Skewed Incentives: How Offshore Drilling Policies Fail to Induce Innovation to Reduce Social and Environmental Costs

Gaia J. Larsen
The accident at the Deepwater Horizon platform in the Gulf of Mexico in April of 2010 showed the potentially catastrophic damage associated with offshore oil drilling. It also highlighted both the technological advances that have made drilling in deeper and more dangerous waters feasible and affordable, and the lack of similar advances in technology to prevent harm resulting from such drilling. In light of the Deepwater Horizon disaster and current debate over offshore oil drilling, this article looks at the failure of current policies to adequately incentivize investment in innovation to reduce the environmental and social costs associated with offshore drilling. It examines three policy regimes in particular where the federal government has failed to put in place proper incentives to create technology to reduce the likelihood and severity of offshore oil spills. These three regimes include: policies to influence funding for the development of harm-reducing technology; regulations governing offshore drilling technology; and laws limiting liability for companies engaged in offshore drilling. The article finds that weaknesses in all three of these regimes decrease incentives to innovate to reduce environmental and social harm associated with offshore drilling. It concludes by providing potential policy solutions.

CONTENTS

INTRODUCTION ................................................................. 2
I. GUIDING INNOVATION .................................................. 5
   A. Theories on Innovation .................................................. 5
   B. Two Market Failures .................................................. 7
   C. The Role of Government in Encouraging Innovation .......... 9
II. FUNDING INNOVATION ................................................ 10
   A. Direct R&D Support .................................................. 10
   B. Current Programs for R&D Related to Oil Spill Cleanup .... 12
   C. Current Programs for R&D into Technology to Reduce Harm from Offshore Drilling .... 14
   D. Tax Breaks and Royalty Reliefs for Deepwater Drilling ......... 16
III. REGULATIONS AND INNOVATION ............................. 18
   A. Regulations and Technological Development ..................... 18
   B. Regulations Currently Governing Offshore Drilling Technology . 20
      1. The Safety Case Approach ....................................... 22
      2. Regulations and the Role of Industry .......................... 23
IV. INNOVATION AND LIABILITY ....................................... 24
   A. Tort Liability and Incentives to Innovate ........................ 25
   B. The Oil Pollution Act (OPA) Liability Cap ....................... 26
   C. Exceptions in the OPA .............................................. 27
      1. The Gross Negligence and Violation of Regulations Exceptions ............................................ 27
      2. No Preemption of State Laws ................................. 29

* J.D., 2010, New York University School of Law; Legal Fellow, World Resources Institute. Formerly a fellow at the Institute for Policy Integrity, during which time this paper was primarily written. I wish to especially thank Michael Livermore for his insights, assistance and guidance. I would also like to thank Katrina Wyman, Richard Stewart and David Burnett for their comments and recommendations.
INTRODUCTION

On April 20, 2010, an explosion on BP’s Deepwater Horizon platform in the Gulf of Mexico marked the beginning of a disaster that would see nearly five million barrels of oil spilled into the Gulf, resulting in almost unfathomable levels environmental and social harm. The frustrating months of failed attempts to cap BP’s gushing well during the summer of 2010 between the blowout of the well and its capping on July 5th made one thing clear: while great technological advances had been made to allow drilling for oil in deeper depths and more dangerous conditions, the oil industry had not put equal effort into developing sophisticated technology to ensure that such drilling was safe. Adequate mechanisms were not in place to prevent, stop or clean up after a deepwater drilling accident. Despite the catastrophic Deepwater accident, oil drilling off the coast of the United States looks likely to continue.\(^1\) In order to prevent further catastrophic spills, policies must be in place to ensure enhanced drilling safety.

The process of technological change does not occur automatically, nor does it inevitably follow a path that is socially optimal. Market forces will tend to drive investment into technology that reduces production costs to industry and boosts profits. The market will not automatically provide the same level of incentives for innovation to reduce social and environmental costs, however, for such innovation is less tied to the possibility of financial gain. Instead, policymakers with a broader concept of costs and benefits in mind than those considered by private industry must steer investment into innovation that is optimal for society as a whole.

An innumerable number of governance choices have some effect on innovation; any policy that influences the preferences of consumers, banks, courts, insurance companies or employees can affect the choices of potential innovators. Generally though, policies meant to support innovation can be divided into two categories: supply-side policies that reduce the cost to industry of engaging in innovation, and demand-side policies that increase the interest of industry in developing new technologies.\(^2\) Examples of supply-side policies include support for research at public institutions and more indirect subsidies to firms or other private bodies engaged in research, as well as a patent system to protect investments. On the demand side are various types of regulations, including both command-and-control and market-based mechanisms.

A body of literature has arisen in recent decades on the relative value of different types of policies for encouraging innovation. Within the environmental context, focus has frequently been


placed on the effectiveness of regulatory instruments in bringing about technological change. The focal point of attention has generally been on how to encourage innovation for enhanced pollution control; in recent years the conversation has centered particularly on greenhouse gas emissions and tactics for bringing about new technology for mitigating the effects of climate change. David Popp has, for instance, used patent data to help show the effects of environmental policies on innovation, while Rebecca Henderson and Richard Newell have proposed lessons from other industries to accelerate energy innovation. Jonathan Adler, in turn, advocated recently for the use of monetary prizes as a method for encouraging the development of new technology to help meet greenhouse gas emission reduction targets.

The conversation on the relationship between policies and innovation mirrors a broader discussion of appropriate regulatory choices for optimal environmental preservation. In recent decades this conversation has seen much analysis on how to best evolve traditional forms of environmental regulations to meet current needs. This discussion has looked at both the relative value of different types of policies, such as command-and-control regulations versus market-based mechanisms, as well as the underlying reasons behind the adoption of environmental policies.

3 See, e.g., Scott R. Milliman & Raymond Prince, Firm Incentives to Promote Technological Change in Pollution Control, 17 J. ENVT'L. ECON. & MGMT. 147, 260 (1989) (comparing types of regulatory controls in relation to innovation); Scott R. Milliman & Raymond Prince, Firm Incentives to Promote Technological Change in Pollution Control: Reply, 2 J. ENVT'L. ECON. & MGMT. 292 (1992); Paul B. Downing & Lawrence J. White, Innovation in Pollution Control, 13 J. ENVT'L. ECON. & MGMT. 18 (1986); Wesley A. Magat, Pollution Control and Technological Advance: A Dynamic Model of the Firm, 5 J. ENVT'L. ECON. & MGMT 1 (1978) (finding that both effluent taxes and subsidies raise firm investments in R&D); Bahar Celikkol Erbas, 12 ENVT'L. ECON. & POL. STUD. 139 (2010) (researching the effects of two types of regulation on pollution from the paper pulp industry); Vernon W. Ruttan, Sources of Technical Change: Induced Innovation, Evolutionary Theory and Path Dependence 4, (noting that both investment in scientific and technological knowledge and changes in market demand can induce technological change), available at: http://www.ima.kth.se/im/3c1395/pdf/Ruttan.pdf.


7 Joseph Adler, Eyes on a Climate Prize: Rewarding Energy Innovation to Achieve Climate Stabilization, 35 HARV. ENVTL. L. REV. 1, (2011) (noting the significant political pressure often involved in distributions of government funding for R&D etc.).

8 This discussion has looked at both the relative value of different types of policies, such as command-and-control regulations versus market-based mechanisms, as well as the underlying reasons behind the adoption of different types of environmental policies. E.g., David Schonbrod, Richard B. Stewart & Katrina M. Wyman, Breaking the Logjam: Environmental Protection That Will Work (2010) (suggesting a new framework for environmental governance in the United States); Robert W. Hahn, Sheila M. Olmstead & Robert N. Stavins, Environmental Regulation in the 1990s: A Retrospective Analysis, 27 HARV. ENVTL. L. REV. 377 (2003) (analyzing the growing influence of economics on environmental
This paper brings the conversation about innovation and regulatory choice to the offshore drilling industry. Specifically, it looks at the failure of current policies to provide adequate incentives to develop technology that reduces risks associated with offshore drilling,\(^9\) and suggests solutions for dealing with these problems. It considers two types of technology: that meant to prevent spills from occurring, and that meant to reduce damage once spills occur. While there is much harm associated with offshore oil extraction, including pollution resulting from the eventual use of the oil for fuel, this paper focuses specifically on the damage resulting from oil spills. Since the Deepwater Horizon accident, much discussion has focused on the culture of complacency,\(^11\) and the failure of leadership at both BP and federal agencies.\(^{12}\) Analysts have mentioned too of the lack of adequate technology available to prevent and respond to a catastrophic event.\(^{13}\) Little emphasis has been placed, however, on the systematic way in which current policies fail to encourage innovation to ensure that such technology is developed.\(^{14}\)

The paper looks at three governance regimes which currently fail to adequately push investment into technologies to reduce the social and environmental costs of spills. The first regime consists of policies that directly influence funding for the development of harm-reducing technology, such as direct grants for R\&D or royalty and tax breaks targeted at investments related to innovation. The second regime consists of regulations that currently govern offshore drilling technology. Specific focus is placed on the regulations for blow out preventers (BOPs), the mechanism that failed in the case of the accident at Macondo. The third regime consists of policies governing liability for offshore drilling spills, with a particular focus on the liability cap found in the Oil Pollution Act of 1990 (OPA).

\(^1\)\textsuperscript{9} (2010); BH. \textsuperscript{10} \textsuperscript{11} of Firm Organization and Safety, \textsuperscript{12} E.g. Nathaniel O. Keohane, Richard L. Revesz & Robert N. Stavins, The Choice of Regulatory Instruments in Environmental Policy, 22 HARV. ENVTL. L. REV. 313 (1998) (looking at the reasons why certain types of environmental policies are used and not others); Christopher H. Schroeder, Public Choice and Environmental Policy: A Review of the Literature, (Duke Law School Faculty Scholarship Series, paper 175, 2009) (giving an overview of the debate over public choice theory).

\(^{10}\) Notably, this paper focuses on the development of new technologies rather than the adoption and diffusion of existing equipment, as a thorough analysis of adoption of technology is beyond the scope of this paper. In this particular context however, where the technology in question is to be used by a relatively small number of actors (those engaged in offshore oil drilling and oil spill clean-up), policies related to innovation will tend to influence use as well.


\(^{13}\) Bob Cavnar, Disaster on the Horizon: High Stakes, High Risks, and the Story Behind the Deepwater Blowout, Chp 4, B & 9 (2010); Carl Safina, Sea in Flames: The Deepwater Horizon Oil Blowout 178-180 (2010).

\(^{14}\) The President’s Commission did though recommend an increase in federal funding to R\&D to enhance oil spill response capabilities. Commission Report, supra note 12, at 269-270.
This paper concludes that, taken as a whole, current governmental policies fail to encourage adequate investment into technologies to reduce social and environmental costs associated with offshore drilling. The government currently gives little support for the development of harm-reducing technologies, while instead providing financial incentives that encourage drilling in deeper and more dangerous waters. Meanwhile, regulations on technology are ill-designed to encourage companies to invest in technological innovations to reduce potential harms. Instead the regulations are prescriptive and based largely on standards suggested by the oil industry itself. Finally, the liability cap found in the Oil Pollution Act (OPA) of 1990 takes the pressure off industry to innovate by letting companies discount the risk that they pose on society. This paper therefore concludes with recommendations for addressing these problems.

The offshore drilling industry has made remarkable technological advances in recent decades, which have allowed deeper and faster drilling in American waters. If we choose to allow companies to use this technology to extract precious natural resources, policies must be in place to encourage technological innovation to reduce the harm of such drilling. Section II below gives an overview of the theory of what drives technological change, and the role that government can play in encouraging innovation that is optimum not only for private enterprises but also for society at large. Section III looks at the current role of taxes, royalties and direct investment in R&D in influencing the direction of innovation. Section IV analyses the role of regulations governing technology, while Section V looks at the liability cap’s effects on incentives. Section VI concludes and provides recommendations.

I. GUIDING INNOVATION

A. Theories on Innovation

There has been much speculation on the inputs and circumstances needed to encourage innovation. In the past, innovation was often modeled as simply a process that occurred almost automatically with the passage of time. Robert Solow for instance, Nobel Prize winner for his work on economic modeling and technological change, assumed such changes to be an exogenous factor in the production process. Technology was important to neoclassical growth models, since the effect of diminishing returns meant that without technological change economic growth would eventually cease. Instead of looking at the reasons for technological innovation, however, early economists focused their inquiries largely on the impact of a certain given path of technological innovation on prices, production and growth. Little attention was paid to the stimulators that drove such technological advancement. Given the relatively constant stream of new technological change through history, the traditional assumption that technology develops along a linear path is perhaps understandable. Such an assumption, however, oversimplifies the complex processes the creation and diffusion of new technology.

---

15 The choice whether to drill or not is beyond the scope of this article. While this article assumes that offshore drilling continues to be allowed off the shores of the United States, it should not be read as an endorsement of the choice to drill.
19 Studies of technological change and energy consumption from 1958 to 1974, for instance, failed to account for energy-saving innovations spurred by the energy crises of the 1970s, and so incorrectly assumed technology to increase energy...
there is greater understanding that innovation is the result of deliberate choices influenced by external factors including markets and government policy.

While technology does tend to change with time, it does not do so at a steady rate, nor in an inevitable direction. The concept that innovation is not automatic but rather responsive to outside influences was suggested by John R. Hicks in the 1930s, who posited that "a change in the relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind—directed to economizing the use of a factor which has become relatively expensive." Economists and other scholars have since continued to develop the concept that technological changes do not emerge as manna from heaven, but rather as a result of humans acting intentionally in response to market incentives and other motivators.

The concept that innovation is responsive to market influences has given rise to several theories and models related to the role and characteristics of technological change. Endogenous growth theory (or "new growth theory"), for instance, looks at the interplay between technology and "various structural characteristics of the economy and the society." Early endogenous growth models relied on the so-called AK approach, which treated technological knowledge simply as a type of capital good that responded to investment. In the 1990s, though, new endogenous growth models emerged, based largely on Joseph Schumpeter’s notion of “creative destruction.” Schumpeter believed that in the market “[p]ossibilities for gains to be reaped by producing old things more cheaply are constantly materializing and calling for new investments. These new products and new methods compete with the old methods not on equal terms but at a decisive advantage that may mean death to the latter.” According to endogenous growth models promulgated by, among others, Paul Romer, Philippe Aghion, and Elias Dinopoulous, technological change is a result of this constant process of market-based competition.

While endogenous growth theory considered the reasons behind innovation and thereby took a step away from the traditional linear, neoclassical models of technological change, others have gone further to point out the myriad factors that play into the innovative process. Kline and Rosenberg, for instance, presented a model that emphasizes that innovation “is inherently uncertain, somewhat disorderly, made up of some of the most complex systems known, and

20 Hicks introduced this concept of "induced innovation" in his book The Theory of Wages (1932).
21 Aghion & Howitt, supra note 177, at 1.
22 Id.
23 Id. at 24; Ellen R. McGrattan, A Defense of AK Growth Models, 22 FED. RESERVE BANK MINNEAPOLIS QUART. REV. 13 (1998).
24 Joseph A. Schumpeter, Capitalism, Socialism and Democracy 42 (1942).
26 Aghion & Howitt, supra note 177, at 11.
28 Aghion & Howitt, supra note 177, at 1.
29 See, e.g., Lynn K. Mytelka & Keith Smith, Innovation Theory and Innovation Policy: Bridging the Gap 10, DRUID Conference, Aalborg, June 12-15 2001 ("[E]ndogenous growth] models did not deal well with the uncertainties and dynamics that characterised changes in production and competition then underway; notably, the increasing knowledge-intensity of production and the diffusion of innovation-based competition as markets liberalised around the globe.")
subject to changes of many sorts at many different places within the innovating organization.”  
Paul Davis, in turn, stresses the role of “path dependency” in technological change, while others note the reverse processes and feedback loops inherent in technological innovation.

### B. Two Market Failures

While theories of innovation do not present one unified picture of the drivers behind new technologies, scholars today do have in common one idea: that governmental policy can—and should—influence technological development. Most contemporary growth models see a role for government policy in helping to support appropriate levels of innovation, and to steer that innovation in a productive direction. Rather than leaving the market to invest in innovation, government must provide incentives to boost and guide that investment. The need for government intervention is reinforced by market failures that decrease the incentive of the private sector to invest in developing new technology, particularly technology that will benefit society as a whole more than the investor. In the context of deepwater drilling, these market failures include, in particular, negative environmental externalities and knowledge spill-over.

In industries that produce environmental harm, environmental externalities constitute the most important market failure in relation to investment in innovation. Such externalities allow industry to pass environmental costs associated with their activities on to the public, and so reduce their interest in investing in technology to reduce environmental risks. As Popp et al. write, “[t]echnology creates positive externalities, and so the invisible hand creates too little of it,” while pollution instead “creates a negative externality, and so the invisible hand allows too much of it.” Companies that create environmental externalities benefit from placing this burden on others, and they lack an economic motivation to develop technology that limits their negative

---

33 See Daneker, supra note 322, at 108-111 (outlining the policy implications of nonlinear models).
34 In addition, investment in innovation is unique compared to other investments in that the value is frequently associated with very low-probability but potentially high-value outcomes. The chances of developing a product that can be successfully sold on the marketplaces are often low, but the potential pay-offs of developing such a product can be very large. This uncertainty is compounded by asymmetrical availability of information, in which innovators and funding sources may have access to very different types of information and perceptions. This can create significant bargaining costs and potentially leading to skewed risk calculation in which investors demand inefficiently high rates of return. These factors interact to reduce the willingness of companies, banks and other investors to put money toward innovation, leaving potential innovators constrained by a lack of credit. See Adam Jaffe, Richard Newell & Richard Stavins, *Environmental Policy and Technological Change: The Effect of Economic Incentives and Direct Regulation on Energy-Saving Innovation, 22 Envtl. & Resource Econ.* 40, 40, 44 (2002), (noting that “the developer of the technology is in a better position to assess its potential than are outsiders” which can result in investor reluctance toward funding valid research). See also Kenneth Arrow, *Economic Welfare and the Allocation of Resources for Invention, in The Rate and Direction of Inventive Activity: Economic and Social Factors 609,* 616 (Richard Nelson ed., 1962) (“The central economic fact about the processes of invention and research is that they are devoted to the production of information. By the very definition of information, invention must be a risky process, in that the output (information obtained) can never be predicted perfectly from the inputs.”).
environmental effects—unless policies exist to create different incentives. If policies are not put in place to encourage companies to internalize environmental costs, subsidies and patent protections are likely to have little effect.

A second factor behind the market’s inability to provide proper incentives to invest in innovation relates to the consistent finding by economists that society as a whole gains more than the firm that originally invested in the research and development (“R&D”). This trend is attributed largely to so-called “knowledge spillover.” Knowledge is a public good which, once created, can be used by other firms. The knowledge is thus said to “spill over” to other companies, creating a positive externality for society as a whole. The “spilled” knowledge is itself a source of innovation, since knowledge from other industries or general-purpose technologies can have a significant effect on technological change. Knowledge spillover has a negative effect on innovation too though, as the firm that invests in new technology bears all of the cost but will generally fail to capture all of the benefit. As a result, firms tend to underinvest in innovative research. The most pronounced case of knowledge spillover is in basic or “platform” research—research that is far from the stage of being ready to be sold on the market—as the value of such research may be difficult to monetize or capitalize upon at all. Such early research is particularly important to society as a whole, however, for innovation is cumulative and early discoveries bring potentially significant future impacts.

In response to the spillover problem, legal mechanisms have been developed to enable firms to capture the value of their innovations more fully. Primary among these is the patent system, which gives firms a property right to discovered information that they have discovered or created. Even the most well-developed patent system, however, will fail to enable a firm to capture the full value of an innovation. Information developed by one firm has the potential to be used and built upon in innumerable ways. To write a patent code covering all potential uses for
patented products would be a monumental task. Instead, patent laws today tend to be quite narrow—due in part to an interest in easier enforcement, and in part out of concern over the balance between monopolization and competition over new ideas. As a result, the patent system does not eliminate knowledge spillover or its negative effects on investment in innovation.

C. The Role of Government in Encouraging Innovation

In light of the inability of market forces to ensure investment in innovation at levels that encourage maximum net social benefits, appropriate governmental policies are needed to shift incentives. Though the shape that technology will take in the future cannot be predicted with certainty, governmental policies can be implemented to influence the speed and direction of its development. The government’s ability to influence technological innovation is particularly important for activities such as the exploitation of offshore oil reserves, where private and public interests do not always converge. Unlike in, for instance, the healthcare industry where there may be significant overlap between the interests of industry in creating new technologies to increase public health and the interest of the government in doing the same, industries like offshore oil drilling entail a central aim of generating profit from an activity brings some economic benefits but also great environmental risk. In such cases, the private sector will be particularly unlikely to develop socially beneficial technology.

Formulating policies to bring about desired technological change is not an easy endeavor. Many of the same uncertainties that make private parties under-invest in innovation affect the government’s investment choices as well. In addition, government faces added obstacles to inducing successful and socially beneficial technological development. These include industry opposition, consumer resistance to new products, engineering and scientific challenges, a need for complementary technologies, unanticipated impacts of new technologies, and various types of political pressures. Notwithstanding the difficulties, however, policy makers have many options to influence the speed and direction of technological development.

The lack of technology to reduce the environmental cost of oil drilling is due largely to a lack of appropriate supply and demand-side incentives for such innovation. Secretary of the Interior Ken Salazar himself recognized that the Deepwater Horizon oil spill underscored the need to “reevaluate whether the best practices for safe drilling operations developed over the

44 Kenneth Arrow, Economic Welfare and the Allocation of Resources for Invention, in The Rate and Direction of Inventive Activity: Economic and Social Factors 617 (1962) ("Patent laws would have to be unimaginably complex and subtle to permit such appropriation on a large scale").
45 Id. ("In the interests of the possibility of enforcement, actual patent laws sharply restrict the range of approducible information and thereby reduce the incentives to engage in inventive and research activities.")
46 Id., supra
47 See Federal Trade Commission (FTC), To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy 1-3 (2003) (describing the balance between competition and monopoly in relation to innovation); Kenneth Arrow, Economic Welfare and the Allocation of Resources for Invention, in The Rate and Direction of Inventive Activity: Economic and Social Factors 618 (1962) ("Thus basic research... is likely to be of commercial value to the firm undertaking it only if other firms are prevented from using the information obtained. But such restriction on the transmittal of information will reduce the efficiency of inventive activity in general and will therefore reduce its quantity also.").
48 See, e.g., Gary E. Marchant, Sustainable Energy Technologies: Ten Lessons From the History of Technology Regulation, 18 Widener L.J. 831, 835 (2009) (listing problems faced by governments trying to influence innovation); Adler, supra note 7, at 29-32 (noting the significant political pressure often involved in distributions of government funding for R&D).
years need to be bolstered to account for the unique challenges of drilling in deepwater.”

President Obama’s Commission on the BP Oil Spill and Deepwater Drilling, established to examine the root causes of the Deepwater Horizon explosion and develop options to guard against future spills, provided a similar analysis, which noted that “[m]any critical aspects of drilling operations were left to industry to decide without agency review.” The Commission’s recommendations include implementation of new safety standards and requirements that the oil and gas industry pay fees to support environmental science and regulatory review.

The following Parts evaluate current governmental policies related to technological innovation in relation to the safety of offshore oil extraction and oil spill cleanup.

II. FUNDING INNOVATION

One important supply-side incentive that drives innovation is funding. To overcome the market imperfections that reduce private investment in necessary research, development and implementation of socially-beneficial technologies, government can directly or indirectly subsidize R&D. If the private sector sees some potential benefit in the R&D in question, but nonetheless fails to invest, government subsidies can help overcome that hurdle. Where industry lacks financial interest in engaging in a particular type of R&D, because the socially beneficial technology has little marketable value or cost-saving effects for the industry, funding to public institutions such as national laboratories or universities can help fill that gap.

A. Direct R&D Support

New technology does not emerge without investment. The relationship between investment in R&D and innovation has been studied by many scholars. While the effect of R&D on innovation varies between industries, the type of investment involved, and the actor making the investment, studies generally find that investments in R&D correlate closely with growth in innovation.

An historic example of the importance of government R&D can be seen in space exploration. For many people, the first thing that comes to mind to illustrate an impressive technological feat is images of the first human steps on the moon. In 1961 President Kennedy declared that an American would walk on the moon before the end of the 1960s, and in June of 1969 that became a reality when Neil Armstrong and Buzz Aldrin landed on the moon. The 1969 Apollo mission was a success due to significant government investment in R&D. During the initial decades of space exploration, R&D investment was funded essentially entirely by public

49 DEPARTMENT OF THE INTERIOR, INCREASED SAFETY MEASURES FOR ENERGY DEVELOPMENT ON THE OUTER CONTINENTAL SHELF 18 (May 27, 2010).
51 COMMISSION REPORT, supra note 122, at 126.
52 See recommendations A1-A3 and B#. Id. at 252, 264.
money and conducted largely in government laboratories.\textsuperscript{55} It resulted not only in the lunar landing but also in other unexpected advances, both within space exploration and in other industries. Positive spillover effects from government investment in space-related R&D can be seen not least in the computer industry,\textsuperscript{56} which received important early technology thanks to the investment in space exploration. Space exploration is a unique example of induced innovation in that the federal government was the sole purchaser of the new technology. Positive effects from government investment in R&D have also been measured in many other industries, however, including the pharmaceutical and information and communication technology industries.\textsuperscript{57}

Investment in R&D is often not cheap. The Apollo program, which set the first man on the moon, came to a total cost of $25.4 billion (in 1973 dollars).\textsuperscript{58} This figure is large, particularly in light of the current political climate with its emphasis on cuts in government spending. Proper investment in R&D to reduce harms related to offshore drilling would not require such sums however. Moreover, investment in R&D commonly pays off. The investment benefits resulting from R&D investments are difficult to calculate with precision. Studies indicate, however, that government investment in R&D is often cost justifiable. A study by the National Research Council (NRC) of 39 R&D programs in both fossil energy and energy efficiency found, for instance, that the programs had contributed to the well-being of U.S. citizens by producing economic, environmental, national security, and knowledge benefits.\textsuperscript{59} They deemed that the program benefits “substantially exceed the programs’ costs and contributed to improvements in the economy, the environment, and national security.”\textsuperscript{60}

Public investment in R&D is not a guarantee of success. Such investment faces many of the uncertainties that depress private investment.\textsuperscript{61} In addition, when funding R&D projects government must decide who and what to fund which, as Aghion and Howitt write, leaves “room for genuine mistakes on the government’s part, as well as incentives on the firm’s side to waste resources lobbying for lucrative contracts.”\textsuperscript{62} This problem of picking “winners and losers” in the competition for R&D investments has received attention recently particularly in conversations about the federal government’s support for alternative energy technologies.\textsuperscript{63} The challenges associated with choosing exactly where to direct money highlight the need to ensure that R&D


\textsuperscript{56} Sharon Gaudin, \textit{How Moon Landing Changed Technology History}, COMPUTERWORLDUK.COM.

\textsuperscript{57} See generally, Rebecca M. Henderson & Richard G. Newell (eds.), \textit{ACCELERATING ENERGY INNOVATION: INSIGHTS FROM MULTIPLE SECTORS} (2011); Jesse Jenkins, Devon Swezey & Yael Borofsky, \textit{BREAKTHROUGH INSTITUTE, WHERE GOOD TECHNOLOGIES COME FROM} (2010).


\textsuperscript{61} See Adam B. Jaffe, Richard G. Newell & Robert N. Stavins, \textit{Technology Policy for Energy and the Environment}, 4 INNOVATION POL. & ECON. 35, 57 (2004) (“If the government encourages the diffusion of a particular technology, it is possible that it could become so entrenched in the marketplace that it stifles the development of some other, superior technology.”); Adler, supra note 7, at 30-34 (explaining the potential for R&D grants to become bogged down in political wrangling).

\textsuperscript{62} Aghion & Howitt, supra note 177, at 486, 489.

\textsuperscript{63} E.g., Press Release, U.S. Senate Comm. on Energy & Natural Resources, Murkowski wins Amendments to RES, June 4th, 2009 (Senator Murkowski gaining traction for her argument against the Renewable Energy Standard based in part on her argument that “government should not mandate winners and losers”).
investments are made based on sound decision making—processes, including open, transparent and systematic acquisition and procurement practices. Yet the challenges associated with public investment in R&D are not a justification for leaving all investment in innovation to the private sector. History has repeatedly shown that government investment is critical to overcoming investment barriers, and that private investors cannot be left as the sole funders of technology, especially technology that will benefit the public at large.64 Edwin Mansfield, one of the earliest and most important scholars to research the effects of R&D, found that government investment in R&D not only laid the ground for new technological advances, but also increased levels of private R&D investment.65 Government can, and at times must, step in to guide appropriate levels and types of investment in R&D.

B. Current Programs for R&D Related to Oil Spill Cleanup

The importance of government money for R&D is seen particularly well in the way that innovation related to oil spill clean-up technologies mirrors ebbs and flows in public funding. The first boom in oil spill clean-up technology came in the 1970s, following the grounding of an oil tanker off the coast of England and a blowout outside Santa Barbara, California. These disasters lead to greater resource allocations from the federal government for R&D and a resulting step forward in the national capacity to respond to oil spills.66 ADD By the mid 1980s, however, memories of the Santa Barbara blowout had faded, and investment in R&D for new oil spill technologies waned as a result.67

Then, in 1989, the Exxon-Valdez oil spill in Alaska occurred, and interest in improving oil spill response capabilities peaked again. Largely as a result of the Exxon-Valdez spill, Congress passed the Oil Pollution Act (OPA) in 1990.68 The Act significantly increased federal funding for research into oil spill cleanup, mainly through authorization of the Oil Spill Liability Trust Fund (OSLTF), which is financed primarily through a five-cent levy on every barrel of oil produced in or imported into the United States.69 In addition to the OSLTF, section 2761 of the OPA created the Oil Pollution Research and Development Program, coordinated by an Interagency Coordinating Committee on Oil Pollution Research, which consists of representatives from the Department of Commerce (including NOAA), the Department of

---

64 See generally REBECCA M. HENDERSON & RICHARD G. NEWELL, supra note 6 (discussing ways in which government investment has played a role in encouraging innovation success in various fields); JESSE JENKINS, DEVON SWEZY & YAELE BOREFSKY, BREAKTHROUGH INSTITUTE, WHERE GOOD TECHNOLOGIES COME FROM (2010) (showing the role of government investment in the development of several types of technology); VAN GEEHUIZEN, ET AL., supra note 4 (indicating the way in which different governments have helped encourage energy innovation). See also, Lewis Milford, Picking Winners and Losers, blogpost, available at: http://www.cleaneconomy.org/blog/picking-winners-or-losers/#post-comments.
67 Id.
69 Collection of this fee ceased on December 31, 1994, because of a “sunset” provision in the law. However, in April 2006, the tax resumed as required by the Energy Policy Act of 2005. The OSLTF receives funds from four primary sources: interest on fund principal; cost and damage recovery from parties responsible for oil spills; and penalties (to include civil penalties). The OSLTF has two major components, an “emergency fund” and a “principal fund.” Funds from the principle are used to, among other things, support research and development in oil clean-up solutions. For more information see: http://www.gomr.mms.gov/homepg/regulate/regs/laws/osltf.html.
Energy, the Department of the Interior, the Department of Defense, and the Environmental Protection Agency.\textsuperscript{70}

Since the Act’s passage in 1990, OPA funding, funneled primarily through the OSLTF, has helped several federal agencies and programs engage in R&D related to oil spill cleanup. The U.S. Coast Guard, for instance, used its funding to conduct research into oil spill response planning and management, oil detection and surveillance, and spill cleanup and alternative countermeasures.\textsuperscript{71} These efforts led to a new database system for cataloging available response equipment and personnel, new fire-resistance booms, and new sensor equipment, among other things.\textsuperscript{72} In addition to the Coast Guard’s work, the Bureau on Ocean Energy Management, Regulation and Enforcement (BOEMRE)\textsuperscript{73} runs an Oil Spill Response Research (OSRR) Program funded largely through the OSTLF. The program’s main topic areas for research include remote sensing and detection of spilled oil, assessing the physical and chemical properties of crude oil, mechanical containment and recovery, developing chemical treating agents and dispersants, in situ burning, and deepwater operations.\textsuperscript{74} The program also oversees operations at the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) in Leonard, New Jersey, a facility capable of simulating conditions on the open sea for research and testing purposes.\textsuperscript{75}

In addition to the work of the Coast Guard and BOEMRE, the National Oceanic and Atmospheric Administration (NOAA) runs a Costal Response Research Center focused on developing new responses to oil spills and new methods of environmental restoration. The center is a collaboration between NOAA's Office of Response and Restoration and the University of New Hampshire. To date its work has focused largely on the impact of oil spills and current oil spill response techniques, such as dispersants.\textsuperscript{76} Finally, section 5001 of OPA authorized the creation of a Prince William Sound Oil Spill Recovery Institute (OSRI), with a mission to “identify and develop the best available techniques for preventing and responding to oil spills in the Arctic and sub-Arctic.”\textsuperscript{77} OSRI’s work focuses on understanding and responding to oil spills,\textsuperscript{78} and it has supported research in applied technology and predictive ecology.\textsuperscript{79}

The government’s investment in oil spill research has paid off. In evaluating the results of the first ten years of research after passage of the OPA, the U.S. Coast Guard estimated that technology developed during that time may have brought future cost savings of $1 to $2 billion over a ten-year period.\textsuperscript{80} A study conducted by Dagmar Etkin and Peter Tebue found similar results. The authors analyzed the cost savings associated with developments in the three primary oil removal technologies: mechanical recovery, use of dispersants, and in situ burning. Their analysis consisted of a comparison of the environmental, socio-economic and cleanup costs

\textsuperscript{70} \textsc{Coast Guard Report, supra} note 66, at 1.
\textsuperscript{71} \textit{Id.}
\textsuperscript{72} \textsuperscript{Formerly known as the Minerals Management Service (MMS).}
\textsuperscript{74} "About the Ohmsett Facility, available at: http://ohmsett.com/facility.html."
\textsuperscript{75} More information on the center is available at: http://www.crrc.unh.edu.
\textsuperscript{76} 33 U.S.C. § 2731 (2011).
\textsuperscript{80} \textsc{Coast Guard Report, supra} note 66, at 1.
associated with the three technologies before passage of the OPA, compared with ten years later. Their findings indicate that R&D investments created new oil spill clean-up technologies, such as improved dispersants and booms, with the capacity to produce net cost savings “on the order of hundreds of millions of dollars” over a decade, as compared to technologies in existence prior to the Exxon-Valdez disaster.\(^81\)

Unfortunately, however, despite the high rate of return, funding for oil spill cleanup has steadily declined since the initial years after the passage of OPA. Indeed, only half of the funds authorized for oil spill research and development in the OPA were ever appropriated.\(^82\) Ten years after passage of the Act, the Coast Guard had cut its R&D spending by ninety percent, down to $300,000 in 2001 from its peak at $4 million in 1993.\(^83\) The Interagency Coordinating Committee’s Oil Pollution Research and Technology Plan confirmed in 1997 that for federal agencies tasked with oil spill prevention and response, “the historically cyclical nature of public attention and funding” had occurred as policy makers and the public turned their eyes toward other concerns.\(^84\)

Today, innovators in the field report that a lack of funding is a substantial hindrance to the continued development of oil spill clean-up technologies. Nancy Kinner of the Coastal Response Research Center reports that “[a] large infusion of funding for oil spill preparedness, prevention, and response came after the Exxon Valdez in 1989, encouraged in part by implementation of OPA. While R&D funding was authorized and appropriated…the budgets have not grown commensurate with inflation, resulting in less R&D as time goes on.”\(^85\) Scott Pegau of the Oil Spill Research Institute echoes Kinner’s words, noting that “over the past few years the funding level has continued to decline.”\(^86\) Pegau blames the lack of funding on the small budgets of the Coast Guard, BOEMRE and NOAA, and on the lack of a national oil pollution research plan which, he says, “makes it more difficult to sell the needs for particular research.”\(^87\) The report from the President’s Commission agreed with these statements, finding that both federal and non-governmental research and development in the area are under-funded.\(^88\)

**C. Current Programs for R&D into Technology to Reduce Harm from Offshore Drilling**

While oil spill cleanup technologies have seen funding cycles ebb and flow, safety technologies have not experienced any booms in funding. BOEMRE is the federal bureau primarily responsible for supporting innovation related to the safety of drilling offshore. As part

---


\(^82\) COMMISSION REPORT, supra note 122, at 269.

\(^83\) COAST GUARD REPORT, supra note 66.

\(^84\) INTERAGENCY COORDINATING COMMITTEE ON OIL POLLUTION RESEARCH, OIL POLLUTION RESEARCH AND TECHNOLOGY PLAN 1 (1997).


\(^87\) Id.

\(^88\) COMMISSION REPORT, supra note 122, at 269. Recommendation C4 states: “Congress should provide mandatory funding for oil spill response research and development and provide incentives for private-sector research and development.” Id. at 270. Recommendations C5 and C6 call for further research into the use of of dispersants and offshore barrier booms. Id. at 271.
of that mission, the agency runs a Technology Assessment and Research (TA&R) Program to support research associated with operational safety and pollution prevention. The TA&R program includes an Operational Safety and Engineering Research (OSER) Program. Through OSER, BOEMRE partners with private and public institutions to conduct research on the risks and potential rewards associated with new drilling techniques, new drilling materials, the unique challenges of deepwater exploration, and other relevant safety issues. In addition to these R&D programs, BOEMRE presents a Safety Award for Excellence (SAFE Aware) each year at district and national levels to companies with exemplary safety records.

Other federal agencies also support R&D related to offshore drilling and oil spills. The Department of Energy’s National Energy Technology Laboratory (NETL) conducts research into new technologies related to enabling continued and safe exploitation of domestic oil and gas reserves. NETL’s project portfolio includes both onsite research and research conducted through partnerships, cooperative research and development agreements, financial assistance, and contractual arrangements with universities and the private sector. Also, The Department of Transportation has a Pipeline and Hazardous Materials Safety Administration (PHMSA), which runs an R&D program on pipeline safety, including offshore oil pipelines.

Finally, Section 999 of the Energy Policy Act of 2005 provided $50 million in federal funding per year for ten years dedicated to the research, development, and commercial application of technologies for “ultra-deepwater and unconventional natural gas and other petroleum resource exploration and production.” This money has been used to fund the Research Partnership to Secure Energy for America (RPSEA), a consortium of U.S. universities, industry and independent research organizations. The goals of the RPSEA are to extend basic understanding of the challenges involved in ultra-deepwater drilling, develop new technologies to allow safe exploration of oil in ways impossible with existing technologies, and enhance existing technologies to reduce the time it takes to develop an oil field.

The BOEMRE TA&R Program and the NETL and RPSEA initiatives provide important research into the risks associated with new offshore drilling technology, and they provide incentives for further technological development. Unfortunately, however, the programs are small in size with small budgets and so have not been able to induce development of technology to a sufficient degree to ensure that drilling can be conducted safely without undue risks to the environment. The lack of technology available to respond adequately to a catastrophic blowout such as that which occurred at the Deepwater Horizon platform is a prime example of how research has failed to keep pace with development of new exploration techniques.

The risks of a catastrophic blowout were not unknown to the industry or federal agencies prior to the Deepwater Horizon incident. An Environmental Assessment of a deepwater well

---

89 For a list of projects related to drilling see: http://www.boemre.gov/tarprojectcategories/drilling.htm.
89 For a list of projects related to new materials see: http://www.boemre.gov/tarprojectcategories/material.htm.
89 For a list of projects on deepwater research see: http://www.boemre.gov/tarprojectcategories/deepwate.htm.
89 About RPSEA, http://www.rpsea.org/about.
89 For an overview of the technologies used to respond to the disaster see Commission Report, supra note 12, at 129-170.
proposed by Shell Deepwater Development Inc., written by BOEMRE (then MMS) in 2000 as required under National Environmental Protection Act (NEPA), admitted that little was known about the potentially increased risks associated with blowouts in deeper waters.\textsuperscript{100} The assessment acknowledged: “[t]he form that a[n oil] slick will take if released during a subsea blowout may be very different from oil spilled at the surface and may affect the residence time of the slick. Very little is understood about the chemical behavior, transport, and physics of the rising plume during a subsea blowout.”\textsuperscript{101} Despite these findings, however, the report concluded that the proposed drilling activities “would not cause significant or undue harm to the quality of the human environment,”\textsuperscript{102} thus eliminating the need for a full Environmental Impact Assessment under NEPA.

BOEMRE (and its predecessor) have commissioned at least twelve studies related to blowout prevention and mitigation since 1979.\textsuperscript{103} Several of the studies warn of the major damage that could arise with a deepwater blowout, and the lack of available technology to prevent such catastrophe. As an example, the most recently commissioned study found that “where there has been a catastrophic failure either of the surface equipment, the wellhead system or high casing, or at almost any point where influx is flowing outside of the blowout preventers, options [for restoring control over the well] become very rapidly non-existent.”\textsuperscript{104} A study conducted by PCCI, Inc., a marine and environmental engineering company, similarly identified many technical hurdles to stopping an uncontrolled flow of oil from a deepwater blowout.\textsuperscript{105} The government was thus aware of the risks. Nonetheless, the agency failed to spur the creation of adequate safety technology to balance out the development of new technologies for deeper drilling.

D. Tax Breaks and Royalty Reliefs for Deepwater Drilling

Beyond directly funding R&D, another method for encouraging technological development is to influence the cost to producers of certain types of investments, such as those involving risk to human health and the environment. This can be done, for instance, by tailoring the levels of taxes or royalties paid by industry based on the risk level of their activity.\textsuperscript{106} A classic example of such a policy is a pollution tax: the more an industry risks human and ecological health through pollution, the higher the tax it must pay. This can help incentivize new pollution-reducing technology.

In the oil industry, economic incentives for technological development have come largely in the form of tax breaks and royalty relief associated with the production of oil. These subsidies have encouraged innovation. Unfortunately, however, they have tended to reinforce already

\textsuperscript{100} Shell Deepwater Development Inc., Site-Specific Environmental Assessment, Initial Development Operations Coordination Document No. N-6570, Appendix D 3 (May 9, 2000).
\textsuperscript{101} Id. at D 9.
\textsuperscript{102} Id. at ii.
\textsuperscript{103} A list of all research projects commissioned by BOEMRE related to drilling is available at http://www.boemre.gov/tarprojectcategories/drilling.htm. See also DEPARTMENT OF THE INTERIOR, INCREASED SAFETY MEASURES FOR ENERGY DEVELOPMENT ON THE OUTER CONTINENTAL SHELF 6-7 (2010), available at: http://bit.ly/b3VnFB.
\textsuperscript{104} Jerome J. Schubert et al., Development of a Blowout Intervention Method and Dynamic Kill Simulator for Blowouts Occurring in Ultra-Deepwater 4, (Minerals Management Services Project No. 408, 2004).
\textsuperscript{105} PCCI, Inc., Oil Spill Containment, Remote Sensing and Tracking for Deepwater Blowouts: Status of Existing and Emerging Technologies (Minerals Management Services Project No. 311, 1999).
existing incentives for industry to drill in deeper and more risky reserves, rather than encourage innovation toward minimizing social and environmental harm. According to the Congressional Budget Office, the petroleum and natural gas industry faces an effective tax rate of 9.2 percent. This is sixty-five percent below the average tax rate in the corporate sector of 26.3, and a lower tax level than enjoyed by essentially any other industry.107 Some of the tax breaks originate nearly a century ago and were intended at that time to encourage development of new technology when only rudimentary drilling techniques were available.108 While the low tax rates for the oil industry is the result of multiple sources of tax breaks, one of those sources is a deduction for intangible drilling costs associated with exploring and drilling for oil.109 The American Petroleum Institute (API), one of the oil industry’s largest lobbying groups, itself views this tax deduction as no different from a deduction to encourage R&D received by other industries.110 It reports that the deductions cover “the wages of workers developing new or improved drilling techniques to get at hard to reach gas or the fuel needed to transport a drilling rig to drill wells in new, unproven locations.”111 In May 2011, democrats in the Senate attempted to pass a bill to revoke the tax breaks enjoyed by the oil industry, but fell short of obtaining the required votes.112 The tax breaks also survived through negotiations over recently passed debt package. These breaks encourage innovation to increase drilling, but not to reduce environmental and social harms.

In terms of royalties, the Outer Continental Shelf Lands Act (OCSLA) allows the Secretary of the Interior to “reduce or eliminate any royalty or net profit share” in order to promote development of leased lands and encourage production of marginal resources.113 In 1995, Congress passed the Outer Continental Shelf Deep Water Royalty Relief Act (DWRRA).114 An Act meant to enhance domestic energy security by encouraging extraction of hard-to-reach oil. The DWRRA allowed the Secretary of the Interior to grant royalty relief for new production from any well located in water depths of 200 meters or greater in the Western and Central Planning Areas of the Gulf of Mexico.115 In making determinations as to levels of relief, the Secretary was to consider “all costs associated with exploring, developing, and producing from the lease” including the “increased technological and financial risk” of the deep-water development.116

108 David Kocieniewski, As Oil Industry Fights a Tax, it Reaps Subsidies, N.Y. TIMES, July 3, 2010. The low tax rates for the oil industry stem from multiple sources of tax breaks, including a deduction for intangible drilling costs associated with exploring and drilling for oil. These costs include such things as wages, fuel and repairs, and generally make up 65-80% of total costs, and are up to 100% deductible in the first year.
109 26 U.S.C. 263(c); Mark Cussen Oil, a Big Investment with Big Tax Breaks, INVESTOPEDIA, Feb. 9, 2011, available at: http://www.investopedia.com/articles/07/oil-tax-break.asp#axzz1Pm3XjYkL.
112 Carl Hulse, Senate Refuses to End Tax Breaks for Big Oil, N.Y. TIMES, May 17, 2011.
116 Id.
The Energy Policy Act of 2005 similarly encouraged oil extraction from undeveloped deepwater reserves. The 2005 Act attempted to provide comprehensive energy legislation and was passed in light of growing concern over the United States’ dependence on foreign energy sources. While the Act provided tax incentives for energy efficiency and for research into renewable and alternative resources, it also provided significant tax reprieves for the harvesting of fossil fuels. Section 345 of the Act allows royalty relief for drilling in the Gulf of Mexico in waters deeper than 400 meters.\(^{117}\) The volume of oil exempted from royalties increases with the depth of drilling: wells in water depths between 400 and 800 meters, up to 5 million barrels of oil equivalent, can be free of royalties; for water depths greater than 2,000 meters, the number of exempted barrels goes up to 12 million.\(^{118}\) By reducing the cost of deepwater oil extraction, these royalty reductions encourage the oil industry to develop technologies that enable drilling in more harsh and dangerous conditions. The royalty reductions do not, however, ensure simultaneous development of technology to respond to the environmental risks associated with such drilling.

### III. Regulations and Innovation

In addition to systems that provide funding for technological development, the regulatory system can also be used to require or encourage private investment in the development and use of socially-beneficial technology. The link between regulations and innovation is not straightforward. Nonetheless, while investment into R&D encourages innovation by reducing costs, the regulatory system can push companies to develop new technologies. Regulations can, for instance, put in place emissions standards or similar requirements that necessitate the invention of new technology. While current regulations governing offshore drilling may encourage a degree of innovation to reduce social and environmental risks, there is much room for improvement.

#### A. Regulations and Technological Development

Regulations can be technology-based or performance-based. Technology-based standards require adherence to a certain method of production or use of a designated type of technology. In the offshore drilling context, a technology-based standard would define requirements for drilling safety based on existing technology. Performance-based standards on the other hand set targets based on acceptable levels of risk, and then allow some flexibility in how these targets are met. A performance standard for offshore drilling would thus be set based on an evaluation of how much risk can be acceptably be placed on society.

Evaluating and comparing the efficacy of these two types of command-and-control regulations in encouraging innovation is not straightforward. Both types of regulation tend to have some effect on innovation, since both induce or require a company to act differently than it

\(^{117}\) 42 U.S.C.A § 15905 (2010).

\(^{118}\) 42 U.S.C.A § 15905(b) (2010). Royalty relief is calculated based on the following formula:

(b) SUSPENSION OF ROYALTIES.—The suspension of royalties under subsection (a) shall be established at a volume of not less than—

1. 5,000,000 barrels of oil equivalent for each lease in water depths of 400 to 800 meters;
2. 9,000,000 barrels of oil equivalent for each lease in water depths of 800 to 1,600 meters;
3. 12,000,000 barrels of oil equivalent for each lease in water depths of 1,600 to 2,000 meters; and
4. 16,000,000 barrels of oil equivalent for each lease in water depths greater than 2,000 meters.
otherwise would have. Generally though, economists tend to consider performance-based standards as more innovation-inducing. Technology-based standards may bring incentives to reduce equipment costs, but otherwise provide little motivation to create new technologies to reduce social and environmental harms. Instead risk they risk “locking in” a particular type of technology by encouraging industry to invest in and become dependent upon that particular type of equipment. Performance-based standards, on the other hand, can more easily create incentives for firms to reach environmental goals, and so may provide greater motivation for companies to develop enhanced technology.

One factor in the success of all types of regulations in inducing technological change is the stringency of the regulations. More stringent standards will tend to force development and use of new technology, rather than merely marginal changes to existing equipment and adaptation of existing technology. This is particularly true if regulations require adherence to standards that are considered technologically infeasible when the legislation is passed—so-called “technology-forcing” standards. Such standards bring certain drawbacks: they require more compliance time and involve greater uncertainty because it is difficult to accurately predict the level of technology that industry is capable of producing. Ultimately, however, more stringent regulations will provide greater impetus for innovation to more reduce environmental harm than weaker ones.

119 Adam Jaffe, Richard Newell & Richard Stavins, Environmental Policy and Technological Change: The Effect of Economic Incentives and Direct Regulation on Energy-Saving Innovation, 22 ENVTL. & RESOURCE ECON. 41, 50 (2002) (all types of regulations “have the potential for inducing or forcing some amount of technological change, because by their very nature they induce or require firms to do things they would not otherwise do”).

120 See Popp, Newell, Jaffe, supra note 40, at 11. Avoiding such lock-in is of particular importance under non-linear models of innovation, which emphasize the effect of past decisions on present choices. See Paul David, Technical Choice, Innovation and Economic Growth (1975) (emphasizing the role of “path dependency” in the direction of technological innovation); Daneke, supra note 32, at 108 (noting that a “lock in” of technology “must be guarded against” under nonlinear models).


122 See, e.g., Scott R. Milliman & Raymond Prince, Firm Incentives to Promote Technological Change in Pollution Control, 17 ENVTL. ECON. & MGMT. 247-265 (1989); René Kemp, Technology and Environmental Policy: Innovation effects of past policies and suggestions for improvement 36, Organization for Economic Co-operation and Development (OECD) (2006). But see David Ulph, Environmental Policy and Technological Innovation, in New Directions in the Economic Theory of the Environment 43, 51 (Carlos Carraro & Domenico Siniscalco eds.) (finding that while environmental taxes did have a direct effect of increasing R&D spending, the indirect effect of restricting output made the ultimate effect of taxes on innovation ambiguous).


124 Nentjes, de Vries & Wiersma, supra note 123, at 906.
A good example of the role of regulation is seen in the Clean Air Act (CAA) and the phase-out of leaded gasoline. Passage of the CAA and subsequent amendments had an important influence on the development of new technology to reduce air pollution. Lead was first introduced into gasoline in the 1920s to enhance octane levels. Prior to passage of CAA Amendments, refiners were allowed to add up to four grams of lead per gallon.\textsuperscript{125} Section 211 of the CAA, as Amended in 1970, granted the EPA authority to regulate fuel or fuel additives for use in a motor vehicle, motor vehicle engines, or off-road vehicles if the resulting emissions may reasonably be anticipated to endanger public health or welfare.\textsuperscript{126} The first regulatory program implemented by the EPA under Section 211 phased out the use of lead in gasoline.\textsuperscript{127} The health-based regulations required refineries to limit lead in gasoline to 1.7 grams per gallon (on average across both leaded and unleaded fuels) by 1975, and 0.5 grams per gallon by 1979.\textsuperscript{128} In 1990, Congress amended the CAA yet again to provide for a total phase out of lead in gasoline by 1995.\textsuperscript{129} Largely as a result of the new lead standards, refineries developed new methods for producing high-octane gasoline without the use of lead.\textsuperscript{130} The success of the lead regulations in encouraging the development of new harm-reducing technologies can be attributed in part to their stringency. When studying the effect of regulations on the phase-out of leaded gasoline, Suzi Kerr and Richard Newell, for instance, that a “10% increase in the stringency of gasoline lead regulations was associated with about a 40% increase in probability of new adoptions by refineries.”\textsuperscript{131}

Performance-based standards on industries that produce on-going and regular pollution, such as the automobile industry, may be somewhat easier to conceptualize than similar standards for industries where pollution comes in the form of unpredictable accidents. Automobiles (and many other industries) emit regular and predictable amounts of pollution which can be capped through regulation. Oil drilling from oil drilling comes less predictably in the form of oil spills. Performance-based regulations can be applied even in the case of these less predictable forms of emissions, however. Such regulations can require that offshore drilling companies put in place measures to ensure low levels of risk, and to show how they are ensuring such risk reductions.

\begin{itemize}
\item \textsuperscript{125} They typically added around 2.5 grams. U.S. Energy Information Administration, Petroleum Chronology of Events 1970-2000, \textit{available at}: http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/chronology/petroleumchronology2000.htm#T_1
\item \textsuperscript{126} Clean Air Act Section 211(c)(1), 42 U.S.C. 7545(c)(1) (2011).
\item \textsuperscript{127} Lead phasedown regulations are codified in 40 C.F.R. 80 (2011).
\item \textsuperscript{128} 38 Fed. Reg. at 33,741 (formerly codified at 40 C.F.R. 80.20(a)(1))(1976).
\item \textsuperscript{129} Section 211(k) of the CAA states: "After December 31, 1995, it shall be unlawful for any person to sell, offer for sale, supply, offer for supply, dispense, transport, or introduce into commerce, for use as fuel in any motor vehicle...any gasoline which contains lead or lead additives." 40 C.F.R. 80.22 (2011).
\item \textsuperscript{130} Including downstream conversion units to create new blending components, new catalysts to enhance the capacity of refiners to generate high volumes of high-octane components, and other gasoline additives to substitute for the lubricating qualities of lead. U.S. Energy Information Administration, Petroleum Chronology of Events 1970-2000, \textit{available at}: http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/chronology/petroleumchronology2000.htm#T_1
\item \textsuperscript{131} \textit{Id.}
\end{itemize}
B. Regulations Currently Governing Offshore Drilling Technology

Many overlapping federal and state laws apply to offshore oil drilling and oil spills, including the Clean Water Act, which can impose civil or criminal penalties on oil pollution. Regulations governing offshore drilling are implemented by BOEMRE and find their authority in the Outer Continental Shelf Lands Act (OCSLA). These regulations control leasing, exploration, development, and production of mineral resources in the outer continental shelf. They are codified in 30 C.F.R. 250. Subparts D and E cover all aspects of the drilling operation including permitting, casing requirements, cementing requirements, diverter systems, BOP systems, drilling fluid requirements, equipment testing, and reporting. The regulations are primarily technology-based. According to section 250.107(c), operators “must use the best available and safest technology (BAST) whenever practical on all exploration, development, and production operations.” The regulations contain detailed descriptions of technological requirements for building, maintaining and decommissioning offshore drilling platforms, and the agency generally considers “compliance with [the] regulations to be the use of BAST.” Though the regulations contain some performance-based standards, they are generally prescriptive, with detailed descriptions of technological requirements for building, maintaining and decommissioning offshore drilling platforms, thus limiting the incentive to create new technologies. Section 250.442, for instance, lists specific technological requirements for BOPs. The requirements can be compared with, for instance, those found in Norway, where laws require industry to specify how they are living up to strict standards that are more performance-based and less prescriptive than those promulgated by BOEMRE.

As noted, technology-based standards such as those governing offshore drilling could stymie innovation by locking in place the use of a certain type of technology, for such a standard is based on the technology currently available to prevent and stop a spill – not desired levels of safety. The history of the offshore drilling regulations shows evidence of a lack of innovation in the areas. TA&R program administered by BOEMRE is meant to inform and update offshore

---

132 Section 311 of the Clean Water Act (CWA) makes illegal “discharges of oil or hazardous substances into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone.” 40 C.F.R. 110. The CWA allows civil penalties up to either $25,000 per day of violation or $1,000 per barrel of oil spilled. If the spill is found to be the result of gross negligence or willful misconduct, civil penalties rise to not less than $100,000 per day and not more than $3,000 per barrel. The CWA allows for criminal penalties as well of 1-15 years. 33 U.S.C. 1321(b)(1); 33 U.S.C. 1319(6)(c).
136 Id. An operator can however get approval to use a different technology from the District Manager. 30 C.F.R. 250.408-409 (2011).
drilling regulations, and occasionally such updates do occur. But the updates have been infrequent. Regulations covering subsea BOPs, for instance, went essentially unchanged from 1988 until the date of the Deepwater Horizon disaster. The agency’s definition of the “best available technology” went unchanged for decades.

In a report commissioned by the President and released by the Department of the Interior on March 27, 2010, Secretary Salazar acknowledged the value of considering a more performance-based approach to regulation, and outlined recommendations for enhanced regulations including improved reporting and performance requirements for offshore drilling and BOPs. Several of these recommended changes became codified in September 2010, when the agency issued new drilling safety rules through an emergency rulemaking process. The new requirements respond specifically to the technical and safety problems revealed by the Deepwater Horizon blowout. They include new requirements to address the integrity of a well and new obligations related specifically to BOPs. These changes are welcome but more are needed. Policies ought to be in place to recognize the need for changes at an earlier stage, before such catastrophic losses occur, and to push companies to continue to develop improved equipment to reduce environmental and social costs.

1. The Safety Case Approach

Since the Deepwater spill, much attention has been given to the application of the so-called “safety case” approach to regulating offshore drilling operations. Such a system generally requires companies to conduct site-specific risk assessments, and to create safety management plan for mitigating risks. These plans are then enforced by regulators. The safety case approach is currently used in Norway, for instance, and is seen by many as an alternative to traditional regulations. The increased flexibility of this system is a potentially positive development in that it may reduce the risk of complacency associated with traditional technology-based regulations. However, the approach will not necessarily create greater incentive to innovate. Handing too much responsibility to industry will likely also lead to idleness regarding technological development, since industry actors are unlikely to create management plans that encourage technological development unless pushed to do so. For the safety case approach to provide incentives to innovate, policies will need to at least ensure that industry is held to high standards of risk reduction, standards that are able to encourage or even force technological development.

In October of 2010, Secretary Salazar made safety and environmental management systems (SEMS) mandatory for all offshore drilling operations. SEMS were previously only a

---

139 Requirements for sheer ram capabilities, for instance, were improved after studies indicating such a need. See Department of the Interior, Increased Safety Measures for Energy Development on the Outer Continental Shelf 8 (2010), available at: http://bit.ly/b3VnF8.
141 For instance, they compel operators to comply with new requirements for cementing and casing, 30 CFR 250.415 (2011); 30 CFR 250.420 (2011), install secondary control systems with remote operated vehicle (ROV) intervention capabilities, 30 CFR 250.442(d)-(f) (2011), and provide further training for personnel, 30 CFR 250.442(j) (2011).
144 DET NORSKE VERITAS, supra note 135.
recommended practice. The management systems require offshore drilling companies to assess hazards and methods for reducing risks. The move toward mandatory reporting requirement is a positive development toward a greater emphasis on safety. The guidelines for the SEMS are based entirely on the API’s Recommended Practice 75, however, and are not designed to encourage development of new technologies. Greater demands should be placed on industry to ensure enhanced safety, through both regulations and management system requirements.

2. Regulations and the Role of Industry

One reason behind the lack of regular updates of drilling regulations is resistance from industry. Oil rig operators, for instance, resisted the imposition of a rule to make mandatory the use of remote-controlled shut-off mechanisms such as acoustic switches, which can be used to trigger an underwater valve that shuts down a well even if the rig is damaged or evacuated. In 2003, BOEMRE agreed that the potentially additional security that the devices brought did not justify their cost (an acoustic trigger costs around $500,000), and so decided to not require them. This decision is now being questioned because remote-controlled shut-off mechanisms may have prevented the Deepwater Horizon blowout. Had regulations been more strict, the blow-out may not have happened.

To assist in keeping regulations up-to-date, BEOMRE incorporates by reference recommended practices and standards from industry associations and technical standard-setting groups. Many regulations, for instance, including those governing BOPs, incorporate word-for-word technological standards created by the American Petroleum Institute (API), one of the oil industry’s largest lobbying groups. Reliance on industry to drive safety standards for offshore drilling is not new. M’Gonigle and Zacher complained in 1979 that the process of defining technical standards was reliant on the regulated industry itself. The 1954 and 1962 requirements for non-tankers were, they write:

in effect, emasculated because the necessary technologies were supposedly unavailable. Meanwhile, the industry kept its own "load-on-top" system for tankers under wraps until it…decided to unveil it. This was also to an extent the case with crude-oil-washing, a system that had been considered as early as 1967 but was rejected as "uneconomical." Only when its use became profitable after the OPEC price rise was the system touted for its environmental advantages.

A similar system of industry self-regulations continues today, with a total of 78 API standards referenced in BOEMRE offshore regulations. Industry has access to more information than does the agency regarding available technologies and drilling opportunities and challenges. By-in from industry can also be helpful to boost compliance with the regulations.

---

148 Id.
149 Id.
150 See, e.g., 30 C.F.R. § 250.244(c) (2011); 30 C.F.R. § 250.446 (2011); 30 C.F.R. § 250.800 (2011).
Engagement by companies in rulemaking processes is thus reasonable to a degree. But over-reliance on industry recommendations will stymie a push for new technologies, particularly technology focused on reducing environmental and social harm. Reliance on industry to both regulate and innovate creates scant leverage against the natural tendency of industry to under-invest in environmentally protective technology. Instead of encouraging development of technology to ensure environmental safety, such reliance threatens to retard innovation and timely development of new safety technology.

The role of the API and similar industry bodies in the creation and maintenance of regulations can also dampen incentives for small innovators to develop new technologies. Best available technology standards such as the BOEMRE regulations can theoretically encourage third parties to invent and patent new technologies for industry-wide implementation. A study conducted by the Organization for Economic Cooperation and Development (OECD) found that smaller and newer firms generally tend to develop more innovative responses to regulation. “A possible explanation for this,” writes René Kemp, “is that incumbent firms, especially the big ones, are vested in old technologies—both economically and mentally.”

Small innovators will be less encouraged to innovate however if prescriptive regulations are not updated to reflect new innovations, and industries are not otherwise egged on to implement the new technology, for such circumstances limit the market for their products by reducing the incentive for companies to purchase new technologies. In the offshore drilling context, the API has been accused by some of hindering innovation by third parties by refusing to update their standards to endorse the new technologies. Inventor Ben van Bilderbeek, for instance, believes that API is a major culprit behind his fifteen-year unsuccessful efforts to get the oil establishment to endorse use of a new drilling technique, a technique that van Bilderbeek claims is safer, cheaper and more efficient than current methods of drilling. Van Bilderbeek’s story is echoed in that of Kevin Costner, who in June 2010 testified to the Senate Committee on Small Business and Entrepreneurship regarding the significant difficulty he faced in getting the industry to take interest in his innovative mechanism for oil clean up. Both van Bilderbeek and Costner complain of a resistance to change amongst established industry. BOEMRE’s use of API standards as a basis for regulations presents a risk of projecting industry’s resistance onto the regulatory framework, and so further stifling the incentive to innovate.

IV. INNOVATION AND LIABILITY

A third way in which current policies stifle technological innovation is by limiting the ability of the tort system to ensure that the oil industry internalizes all of its costs. By limiting the amount of damages that oil companies must pay in the case of a spill, liability caps can prevent

---

153 René Kemp, Technology and Environmental Policy: Innovation effects of past policies and suggestions for improvement 36, Innovation and the Environment, Organization for Economic Co-operation and Development (OECD) (2006). See also Benjamin & Rai, supra note 43, at 13 (“the theoretical and empirical literature indicates that small, entrepreneurial firms with little ability (relative to powerful incumbents) to influence the regulatory process are particularly likely to be the sources of breakthrough, or disruptive, innovation”).


these companies from accounting for the full cost of their drilling. As a result, their motivation to create technologies that reduce costs associated with oil spill damages is reduced as well. Several other commentators have called for the cap to be raised or eliminated, including the President’s Commission on the Deepwater Horizon spill.\textsuperscript{156} This Part looks more deeply into the reasons behind the need to make this change.

\section*{A. Tort Liability and Incentives to Innovate}

The system of civil liability forces an actor to pay for harm resulting from his or her actions, and so plays a key role in forcing actors to internalize costs. While regulations force potential injurers to pay up front to comply with safety standards, tort liability makes injuring parties pay \textit{ex post}. In this way the tort system essentially allows one actor to enter into a non-consensual contract with another; the injurer may act, but in exchange he or she is responsible for paying the resulting price of the action, whatever that price turns out to be.\textsuperscript{157} Civil liability can be a particularly effective method of cost internalization when risks are difficult to calculate, or when private parties have superior knowledge concerning the costs, benefits and risks associated with a given activity, as compared to regulating authorities.\textsuperscript{158} \textit{Ex post} liability can also be important in cases where \textit{ex ante} regulation would prove prohibitively expensive to administer.\textsuperscript{159}

The link between liability and innovation is not straightforward and somewhat under-investigated.\textsuperscript{160} Yet it is nonetheless clear that forcing internalization of costs can play a role in encouraging higher levels of innovation in the name of safety and risk reduction. By making companies responsible for the injuries they produce, they will have an incentive to reduce the risk of those injuries. As stated recently by Giuseppe Dari-Mattiacci and Luigi Alberto Franzoni,\textsuperscript{161}

\begin{footnotesize}
\begin{itemize}
\item[\textsuperscript{156}]\textit{Commission Report}, supra note 122, at 283-85.
\item[\textsuperscript{157}]See A. Mitchell Polinsky \textit{Controlling Externalities and Protecting Entitlements: Property Right, Liability Rule, and Taxation Subsidy Approaches}, 8 \textit{J. Legal Stud.} 1, 1 (1979) ("proponents of the liability rule approach...begin with the determination of entitlements. However, the entitlements are then protected by a rule which allows the "active" party to initially reduce the value of the "passive" party's entitlement but thereafter be liable to that party for "damages" determined by some collective body."). Steven Shavell, \textit{Liability for Accidents} 22 (National Bureau of Economic Research (NBER), Working Paper 11781, 2005) (Legal doctrines that impose a ceiling on damages (on the ground that no one could have expected such high damages) or that exclude damages when the probability density...is sufficiently low (on the ground that no one could have expected such an unlikely event) lead to inadequate care and excessive activity levels). \textit{See also} J. Summers, \textit{The Case of the Disappearing Defendant: An Economic Analysis}, U. Penn. L. Rev. 132, 145-85 (1983); Michael Trebilcock & Ralph A. Winter, \textit{The Economics of Nuclear Accident Law}, 17 \textit{Int. Rev. L. & Econ.} 215, 222 (1997).
\item[\textsuperscript{160}]The exact relationship between tort law and innovation is not entirely straightforward. In the field of medicine, for instance, some have found very high levels of liability to actually decrease levels of innovation as new products become associated with higher levels of medical malpractice suits. A. Stein & G. Parchomovsky, \textit{The Anti-Innovation Bias of Tort Law}, 107 \textit{Mich. L. Rev.} 285 (2008).
\end{itemize}
\end{footnotesize}
a party will only invest in “innovation reducing the expected harm…to the extent that the party bears the expected harm.”161 That is, only if actors bear responsibility for the harm that they cause will they be pushed to innovate to reduce that harm. Capping liability limits an actor’s motivation to reduce potential costs to others, and so the incentive to innovate.

B. The Oil Pollution Act (OPA) Liability Cap

Today, the oil industry is not subject to full liability for the harm caused by oil spills. One limitation on liability is found in the Oil Pollution Act of 1990 (OPA). The OPA was passed largely in reaction to the catastrophic Exxon Valdez spill in Alaska’s Prince William Sound in March of 1989, which focused public awareness on the risks associated with transportation of crude oil.

The level of liability that the oil industry should bear in the face of an oil spill was a significant debate during passage of the OPA.162 As originally introduced in the U.S. Senate, the OPA capped both clean-up and damage costs for offshore oil platforms at a total of $100 million.163 This was countered by Senator Slade Gorton of Washington who, supported by several fellow Senators, introduced an amendment to delete the liability caps entirely.164 In so doing, Senator Gorton argued that the “ultimate lesson” of the Exxon Valdez tragedy was that “if you privatize profit and socialize risk, eventually a private corporation will follow these rules and make the public pay for its carelessness.”165

During Senate debate many disagreed with Gorton’s stance and put forth several arguments in support of the liability cap included, among others, the notion that exceptions to the cap justified its existence;166 concern that unlimited liability would allow only large companies to invest in offshore drilling;167 the idea that offshore drilling industry’s good safety record made the cap reasonable;168 and claims that the Oil Spill Liability Trust Fund (OSLTF), also created in the OPA, made the cap inconsequential for oil spill victims.169 Similar justifications were heard recently in attacks against bills introduced in the aftermath of the Deepwater Horizon accident.170

Ultimately, a compromise was reached in the Senate through an amendment introduced by Senator Pete Wilson from California, which proposed language which is now law and found in section 1004(a)(3) of the OPA. This law limits the amount of damages that an operator must pay in the event of an oil spill.171 Offshore extraction facilities are required pay no more than the total of all removal costs plus $75,000,000 in damages in the event of a spill.172 “Damages” are defined in the OPA as injury to natural resources, real or personal property; loss of subsistence

---

162 In the house of representatives, debate centered primarily on whether the federal legislation should preempt state initiatives. It was finally decided that preemption should not occur: 135 C.R. H27940-72.
165 Id.
171 OPA § 1004, 33 U.S.C. 2704. The section was amended in 2006 by the Coast Guard and Maritime Transportation Act, which raised the liability cap for vessels, but not offshore drilling.
use of natural resources; loss of revenues; lost profits and diminished earning capacity; and the
increased costs of public services (recoverable by the state). Once an operator has hit the cap
in payouts, the Oil Spill Liability Trust Fund is supposed to step in to cover remaining damages.

Offshore drilling companies who qualify for the cap are thus only required to pay
$75,000,000 in damages in the event of an oil spill, beyond the cost of cleanup. One need look
no further than the Deepwater Horizon disaster to see how small this number is in comparison to
actual damage potentially caused by offshore drilling accidents. Exact costs of the Deepwater
spill are difficult to calculate, but the Gulf Coast Claims Facility (GCCF), set up to make it easier
for individuals and businesses to file claims for costs and damages incurred as a result of the
spill, had granted more than $3.8 billion in payments one year after the spill. At that point
they had processed approximately 500,000 of a total of approximately 857,000 claims. By the
time the GCCF closes its doors in August 2013, BP, who has voluntarily waived the liability cap,
will thus have handed out compensation to victims at several times the cap’s $75 million limit.
The liability cap thus places an unreasonable limit on the liability of offshore drilling operations,
and in the process dampens the incentive for companies to innovate in the name of safety. The
following sections look at arguments in favor of the cap to show their failure to adequately
justify limiting the liability of the oil industry.

C. Exceptions in the OPA

Many of those in favor of the liability cap argue that exceptions in the statute minimize
any potentially negative impacts of the cap on industry’s accountability. While it is true that
these limitations do ease the effects of the cap on industry incentives to take care, they do not
eliminate its negative effects on the incentive for industry to invest the development of
technology to reduce environmental and social costs.

1. The Gross Negligence and Violation of Regulations Exceptions

One common justification for the liability cap rests on the fact that the cap does not apply
if the spill is the result of “gross negligence or willful misconduct” or any “violation of an
applicable Federal safety, construction, or operating regulation” within the privity or knowledge
of the responsible party. Supporters of the cap argue that this limitation keeps in place
adequate incentives for industry to maintain due levels of care. While these exceptions do
limit the negative effects of the liability cap, negative consequences nonetheless remain.

Many conclude that when an oil spill occurs, a violation of an “applicable Federal safety,
construction, or operating regulations” will essentially always have taken place, thus placing
the injuring party outside of the liability cap and eliminating the effects of the clause. However, it is
far from true that all accidents stem from clear violations of the law. First, it is fully possible for
a spill to occur without a breach of current federal regulations. For instance, use of the best

---

173 33 U.S.C. 2702(b)(2) (2011). Note that damages under the OPA do not include personal injury or emotional damages.
174 The GCCF is administered by Kenneth Feinberg. For more information on the claims facility see:
175 Gulf Coast Claims Facility, Gulf Coast Claims Facility Releases Report on Status of Claims Process on Eve of One Year
Anniversary of Deepwater Horizon Oil Explosion, April 18, 2011, available at:
176 Id.
currently available technology may still lead to an accident resulting in spilled oil. Second, violations commonly go unrecognized in the offshore drilling context. Finally, to place the oil company outside of the realm of the cap, any breach of the regulations must be shown to be the proximate cause of the spill, which will at times be challenge to prove. There are thus several potential scenarios where the exception for violations of the law will not apply.

“Gross negligence and willful misconduct,” in turn, is a high bar to prove for liability. It means that parties who are negligent without being grossly so can still be protected from full liability. A normal negligence standard would at least encourage an optimal level of care, unlike the requirement of “gross” negligence, which allows industry to act negligently, just not grossly so. Yet even such a normal negligence-based exception would not provide adequate incentive to limit optimum levels of activity. Only strict liability will encourage optimal levels of care and activity, and therefore encourage adequate investment in innovation.

Both negligence and strict liability standards encourage potential injurers to take due care when engaging in a risky activity. Under strict liability, injurers are held liable for damages equal to any harm caused by their actions, and as a result are incentivized to minimize both harm imposed on others and the cost of reducing that harm. Under a negligence standard, in turn, an injurer must pay only if the level of care falls below a socially-determined optimal level. Too much caretaking, however, leads to additional costs. Thus also under the negligence standard, potential injurers are encouraged to act with optimal caution, balancing the cost of harm with the cost of care. Only strict liability, though, will encourage injurers to also limit their activity to efficient levels. Under strict liability, an injurer must pay for any injury that occurs due to his activity, even if the greatest care was taken. As a result, any growth in activity level will increase the risk that an accident will occur, even at the most cautious level of care, and the injurer will have incentive to limit engagement in the activity. Under a negligence standard, on the other hand, an actor will not be held liable unless harm is caused by his insufficient care. As long as he stays within the boundaries of due care (and as long as the definition of due care does not include activity level) he can therefore participate in the risky activity as much as he wants without penalty. Strict liability, therefore, more than a negligence standard, motivates companies to

179 An investigation by the Washington Post, for instance, found that many oil spills and related accidents go unpunished by the BOEMRE. Marc Kaufman, Carol D. Leonnig & David Hilzenrath, MMS Investigations of Oil Rig Accidents Have History of Inconsistency, WASHINGTON POST, July 18, 2010, A01.
180 OPA §2704(c) (2011).
184 To give an example of the effects of the liability standards on activity: Say that a negligence standard prevails and an oil vessel is responsible for harm from spilled oil only if it is proven that the spill resulted from insufficient care in transportation. Under such a regime the vessel operator would be careful not to create undue risk in the shipping process. As long as such care was taken however, the operator would feel free to send unlimited numbers of ships unlimited miles.
develop technology that reduces environmental and social costs. For if technology can be
developed to reduce the risk of a spill, companies under strict liability can justify drilling with
greater frequency.  

2. No Preemption of State Laws

A second argument related to exceptions in the OPA is that the Act explicitly does not
preempt state law, and several states have unlimited liability for oil spills. This, it is argued,
makes the liability cap essentially inconsequential. However, the availability of state courts does
not eliminate the effect of the cap in federal law. Not all states are free of liability caps.
Louisiana, for instance, has a cap that mirrors that found in the OPA. Lawsuits brought in
Louisiana will therefore always be subject to the cap. The availability of an alternate forum in
state court is thus not guaranteed, and the liability cap therefore remains of consequence.
Moreover, maintaining the liability cap in federal law gives a normative message from the
federal government to state regulators that oil companies should not be responsible for full
damages caused, and so gives inappropriate guidance.

D. The Liability Cap and the Insurance Industry

Another argument in favor of capping the liability of offshore oil drillers in the case of an
oil spill is that the cap enables insurance companies to function effectively, and so allows small
actors to engage in offshore drilling. James Foley argued recently, for instance, that the liability
cap is necessary in order to help the insurance industry set benefit and premium levels. Foley
contends that eliminating the liability cap would “dismantle the proven and effective system [for
determining premium levels] established by the OPA, which has been relied upon by vessel and
offshore industries over the last twenty years.” It may be true that the liability cap eases the
job of the insurance industry. The insurance market is rather complex and obtaining perfect
levels of insurance and perfect premiums can be difficult. The cap helps reduce the risk that
losses will rise beyond a certain level, and so can act as a guide in setting premium levels.
However, this ease comes with significant drawbacks, including skewed incentives for the oil
drilling industry and reduced ability of the tort system to encourage innovation for harm
reduction.

Insurance works most easily when levels of harm, spread amongst a pool of insured actors,
are relatively steady and predictable. If harm has the chance of being catastrophically large, insurance companies may be unable to charge high enough premiums to cover the potential loss; if the insurance industry has difficulty assessing the individual risk profiles of clients, this may result in adverse selection. Adverse selection occurs when insurance premiums are based on averages across the pool. Insurance then becomes under-priced for parties with above-average risk but over-priced from the perspective of those with lower risk levels.  

High-risk actors will as a consequence tend to purchase the insurance in increasing numbers and as they do so, insurance costs rise in order to cover the losses from riskier actors. As premiums rise, those with lower-than-average risk levels may begin to exit the insurance pool as premiums cease to be cost-justified. If this continues, the pool will eventually contain only high-risk actors and so cease being viable as a tool for risk diversification.

As Foley and others indicate, offshore oil drilling is one such context where risk levels are unpredictable. According to Risk Management Solutions, one of the world leaders in quantifying and managing catastrophe risk, “offshore oil platforms are the most complex and difficult commercial risks to underwrite.” The answer to this problem, however, is not to cap liability and thereby limit the harm that the industry is responsible for in a catastrophic spill. Such a cap not only shifts the risk of loss in such situations to the general public – who has essentially no power to reduce risks – it also reduces the pressure on the oil industry to innovate in the name of harm reduction.

1. Insurance Alternatives

There are alternative methods to mitigate the problem of insurance for the offshore drilling industry, including self-insurance and higher financial solvency requirements. Self-insurance occurs when companies integrate risk into their own operations, by setting aside adequate amounts of funding to cover future accidents, rather than purchase full insurance. This is what BP did prior to the Deepwater Horizon accident. To meet insurance requirements, BP used a captive insurer, Jupiter Insurance Ltd., which prior to the accident had $6 billion in capital and no reinsurance protection. Jupiter’s maximum payout per event is $700 million. Remaining costs, including liability to third-party victims, are covered directly by BP. Self-insurance makes companies themselves responsible for the costs of an accident, and so can put greater pressure on these companies to reduce such costs. From the standpoint of pushing innovation, self-insurance can further increase the pressure on companies to develop harm-reducing strategies.

194 The only means that such victims have to mitigate loss is to move away from the risk. To relocate all of the economic actors within the zone of oil spill danger would be extraordinarily costly, however, as that zone is extremely large. See Michael Trebilcock & Ralph A. Winter, *The Economics of Nuclear Accident Law*, 17 Int. Rev. L. & Econ. 215, 223-24 (1997) (making the same argument regarding nuclear reactors). For a related argument about the “least cost avoider” principle, which states that those that can avoid harm most easily should be responsible for doing so, see Guido Calabresi & Jon T. Hirschoff, *Toward a Test for Strict Liability in Torts*, 81 Yale L. J. 1055 (1972); Guido Calabresi & Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 Harv. L. Rev. 1089,1096-97 (1972); Giuseppe Dari-Mattiacci & Nuno Garoupa, *Least-Cost Avoidance: The Tragedy of Common Safety*, 25 J. L Econ. & Org. 235 (2009).
technologies, since companies that self-insure do not have the same degree of protection from the insurance industry, but must instead stand for full losses caused.

Private risk integration is not a perfect solution. For instance, such insurance is only possible for very large companies. Smaller companies who self-insure may instead find shelter in bankruptcy in the case of a significant accident, making them effectively “judgment proof.”  

Judgment proof actors lack incentives to prevent harm, and instead shift burdens of loss unjustly onto victims. A small actor would not have been able to put up a $20 billion fund, for instance, as BP did with the GCCF in the aftermath of the Deepwater Horizon spill. One method for combating the judgment-proof problem is to put in place high requirements for financial solvency. Unlike lowering levels of liability, financial responsibility requirements keep the pressure on industry to internalize costs.

Today, the OPA requires firms to show $35-150 million in assets before being allowed to drill offshore, depending on the risk level associated with the well in question. Companies can meet this requirement either with their own assets or through adequate levels of insurance. While the maximum cost of an oil spill remains difficult to determine, these financial responsibility requirements should be raised in order to help ensure that companies are not able to shirk their responsibilities through bankruptcy. If set correctly, these financial responsibility requirements can also provide guidance for the insurance industry by indicating likely risk levels.

If financial requirements are raised to better reflect the potential costs of oil spills, it is possible that smaller companies will be unable to participate in the market. This problem concerns those who argue that small businesses should also have a chance to be involved in offshore drilling. During Senate floor debate on the OPA, strong language was used in lauding the liability cap as a protection for small companies. Senator Bennet Johnston of Louisiana, for instance, dubbed an amendment to increase liability for offshore drilling “a major oil drilling company drilling bonanza amendment.” More recently, the same argument has been put forth by current members of Congress, such as Senator Mary Landrieu, also from Louisiana, who argues that lifting the liability cap today would limit the ability of small- and mid-sized drillers to participate in the offshore drilling market.

However, this emphasis on keeping small actors in

---


197 Some, like Giuseppe Dari-Mattiacci, argue that a liability cap may help reduce the problem of judgment proof companies. Dari-Mattiacci suggests that unlimited liability may induce some limited-asset actors to take too much care in fear of bankruptcy. In so doing, they spend too many assets on caretaking, and so further limit their ability to pay damages in the case of an accident. A liability cap, it is argued, will help limit this over-emphasis on care and encourage actors to hold on to their assets, so preventing a worsening of the judgment proof problem. In the oil spill context, this argument breaks down for two primary reasons. One is that it undervalues the more common assumption regarding the effects of the judgment proof problem noted by Shavell and Summer among others: that this problem brings too little, rather than too much caretaking. Second, even Dari-Mattiacci agrees that the cap is not productive if actors are solvent. Actors are likely to be solvent if they are large and well-established, and it is these types of actors that tend to engage in the offshore drilling industry. Since these actors are at low risk of becoming judgment proof, capping liability to prevent such an occurrence is thus unnecessary and counter-productive. Dari-Mattiacci, Giuseppe, Limiting Limited Liability, 11 Econ. Bull. 1 (2006).

198 33 U.S.C §2716(c) (2011).

199 This point is also made by Mark A. Cohen et al., supra note 11, at 31-33.


the market is misplaced. Limiting the industry’s liability to protect small actors simply shifts the risk of harm to others in the public. Appropriate financial responsibility requirements can provide the same guiding role for insurance as a liability cap without the negative impact; if damages are larger the company will still have to pay (as much as they can). The incentive to innovate thus remains.

E. Levels of Responsibility

A final argument in favor of OPA’s liability cap is that it balances out other burdens borne by the oil industry. From this point of view, the industry does not need further incentive to innovate. It already has plenty of pressures from various directions. While these arguments may carry weight for certain industries, they are not strong when it comes to the current offshore oil drilling industry.

1. Risk Aversion

One justification that has been used to defend limiting the liability of polluters is that such liability balances out oil industry aversion to the risks associated with offshore drilling. Risk aversion occurs where an actor prefers a certain result over one that is less certain, even if the less certain payoff is expected to be higher. Risk aversion is not a market distortion per se. But if a potential injurer is risk averse and engaged in a socially beneficial activity, it may make sense to limit the injurer’s liability in order to counteract the actor’s overly-high level of care, even though this will reduce incentives to take care. This is not the case with offshore oil drilling, however.

Significant scholarly work has been conducted on the effect of risk aversion on efficiency, since the level of risk aversion of an actor will affect their willingness to engage in an activity. The presence and degree of risk aversion is influenced by a variety of factors. One is a natural human tendency to prefer security over risk. Some explanations of this tendency include: the decrease in marginal utility of gains, which results in people valuing money potentially lost over money potentially gained; the certainty effect, resulting from people valuing sure gains over highly probable gains; and loss aversion, which makes people weight losses more than gains. The wealth of an actor can also have a significant effect on the actor’s relationship to risk. Two main factors can help explain the tendency of wealthier actors to be more willing

202 To use a simple example, an actor flips a coin. If it lands on heads she gets $100; if it lands on tails she gets $0. The expected payoff for both scenarios is $50. A risk averse individual will choose a certain payout of less than $50, rather than take the risk of possibly receiving nothing.
206 Empirical studies looking at the willingness of subjects to gamble conducted by Luigi Guiso and Monica Paiella and Christian Gollier, for instance, found risk tolerance to be a concave function of endowment. Two main factors can help explain the tendency of wealthier actors to be more willing to take on risk: high levels of liquidity and the ability to hedge against risks. These can result in larger actors being able to absorb more easily the cost of a loss, and so help outweigh
to take on risk: high levels of liquidity and the ability to hedge against risks.\(^{208}\) Those factors can result in larger actors being able to absorb more easily the cost of a loss, and thereby help outweigh any aversion to uncertainty.\(^{209}\)

The real-world relationship between risk aversion and liability is complex. Generally though, if an actor is risk averse, government policies to reduce the amount of risk born by that actor and to maximize utility may be advisable.\(^{210}\) Policies to counteract risk aversion are only called for if actors need to be encouraged to undertake a socially-beneficial activity, however. This is not the case when it comes to offshore drilling. First, offshore drilling is not an unknown investment today. Instead, it is generally viewed by the industry as an important area of investment and growth. There is no need to encourage companies to invest in offshore drilling if policymakers decide that such drilling is socially appropriate, since companies are ready and willing to drill.\(^{211}\) Finally, while the insurance industry is not without its complexities, as noted above,\(^{212}\) the oil industry is nonetheless able to transfer risk to the more risk neutral insurance companies if they so choose, and so reduce their own risk burden if necessary.\(^{213}\) Risk aversion is thus not a justifiable reason to limit pressure on industry to be subject to full liability.

2. “Crushing Liability”

Sometimes liability may be capped to help mitigate the problem of an injuror being held liable for damage beyond that actually caused by the actor, what Shavell has termed “crushing liability.”\(^{214}\) Crushing liability is most likely to occur when causation is difficult to ascertain. For
instance, in the case where a drug is found to cause negative side effects such as a stroke, the manufacturer of the drug would be subject to potentially crushing liability if it was held liable for all cases of stroke suffered by those that had ingested the drug, and not just those that had suffered a stroke directly due to the medicine in question. If an actor is subject to crushing liability, its cost of engagement will include both the cost of care plus the total of all expected accidental losses. 215 As a result, the actor will not need additional incentives to reduce costs through innovation: he is already accounting for too many costs.

In the case of an oil spill, it is possible that the injuring company may be held liable for certain harms that were not actually the direct result of the spill. These excesses, though, will in all likelihood be significantly outweighed by damages caused but not claimed. Take the Deepwater Horizon oil spill as an example. 216 Many of those injured will receive damages through the courts or the GCCF, and it is feasible that some of the harm claimed will not have been directly caused by the spill. For instance, certain restaurants or other tourist facilities claiming lost earnings or profits may have incurred some degree of that loss even without the spill. This overpayment, however, is unlikely to be “crushing.” Indeed the overpayment will likely be dwarfed by an underpayment of true costs.

The underpayment of costs results from the fact that a party responsible for a large accident involving many people and significant environmental harm will in all likelihood not be held responsible for all damage caused by the accident. One primary reason for this lack of full internalization is the difficulty of adequately calculating such harm. Damage to complex environmental systems is challenging to understand, let alone monetize. 217 As a result, much current and future harm to people and nature will likely go unaccounted for. Second, the tort system is not currently structured to allow suits from every injured party. Loss of existence value or use value, for instance, does not currently give standing in American courts. 218 Finally, even parties with valid claims for damages may not exercise the right to receive compensation. This will be the case particularly if the loss suffered was not significant enough to warrant the cost of filing a claim. In situations of widespread pollution, the number of such victims may be quite large and unclaimed damages significant.

Incomplete internalization will thus likely outweigh any excess damages paid by those responsible for significant oil spills. A liability cap is thus not necessary to avoid “crushing” the industry with excess liability.

\[\text{Risk, 77 Va. L. Rev. 257, 280 (1991) (suggesting that the liability cap "may be perceived as an attempt to avoid what Professor Shavell has termed "crushing liability" that would otherwise induce the actor to abandon a socially useful enterprise"). See Shavell, An Analysis of Causation and the Scope of Liability in the Law of Torts, 9 J. Legal Stud. 463, 465 (1980).}\]


\[\text{216 A database of reported effects on fish and wildlife is available at the joint federal agency website: http://www.restorethegulf.gov/fish-wildlife.}\]

\[\text{217 For a brief overview of different methods for evaluating environmental harm see Michael Faure, Environmental Liability, in Tort Law and Economics 247, 255-57 (Edward Elgar ed. 2009).}\]

\[\text{218 But see the decision in Ohio v. Department of the Interior mandating that DOI take into consideration non-economic values, such as "use values," "option values," and "existence values" in their National Resource Damage Assessment (NRDA) of the Exxon Valdez disaster. 880 F.2d 432 (D.C. Cir. 1989). See also Deborah S. Bardwick, The American Tort System's Response to Environmental Disaster: The Exxon Valdez Oil Spill as a Case Study, 19 Stan. Envtl. L.J. 259 (2000).}\]
3. Positive Externalities

Third, related to the idea that full liability puts too large a portion of liability on oil producers is the notion of positive externalities. The term “positive externality” connotes the idea that companies at times provide benefits to society for which they do not receive full compensation. A good example of such a positive externality is seen in the pharmaceutical industry’s creation of vaccines. In that case economists have shown that a genuine positive externality exists: herd immunity. Herd immunity is “the indirect protection of unvaccinated (susceptible) individuals in a largely vaccinated population.” Gillette argues that indemnity rules for vaccine manufacturers were instituted “to counter the tendency to underproduce” these important products. Limiting liability for producers may be justifiable in such circumstances in order to encourage optimal investment. However, herd immunity is a unique situation, different from the case of oil pollution.

The offshore drilling industry also has positive externalities. Primary among them is the provision of a domestic energy source. This arguably reduces the need to seek oil in volatile places around the globe, and lowers the military costs and other expenses associated with such a quest. Domestic drilling may also help lower domestic gasoline prices. These positive externalities are small, however, compared to the negative externalities associated with the industry. Robert Hahn and Peter Passel, for instance, although they advocate for more domestic offshore drilling, concede that allowing such drilling in currently off-limits areas, as well as the Arctic National Wildlife Refuges, will only decrease oil prices by up to 1-2 percent. At $100/barrel a 1% decrease will translate into approximately 2.4 cents/gallon – not a figure that consumers are likely to notice.

The primary negative externalities related to oil extraction are the serious costs associated with air pollution resulting from subsequent burning of the oil, and the risk of catastrophic spills like the Deepwater Horizon accident. Unlike in the case of vaccines, positive externalities do not outweigh negative externalities. Indeed, it is the other way around. The National Research Council, for instance, estimated that light and heavy-duty vehicles operated by gasoline caused aggregate national damage to health and other harms totally nearly $100 billion in 2005. Much of this harm is the consequence of burning products derived from oil such as that extracted in the Gulf of Mexico. These numbers only take into account such harms as illnesses from air pollution, and do not consider, for instance, the cost of greenhouse gas emissions. Nor do they account for the cost of oil spills such as that at the Deepwater Horizon rig. These costs add up to many billions of additional dollars in harm to society. Limiting liability is thus an unnecessary subsidy to an industry already running a net social deficit.

---

220 Michael Drummond et al., Do We Fully Understand the Value of Vaccines?, 25 VACCINE 5945, 5955 (2007).
224 Id. at 641.
225 Including both health effects and effects on global climate change.
226 NATIONAL RESEARCH COUNCIL (NRC), HIDDEN COSTS OF ENERGY: UNPRICED CONSEQUENCES OF ENERGY PRODUCTION AND USE 150 (2009).
The many arguments used to support the liability cap are insufficient to justify the cap’s existence and its negative impact on industry incentives to innovate. Civil liability plays a key role in forcing industry to internalize social and environmental costs, and thereby in creating appropriate incentives to create technology to reduce those costs. Limiting liability sends the signal that these costs can instead be discounted, thus reducing the incentive to innovate.

CONCLUSION AND RECOMMENDATIONS

After decades of moratoria on offshore drilling, today policymakers are moving to allow increasing levels of oil extraction on the outer continental shelf.\textsuperscript{227} Even the catastrophic Deepwater Horizon spill resulted in only a momentary halt to drilling.\textsuperscript{228} Indeed, in May 2011 President Obama called for an increase in drilling both on and offshore.\textsuperscript{229} Much of the current debate regarding offshore drilling concerns whether such drilling should be expanded into the Arctic waters off the coast of Alaska, where drilling conditions are harsher and oil spill response significantly more difficult than in the Gulf of Mexico.\textsuperscript{230} Politicians and policymakers no longer seriously debate whether offshore drilling should be permitted at all.

If policymakers decide that drilling under American waters should continue and even expand into new territories, they must match that choice with policies to make such drilling safer and less costly to humans and the environment. One way to do so is with policies that encourage better technology. While technology tends to change over time, it does not automatically develop toward maximum net social benefit, as is witnessed in the offshore oil industry. Much of the technological developments related to offshore drilling to date have been the result of profit-driven interest from the oil industry. As a result, innovation has focused primarily on enhancing the efficiency and effectiveness of oil extraction at greater water depths and distances from land, to maintain oil output and hence profits for the industry. Meanwhile, technological development to reduce environmental and social costs has lagged behind.

The ability to influence technological change gives policymakers the power to encourage innovation into socially beneficial technology. Incentives should be put in place to ensure that technological development for cleaner and safer oil drilling keeps pace with the industry-driven technological advancements that allow drilling in increasingly harsh and risky conditions. Current policies are unable to adequately provide such incentives. In order to begin to rectify this problem of under-performing policies the following actions are recommended.

In order to boost appropriate technological development, new investment in R&D is necessary, focused particularly on enhancing knowledge about drilling-related environmental

\textsuperscript{227} The offshore drilling regime in the United States has been subject to a variety of moratoria over the past several decades. In 1982, Congress placed a moratorium on new offshore oil drilling by preventing BOEMRE from issuing new drilling leases for protected areas. In addition, President George H.W. Bush implemented a moratorium in 1990, under authority granted to him in the OCSLA. The presidential moratorium was not lifted until July 2008. Shortly thereafter, Congress decided to let the appropriation-based moratorium expire and drilling commenced.

\textsuperscript{228} In the wake of the Deepwater Horizon spill, on July 12, 2010, Secretary Salazar again placed a moratorium on most deepwater drilling activities. This moratorium, which was set to expire in November 2010, was lifted in October, a month early. Secretary of the Interior, Decision Memorandum, Termination of the Suspension of Certain Offshore Permitting and Drilling Activities on the Outer Continental Shelf, Oct. 12, 2010; \textit{Pew Environmental Group, Oil Spill Prevention and Response in the U.S. Arctic Ocean: Unexamined Risks, Unacceptable Consequences} (2010).


and social risks, and methods to reduce those risks. The federal government can play a positive role in encouraging innovation by providing more funding for the development of technology to prevent and clean up oil spills. Since it is the oil industry that reaps the primary financial benefits from offshore drilling, money for these increased investments should come from royalties and taxes on industry. Funding should not be cyclical, rising and falling with catastrophic spills, but should be sustained and predictable to allow for persistent efforts and predictable funding flows.

A first step in the process of raising funds for R&D is to eliminate the tax breaks and royalty reliefs currently enjoyed by the oil industry, and to direct this money instead toward efforts to reduce the social and environmental costs of offshore drilling. These financial breaks divert money from efforts to make drilling safer, and simultaneously skew incentives by rewarding risky drilling in new environments and deeper waters. Oil companies are today seeing record profits. A portion of these profits should be used to reduce offshore drilling risks.\(^{231}\)

Second, BEOMRE should change regulations governing offshore drilling technology to be simultaneously stricter and more performance-based. Such a change could provide economic incentives for industry to invest in developing new technologies to enhance safety. Since industry is highly knowledgeable in terms of drilling technology and drilling risks, industry members should be active participants in helping to develop appropriate regulations, but their participation should not guide the regulatory process. Instead, new regulations should be based on investigations, risk analysis, and research by government agencies or other independent parties.

Increased use of the “safety case” approach, which places the onus on industry to come up with measures to reduce risks, may provide a tool for enhancing current regulations, but the approach will not be an automatic improvement. Nor will it entirely replace the need for specific regulations. Regulations need to push the envelope of what is considered appropriate levels of risk, and force industry to enhance safety.

Finally, the liability cap found in the OPA should be eliminated. The cap further limits incentives for industry to innovate to reduce social and environmental costs. It allows industry to potentially shift some of the costs of oil drilling to oil spill victims, and so permits industry actors to avoid internalizing all of the costs created by their actions. In so doing, the cap allows industry to discount not only the potential costs of an oil spill, but also the value of investing in harm-reducing technology to reduce those costs.

Instead of limiting liability, the OPA’s financial requirement, the minimum financial resources that a company must have before engaging in offshore drilling, should be raised in order to guide the setting of insurance premiums and ensure that companies are able to respond in the event of a spill, as BP has done with its $20 billion fund to reimburse oil spill victims. Doing so may make it difficult for certain smaller actors to participate in the offshore oil drilling market, but that consequence is perhaps necessary to ensure that firms can be held responsible for damages caused.

While there is no automatic method for encouraging socially beneficial innovations, the above policies will put in place the appropriate incentives to help ensure that technologies are developed to ensure that offshore drilling is safer. Implementation of all three of these policy changes could bring significant improvements in the incentive structure currently enjoyed by the oil industry. Changes to just one of these regimes though would be an improvement in itself. Only with effective, aggressive, and intelligent policies will offshore drilling become safer and

\(^{231}\) Krauss, supra note 211.
less likely to result in further catastrophic harm such as that caused by the Deepwater Horizon spill.