_obj_id_BA8940AF40409A50D81F7

99BDD859F9C65A70400/filename/PHH50-0047-0205_How_to_Use_the_HMR.pdf
Pipeline and Hazardous Materials Safety Administration (PHMSA). (2016a). Mission & Goals. Accessed March 1, 2016 2016, from http://www.phmsa.dot.gov/about/mission
Pipeline and Hazardous Materials Safety Administration (PHMSA). (2016b). Incidents from 1996-2015. Retrieved from https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages
Ramsay, Cameron, Bolsover, Andrew, Jones, Richard & Medland William. (1994). Quantitative Risk Assessment Applied to Offshore Process Installations. Challenges after the piper alpha disaster. *Journal of Loss Prevention in the Process Industries, 7*(4), 317-330.
Safe Work Australia. (No date) Major Hazard Facilities guide. Retrieved from http://www.safeworkaustralia.gov.au/sites/swa/whs-information/mhf/pages/mhf
Seawright, Jason, & Gerring, John. (2008). Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options. *Political Research Quarterly*, *61*(2): 294–308.
Smith, Peter. (1995). On the Unintended Consequences of Publishing Performance Data in the Public Sector. *International Journal of Public Administration*, *18*(2): 277–310.
Stafford, Sarah. (2013). Will Additional Federal Enforcement Improve the Performance of Pipelines in the U.S.? *International Review of Law & Economics, 37*, 137-146.
Steinzor, R. (2011). Lessons From the North Sea: Should "Safety Cases" Come to America? *Boston College Environmental Affairs Law Review, 38*(2), 417-444, 211-212.
United Kingdom Health and Safety Executive (UKHSE). (2007). Key Programme 3 Asset Integrity Programme. Retrieved from http://www.hse.gov.uk/offshore/kp3.pdf
United Kingdom Health and Safety Executive (UKHSE). (2009). Key Programme 3 Asset Integrity: A Review of Industry's Progress. Retrieved from http://www.hse.gov.uk/offshore/kp3review.pdf
van Thiel, Sandra, & Leeuw, Frans L. (2002). The Performance Paradox in the Public Sector. *Public Performance & Management Review*, *25*(3): 267–281.
Vectra Group Limited. (2003). Literature Review on the Perceived Benefits and Disadvantages of UK Safety Case Regimes. Retrieved from: http://www.hse.gov.uk/research/misc/sc402083.pdf
Vickers, Ian, James, Philip, Smallbone, David, & Baldock, Robert. (2005). Understanding Small Firm Responses to Regulation. *Policy Studies, 26*(2), 149-169

Appendix A. Continuum of Dysfunctional Behavior



Appendix B. Notes on the Literature Included in this Analysis

The primary criterion used to determine what literature should and should not be used to inform our analysis was credibility of the source. All literature used in this paper was retrieved from peer-reviewed journal articles, government publications, and government websites. This criterion was used in order to set a high-bar for the quality of the analyses and theoretical discussions, used to create this paper. With respect to the papers used to evaluate high-hazard industries, this paper drew heavily on the published literature available on the offshore oil and gas industry because it was the most closely aligned with PHMSA's operations and mission. That said, some researchers have addressed the applicability of performance- and management-based regulations to other high-hazard industries – for example, mining in Australia. The papers used to discuss the offshore oil and gas industry in this analysis represent a significant portion of the existing literature. Papers addressing the technical components of safety modeling and engineering were generally not used in this paper because their foci were outside of the scope of this analysis and beyond the technical capacity of the authors' understanding. Keywords used to find the papers used in this analysis included but are not limited to various combinations of the following terms: performance-based regulations, management-based regulations, high-hazard industry(ies), OECD, offshore oil and gas, pipeline safety, hazardous materials, hazardous materials transportation, Safety Case regulations, self-regulation, enforced self-regulation, prescriptive regulation, outcome-based regulation, outcomes-oriented regulation, meta-regulation, empirical, and applicability.