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), which is 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 2,500,000 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 $7,600,000,000 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 of firms is crucial because of the high economic, environmental and social costs associated with non-compliance.

In 2003, PHMSA’s Office of Pipeline Safety implemented a performance-based standard which 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 United States 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). Propo-
ponents 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

Prior to 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 well as 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, and (iii) PBR introduces uncertainty into social, environmental, and economic outcomes because of complex technologies and uncertain causal relationships between standards and (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

The published literature 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, sixteen percent operated between 10 and 100 miles of pipeline, and just under thirteen 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 important, 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 for 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 the United Kingdom, Australia, and Norway’s regulations of offshore oil and gas drilling are the most heavily studied examples. That said, a 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, AU, and Norway regulations as management-based because they require firms to engage in planning process and to implement management practices which aim to achieve a specific outcome, in this case, this is 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 towards 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 selected to include this body of literature in our analysis.

4 Our Approach

Our knowledge of the high hazardous 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 performance based regulation. We hope that the evidence presented and the considerations of this paper will provide the 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 per-
formance-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 are generally more efficient than current prescriptive regulation, we have sought to determine what can influence the appropriateness of a given regulatory regime 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. 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 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 require 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 while controlling for the influence of external factors 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. Indeed, a good portion of the public management literature has used the JTPA as a ‘laboratory’ of sorts for the investigation of performance standards regulation (Heckman, Heinrich, & Smith, 2011: 3).

In contrast to the large-N quantitative approach in studies of job training programs, most studies of high hazard industries, buildings, and environmental management 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 their 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, that potential risks and hazards had 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 only updated 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 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, in Norway, firms 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. In addition, we address the limitations of applying lessons from non-high hazard industries to high hazard industries. Finally, we recommend topics for future research by the National Academies of Science as they assess whether or not 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 requires 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, since 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 supported by organizational procedures that support an interagency 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). It is important that standards are clear and simple as it provides 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 since it may produce inconsistencies in the enforcement of vague standards.

Further, standards should be designed to be relatively flexible in order to accommodate innovative solutions that do not comply with current legal commands (Heinrich & Marschke, 2010: 191). New scientific knowledge and innovative solutions may therefore give rise to a reevaluation and possibly adjustments of performance standards (OTA, 1995: 91). It has been argued that PBR may not
increase the flexibility of regulated entities if performance standards are capturing intermediate outcomes with a loose binding to the regulation’s ultimate goal (Coglianese, forthcoming: 20-21).

**Empirical Evidence**

**Building Regulations in New Zealand - unclear performance standards lead 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 of 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 of 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
Specifically, site managers did not know what information needed to be provided in order to create a compliant safety case, and 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 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 (Vectora 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 “it 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 cannot enforce standards uniformly (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 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), as it recognizes that allocation of resources that is non-optimal on a societal level can be caused by performance targets that direct “emphasis [towards] 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 Courty 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 (Courty & 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 only terminating participants once 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 (Courty & 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 cream skimming cheat by enrolling those with high expected earnings or low unemployment rates. The agencies were orienting towards the measurements and behaved rationally to maximize their perfor-
mance. 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 seventeen performance elements which taken together were intended to provide a representation of the quality of the plant maintenance management system, which included “Safety Critical Elements,” defined as parts of an offshore installation which work to prevent, control or mitigate major accident hazards, as well as an element which focused on the general state of the plant, and were scored using a traffic light system in order rate the quality of these element (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% of inspected facilities’ were only receiving 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.
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 companies (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 dual goals of private industry, profit maximization and provision of safety for the wellbeing 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 of the United States’ 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 requires 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, since 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 tMBR 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 was that PBR and MBR require a long-term implementation process 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 as 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 require a willingness of regula-
tors to allocate resources for this purpose which correspond with the argument that enforcement of PBR may be more costly for 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 manager 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 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 themselves 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 also 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, they were also constrained by their own budgets. Each of these factors contributed for the struggle that the UKHSE experienced in reviewing the
safety cases which were 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 report from 2014 by the Office of Inspector General for the Department of Transportation, we are skeptical that agencies 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 supported by organizational procedures that support an inter-agency learning environment.

Challenge 4: Technical and Analytical Capacity of the Regulated Entity

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 in order 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 frequently engaged in gaming behavior in order 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) that is used to demonstrate if hazards have been mitigate 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 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 were significant for multiple reasons. First of all, 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 firms first safety cases was estimated to be on the order of £1 million pounds (Grant, Moreira, & Hen-
ley, 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 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 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: 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 must therefore rely on uncertain predictive models.
Within high hazard industries, reduction of risk is rarely the performance target which 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 very difficult to measure, while highly 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 acts 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 only a reliable measure 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 PBRs arise 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 overtime (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 only required 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 towards 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 3-year to a 5-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 also 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, they 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 they relied on a variety of data sources to develop this report, including surveys, interviews, industry-reported data and historic inspection data, their findings were validated by inspecting just 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 amongst 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 offshore oil and gas industry despite these previously mentioned challenges (Bennear, 2015: 18; Paterson, 2011: 9; Vectra Group Limited, 2003: 50). While 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 as this is an empirical question and to date no empirical analyses have address this topic.

While it is not yet clear whether or not 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 amongst states with respect to the frequency 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% compared to pre-regulatory conditions, they were also more likely to take actions which 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 the regulators themselves. 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: 1720173). The proposed by-product of this process is a culture of safety in which in accordance with the 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 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 towards non-prescriptive regulation

Another 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 stand-
ards or achieve equivalent performance using alternative (and possible 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 towards 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 Programs 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 towards 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, AU, and Norway since 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 \textit{ex ante} whether MBR or PBR is likely to lead to 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 U.S. 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 towards the Innovation Center under Center for Medicare and Medicaid. The Innovation Center was established “for the purpose of testing innovative payment and service delivery models (for health care providers, red.) 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 practice and adopted in new models; (ii) engaging a broad range of stakeholders (e.g. care providers, 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 they work 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 regu-
ulatory regime in high hazardous industries will create uncertainties to both the regulator and the regulated 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 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 or its faculty.
Bibliography
Buchanan, A. H., Deam, B. L., Fragiomo, M., Gibson, Tony, & Morris, Hugh. (2006). Fifteen Years of Performance-Based Design in New Zealand. 9th World Conference on Timber Engineering.


Appendix A. Continuum of Dysfunctional Behavior

1. Gaming of chemical regulations,
2. Emphasizing quantity over quality in job training programs

Creative accounting of participants enrollment and termination in job training programs

Marginal misallocation of resources in UK safety case

Unintentional Dysfunctional Behavior

Adverse Impact on Performance

Intentional Dysfunctional Behavior

Cream skimming job training participants