Public Policy Towards Offshore Oil Spills

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July 10, 2019

Abstract: On April 20, 2010, the Macondo well suffered a blowout, causing the mobile offshore drilling unit "Deepwater Horizon" to explode and eventually sink. Oil flowed from the well into the Gulf of Mexico for 87 days. In the aftermath of this event, the United States Government proposed significant regulatory changes related to offshore oil and gas exploration and production. In this paper I consider the likely costs and potential benefits from these new regulations. While both costs and benefits are very large, plausibly running into billions of US Dollars, a strong case can be made in favor of the regulations.

Keywords: Public policy, oil spills, catastrophe

JEL codes: D610, D611, Q580

*phone: +1-307-766-2178; fax: +1-307-766-5090; e-mail: bambuzlr@uwyo.edu. I thank audience participants at the University of Bath, the CESifo area conference on Public Economics, Georgia Tech University, University of South Denmark and the University of Wyoming for stimulating conversation. Special thanks are due to Mireille Chiroleu-Assouline, Ben Gilbert and Sasha Skiba for thoughtful input on earlier drafts. The usual disclaimer applies.

1 Introduction

On April 20, 2010, the Macondo well suffered a blowout, causing the mobile offshore drilling unit "Deepwater Horizon" to explode and eventually sink. Oil flowed from the well into the Gulf of Mexico for 87 days. The extended and substantial flow of oil caused direct and indirect economic harm, primarily in the Gulf of Mexico region. Recent estimates indicate well over 1,000 miles of shoreline have been contaminated (Nixon et al., 2016). The volume of oil released into the environment was the largest ever recorded from an offshore spill in the history of the United States (US), and was the third largest spill ever observed globally.[1] Potentially impacted individuals include participants in the gulf coast fishing industry (Sumaila et al., 2012), individuals employed in the tourism industry, (Eastern Research Group, 2014; Oxford Economics, 2010; Ritchie et al., 2014) and property owners (Siegel et al., 2013). The perception of substantial harm naturally leads to concerns about the potential for large damages from future spills, which in turn triggered calls for more stringent standards governing offshore oil and gas activities.

In response to these concerns, the US Government adopted new rules governing offshore oil and gas exploration and production on 29 April, 2016.[2] Primarily,

[1] The court determined that 3.19 million barrels of oil were released into the environment, placing it behind the oil spill associated with the first Gulf war (roughly 11 million barrels) and the Lakeview gusher, an out of control blowout that occurred in Kern County, California in 1910 (roughly 9 million gallons). See http://geology.com/articles/largest-oil-spills-map/ for discussion.

[2] "Oil and Gas and Sulfur Operations in the Outer Continental Shelf-Blowout Preventer Systems and Well Control", 81 FR 25887, Federal Register pp. 25887-28038; at `https://www.federalregister.gov/documents/2016/04/29/2016-08921/oil-and-gas-and-sulfur-operations-in-the-outer-continental-shelf-blowout-preventer-systems-and-well?utm_campaign=subscription%20mailing%20list&utm_medium=email&`

these new regulations strengthened "blowout preventer" (BOP) characteristics, features designed to bring a well back under control following an incident, features requiring shear rams be designed to include a technology that allows the drill pipe to be centered during shearing operations,[3] requirements of more rigorous third-party certification of the shearing capability of the BOP, and requirements for real-time monitoring of deepwater wells.

Appraisals of the likely cost of these regulations varies dramatically between industry and government sources. The agency that promulgated this set of regulations, the Bureau of Safety and Environmental Enforcement (BSEE), puts the costs less than \$100 millions per year, while the American Petroleum Institute (API), a key industry lobbying organization, argues the costs will be in the range of \$3 billions per year.[4]

Because the new regulations are likely to impose significant costs, it is natural to ask how large the damages from the Macondo spill were. One way to estimate of the magnitude of these damages would be to collect massive amounts of data, for example by instituting a rigorous survey scheme. To illustrate such an approach, a number of well-known scholars discussed in detail the survey designs that were constructed and executed to assess various damages associated with the spill at

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[3] Shear rams are designed to sever the drillpipe following an incident, thereby staunching the flow of oil. It is believed that the shear ram mechanism failed following the Macondo blowout, thereby allowing oil to flow from the wellbore.

[4] See Bureau of Safety and Environmental Enforcement (2016) and Quest Offshore (2015). The APT report was published more than 9 months before release of the final rule; during this period, a variety of adjustments to regulation were undertaken in response to stakeholder input. As such, the final proposed regulation was less onerous than the version evaluated by API, so that Quest Offshore (2015) almost surely overstates the costs of the new regulations.

the recent annual conference of the Association of Environmental and Resource Economists. Scores of economists were involved in the process, which took years to complete. In the end, then, such a detailed approach seems likely to have been costly and difficult. It also bears the stigma, fairly or not, associated with the use of survey methods to assess values, as well as the need to properly define a broad set of affected households to whom the survey estimates would be extrapolated.[5]

An alternative, less complex, method relies on publicly available information related to claims programs that were undertaken in response to the oil spill, and so is significantly less costly to undertake. Using this data, I estimate the order of magnitude of economic harm associated with the spill to be roughly 14.5 billion US Dollars. My estimate is roughly comparable to the detailed estimate obtained by the NOAA Total Value Team, which is in the range of $20 billions (Bishop et al., 2017).

The final element in this inquiry is an evaluation of the risks associated with deepwater exploration and production. Using data taken from the BSEE website, I argue that the risk of an incident rises substantially as endeavors push into deeper water. In light of this pattern, and the plausible level of annual drilling going forward, a compelling argument in support of the new regulations can be made.

I start the discussion with a short summary in section 2 of the sequence of events in the aftermath of the blowout. In section 3, I discuss the claims regimes put in place, under which those harmed by the oil spill could seek compensation. Included here is a description of various features that were intended to verify the

[5] A detailed description of the approach taken, and the rationale for that approach, are available in NOAA Total Value Team (2016a) and NOAA Total Value Team (2016b).

accuracy of claims, along with a discussion of appeals process available to both BP and claimants. In section 4 I describe the magnitude of settled claims arising from the claims regimes. Given the rigor of the regimes, as discussed in section 3, I argue that the sum of these claims represents a credible estimate of the economic damages suffered as a result of the spill. In section 5 I discuss the potential costs of the new regulations. Taking both the industry and the government estimates into consideration, I suggest the costs (aggregated across all wells drilled) are unlikely to exceed $2.8 billions per year. In section 6 I discuss the failure rate of newly exploration and development drilling, and in particular the relation to the water depth in which wells are drilled; these results indicate a statistically important pattern of increasing risk as wells are drilled in deeper waters. Section 7 offers concluding remarks.

2 Background

The operator of the Macondo well was BP Exploration and Production – a wholly owned subsidiary of BP. In the aftermath of the Macondo blowout and ensuing oil spill, BP was charged with violating the Oil Pollution Act, to which BP pled guilty. The implication was that BP was responsible for compensating those who suffered economic harm as a result of the oil spill (Goldberg, 2010).

Three main regimes allowed injured parties to seek compensation from BP for certain types of economic damages. From May 2010 to August 23, 2010, claims were processed by BP directly (the "BP Claims Program"). In all three claims regimes, claimants were required to submit detailed information to the claim organization. From August 2010 until June 2012, claims were processed by the Gulf Coast Claims Facility (the "GCCF Program"). After June 2012, claims were processed by the Deepwater Horizon Court Supervised Settlement Program (the "Settlement Program").[6]

2.1 *The BP Claims Program*

The BP Claims Program received over 154,000 claims, and made over 127,000 payments to more than 30,000 claimants (BDO Consulting, 2012, p. 12). The total amount paid was slightly less than $400 million. Claims processed included health related effects, adverse impacts to fisheries, real estate losses, property damage losses, tourism losses, and lost wages. Claimants were required to provide documentation to support their claim, such as documentation to establish their lost income, their commercial economic loss, and their property damage. BP extensively reviewed claims processed by the claims adjusters and forensic accountants hired to run the BP Claims Program. The BP Claims Program provided payments for past losses only; it did not issue payments to cover future anticipated losses.

[6] A description of the BP claims program is available at "Gulf of Mexico Oil Spill - Claims and Other Payments - Public Report - July 31, 2015", which may be downloaded at http://www.bp.com/content/dam/bp-country/en_us/PDF/GOM/Public-Report-July-2015.pdf. A summary of the BP claims program, as well as the GCCF program, is contained in BDO Consulting (2012). The full legal document describing the Settlement program is contained in "Deepwater Horizon Economic and Property Damages Settlement Agreement as Amended on May 2, 2012, Rec. Doc. 6430-1", which can be accessed at http://www.deepwaterhorizoneconomicsettlement.com/docs/Amended_Settlement_Agreement_5.2.12_optimized.pdf.

The BP Claims Program was suspended on August 22, 2010.[7]

2.2 *The GCCF*

The GCCF Program commenced on August 23, 2010. It processed claims involving lost earnings or profits for individuals and businesses, damage to real or personal property, loss of subsistence use of natural resources, as well as removal and clean-up costs, and physical injury or death. Hundreds of trained claims processors processed these GCCF claims.

The GCCF Program was split into two phases. The first phase, known as "Phase I," processed claims for documented losses sustained during the first six months following the Macondo blowout; the focus was on quick disbursement of funds, which was accomplished by a claims process known as "Emergency Advance Payment." During this phase, claims payments accelerated dramatically in comparison to the BP Program. Funds paid out during this phase reflected damages suffered to that point; in particular, recipients were not required to waive future rights. The second phase, "Phase II," processed three types of payments: quick payment, interim payment and final payment. The quick payment claim involved a one-time payment of $5,000 for individuals or $25,000 for businesses; claimants were required to sign a form promising not to bring future suits against BP. Interim and final payments involved compensation for documented past losses or damages caused by the Spill. These claims were incremental to any past claims, either from the BP Program or from Phase I of the GCCF. Interim payments were

[7] At the conclusion of the GCCF, BP resumed paying a small number of claims directly; these payments totaled $11.8 million.

limited to losses sustained by the claimant up to the date the claim was filed; there was no attempt to quantify anticipated future losses. By contrast, final payments included both past losses and an estimate of future losses. To make a claim, an individual had to demonstrate that the loss had been proximately caused by the oil spill, and had to provide evidence as to the magnitude of the loss.[8]

Figure 1 displays the payment history during the BP Claims Processing period and the first 16 months of the GCCF.[9] While claims increased sharply during the first phase, it is noteworthy that significant amounts of money were paid out on a month-by-month basis during Phase II. While the figure is truncated at the end of 2011, claims were accepted through June 2012. At that time, claims were handled under the Court Sponsored Settlement Program.

2.3 *The Settlement Program*

Towards the end of 2011, a class action suit against BP was gathering momentum. Such a proceeding would likely be costly and time consuming, and entailed substantial risk – for both potential plaintiffs and for BP. Recognizing these risks, the parties negotiated a settlement in mid-April 2012. An amended version of this agreement was filed with the court in early May, and was sanctioned on December 21, 2012.[10] Claims started being processed under the Settlement Program in July

[8] See Gulf Coast Claims Facility (2010). While receiving an interim claim did not entail releasing BP from future liability, claimants receiving a final payment were required to sign a form promising not to bring future suits against BP.

[9] Reproduced from Figure 2 in BDO Consulting (2012, p. 60).

[10] A copy of the amended agreement can be accessed at www.deepwaterhorizonsettlements.com/Documents/Economic%20SA/Settlement_Agreement.pdf, and a copy of the Court's order can be accessed at www.deepwaterhorizonsettlements.com/Documents/Econ%20Order%20Granting%20Final%20Approval.pdf.

of 2012.

The Settlement Program addressed many types of individual and business economic losses, losses in real property value, and subsistence losses. Claims under the Settlement program fell into 12 categories: Seafood Compensation Program; Individual Economic Loss; Individual Periodic Vendor or Festival Vendor Economic Loss; Business Economic Loss; Start-Up Business Economic Loss; Failed Business Economic Loss; Coastal Real Property; Wetlands Real Property; Real Property Sales; Subsistence; Vessels of Opportunity Charter Payment; and Vessel Physical Damage. The Economic and Property Damages (E&PD) Settlement Class includes people, businesses, and other entities in the "Gulf Coast Area" that were harmed by the oil spill.[11] Claims eligible for payment under the E&PD include Seafood Compensation, Economic Damage, Loss of Subsistence, Vessel Physical Damage, Coastal Real Property Damage, Wetlands Real Property Damage, and Real Property Sales Damage. Both claimants and BP had the right to appeal proposed claim settlements.[12]

3 Mechanics of the claims processes

Under both the GCCF and the Settlement Program, claimants were required to provide documentation of any alleged losses. For example, individuals making

[11] This area consists of states of Louisiana, Alabama and Mississippi, and the counties of Chambers, Galveston, Jefferson and Orange in the state of Texas, and the counties of Bay, Calhoun, Charlotte, Citrus, Collier, Dixie, Escambia, Franklin, Gadsden, Gulf, Hernando, Hillsborough, Holmes, Jackson, Jefferson, Lee, Leon, Levy, Liberty, Manatee, Monroe, Okaloosa, Pasco, Pinellas, Santa Rosa, Sarasota, Taylor, Wakulla, Walton and Washington in the state of Florida.

[12] BP's appeals were limited to claim payments in excess of $25,000.

claims related to lost real or personal property under the GCCF were required to provide "[i]nformation or documentation showing the value of the property both before and after damage"; for lost profits or earning capacity, the individual was required to provide "[i]nformation concerning the Claimant's lost profits or earnings that were caused by the injury, destruction, or loss of specific property or natural resource as a result of the Spill (such as lost earnings by a fisherman whose fishing grounds have been closed or a hotel or rental property that has had decreased profits because beaches, swimming, or fishing areas have been affected by the oil from the Spill)" (Gulf Coast Claims Facility, 2010, p. 3). For claims related to mitigation expenses, the individual was required to demonstrate that "[t]he actions taken were necessary for removal of oil discharged due to the Spill or to prevent, minimize, or mitigate oil pollution from the Spill" and that "[t]he removal costs incurred as a result of these actions are reasonable and necessary" (Gulf Coast Claims Facility, 2010, p. 2). The GCCF Program was quite rigorous; indeed, over 60% of claimants who filed under the GCCF were denied.

GCCF claims processing involved sorting claimants into one of four categories (BDO Consulting, 2012, pp. 37, 39-40):

1. individuals and businesses that depended heavily on resources and tourism from the Gulf and who were located in zip codes that bordered the Gulf shore;

2. individuals and businesses from Gulf Alliance counties who were not located in zip codes that bordered the Gulf shore, along with businesses that located in zip codes bordering the Gulf that were not heavily reliant on Gulf resources

and tourism;

3. claimants that were not located in the Gulf Alliance counties, or who were not heavily reliant on Gulf resources and tourism;

4. and claimants who were deemed not deemed not to be eligible for compensation by the GCCF.

If an individual claimant was found eligible, his or her losses were determined by comparing actual 2010 earnings against projected 2010 earnings. Projected 2010 earnings were the highest of the claimant's earnings for 2008, 2009 or annualized 2010 prior to the Spill, which were then seasonally adjusted. The resultant amount was then subtracted from the claimant's actual earnings to determine the claim payment. For Final Payment claims less than \$500,000 or more, the analysis included a prediction of future losses. These predicted future losses were incorporated by a "Future Recovery Factor," which was based upon a multiple of the claimant's documented 2010 loss amount; as such, one can think of this component as reflecting an estimate of the expected present discounted value of future damages. For claimants with documented 2010 losses of \$500,000 or more, the GCCF did not automatically apply a Future Recovery Factor (BDO Consulting, 2012, pp. 35, 41, 43).

Table 1 describes the spatial distribution of payments under the GCCF. Here, I list claims paid and monies disbursed to each of the five states, differentiated between coastal counties and inland counties. One would expect substantially larger damages in the coastal counties, as they bore the brunt of the impacts from the spill; the table clearly supports this conjecture. For Alabama, Louisiana and Mississippi – the three states that were most directly exposed to the spill – both the number of claims and monies paid out were roughly two orders of magnitude larger for the average coastal county than for the average inland county. The Florida panhandle counties were also directly impacted, though counties farther south were largely spared exposure; as such, the dichotomy between coastal and inland counties and inland counties is a bit smaller than with Alabama, Louisiana and Mississippi. In Texas, where the coast was far less exposed to the spill, the distinction between coastal and inland counties is smaller still. In total, over $7.5 billion was paid out under the GCCF.[13]

Under the Settlement Program, claimants were required to establish causation for certain claims, though causation was presumed for other claims. However, even where causation was presumed, claimants had to show an economic loss in the period following the oil spill as measured by reduced income or reduced profits in the period after the spill as compared to an earlier benchmark period. In defining the benchmark period, most claimants were allowed to use either 2009, the average of 2008 and 2009, or the average of 2007, 2008 and 2009 to form their benchmark.[14] As with the GCCF, the foundation for any losses assessed was the

[13] A simple linear regression shows that population, presence in the "Gulf Coast Area" and presence in a coastal county all exerted positive and statistically significant impacts on both the number of claims paid and the amount of money disbursed. All else equal, Coastal counties exhibited markedly larger effects than did Gulf Coast Area counties. These results are available in an online appendix; the appendix also contains a map containing a color-coded display of total claims payments under the GCCF, across counties in the five state region.

[14] Individuals who changed jobs between the base period and 2010, or who started work on or after April 21, 2009 had to include 2011 in their benchmark period. See www.deepwaterhorizoneconomicsettlement.com/docs/QRG_IEL.pdf.

difference in earnings before and after the spill occurred.

Table 2 display some relevant statistics for the Settlement Program.[15] Here, I display the aggregate amount offered, the total amount of accepted offers, and the total amount paid, for each claim type; entries are listed in decreasing order of monies offered. Business Economic Losses are the most important category, while the second most import category is the Seafood Compensation Program. Combined, these top two categories represent about 5/6 of all monies offered, and of all money offers accepted. In total, over 87,000 unique claimants were paid over $7 billions under the Settlement Program.

A legitimate concern with both the GCCF and the Settlement Program is that not all claims submitted were valid, which could potentially taint the expository value of claims paid. To the extent that there is any indication that claims were carefully evaluated, such concerns are at least partly addressed. As I noted above, well over half the claims filed under the GCCF were denied, pointing to a rigorous evaluation process. More detailed evidence is available under the Settlement Program. Table 3 shows the number of claim forms filed, the number of claims that were denied, and the fraction of claims denied, by claim type (arrayed in the same order as in Table 2). Of the 342,230 claims that were filed under the program, 124,596 were denied, corresponding to a 36.4% rejection rate. Some categories, such as property markets and vessel damage, had smaller denial rates, perhaps because such claims were easier to evaluate (and hence parties with questionable

[15] This table was constructed using information drawn from reports filed by the claims administrator. These reports were posted for every month between September 2012 and May 2016. I use data from the most recent report (Juneau, 2016).

claims would be less prone to seek compensation). In other categories, including failed and startup business loss, claims would be much harder to substantiate (as causation would be trickier to establish); denial rates in these categories exceed 50%. Significantly, the claims category with the largest monetary outlay – Business Loss – had a denial rate of roughly 1/3. Overall, the magnitudes of these denial rates offer at least casual empirical support for the conjecture that claims were subject to a rigorous evaluation.

Further evidence regarding the claims evaluation process under the Settlement Program comes from results from its appeals process. As I noted above, both BP and claimants had the opportunity to appeal the specific claims. Both BP and claimants appealed roughly 23% of the claims that were eligible for appeal (Juneau, 2016, p. 9). Overall, slightly more than 9,800 appeals were filed; of these, with roughly 3/4 of those filed by BP (Juneau, 2016, Table 5, p. 3 in Exhibit A). Table 4 displays statistics from the appeals process under the Settlement Program. Here, I split out the number of appeals processed, together with the number of appeals that resulted in higher or lower payments; for reference, I also include the number of claims paid and amount of monies paid; all these values are reported by claims category. The first point to be made is that the lion's share of appeals result in no change in payment – of the more than 9,800 appeals processed, less than 2,000 resulted in an adjusted payment. Conditional on the appeal changing the amount paid, downward revision was more common than upward revision; these lower outcomes correspond to slightly more than 1/6 of appeals processed.[16]

[16] At the time of writing, slightly more than 1,000 appeals are unresolved, of which nearly 70% were filed by claimants.

One way to view the negotiated settlement is as the result of a bargaining process (Posner, 1973). Let V_d represent the expected value of damages resulting from trial, as estimated by the defendant (here, BP), and V_p represent the expected value of damages resulting from trial, as estimated by the plaintiff (here, the collection if individuals in the certified class); let T_d (respectively, T_p) represent the expected transactions costs associated with litigation that would be borne by the defendant (respectively, plaintiff). There will be a negotiated settlement so long as $V_p - T_p$ (the net amount the plaintiff anticipates receiving if the case goes to trial) is smaller than $V_d + T_d$ (the net amount the defendant anticipates paying if the case goes to trial). In this event, the negotiated settlement can fall anywhere between $V_p - T_p$ and $V_d + T_d$; the ultimate settlement equals damages plus a residual term that depends on the two parties' bargaining strengths. While this discussion models the interaction between a defendant and a single plaintiff, the logic applies equally well if there is a group of plaintiffs, as in a class action suit. In that case, the estimated damages are based on the groups' aggregated damage, and the transactions costs are based on the combined costs of all group members; nothing else of substance is different from Posner's scenario.

This general framework can be applied to any point of contention during the pre-trial bargaining; in particular, one can think of such a process governing the methods used to assess claims, to establish causation, to project future expected damages, and to deal with appeals. As a result, and because the parties involved in the negotiations had no reason to accept a deal they felt was disadvantageous, the resultant mechanism should be informative about parties' beliefs regarding the accuracy of agreed upon methods for assessing damages. The fact that most appeals were denied is at least broadly corroborative of this conjecture.

4 Economic Harm from the Spill

Conceptually, the amount of lost income due to the oil spill would be the difference between businesses' and individuals' actual earnings and what they would have earned in the period after April 20, 2010 had the oil spill not occurred. An obvious proxy for individuals or businesses earnings had the oil spill not occurred is earnings preceding the spill. An estimate of harm can then be made by comparing the earnings realized after the spill against the earnings that the business or individual realized during the period before the spill.[17]

Both the GCCF and the Settlement Program compared post-spill income or profits to pre-spill levels. Many claims used the average of 2007, 2008 and 2009, or the average of 2008 and 2009, or 2009 as the benchmark period. Individuals who changed jobs between the base period and 2010, or who started work on or after April 21, 2009 had to include 2011.

This method may somewhat overestimate or underestimate the precise amount of economic harm experienced by an individual or entity due to the oil spill because the benchmark period earnings may be slightly lower or higher than the earnings that the individual or business would have realized but for the spill. Businesses

[17] An alternative approach would be to forecast underlying trends relevant to each individual, for example by analyzing in detail the industry they participate in. This alternative method would be complex and unwieldy when so many claims had to be processed, likely leading to very large transactions costs.

experience natural variations in their income or profits from year to year, for example because of variations in weather or patronage. The volume of fish caught vary, as do the prices the fish fetch, from one year to the next; hotel room rentals vary from one year to the next; tourism generally is subject to variations in receipts from one year to the next. There are also broad-based macro-economic trends that may impact all industries within a particular region. All these effects, which are external to the oil spill, may make the benchmark period earnings slightly different from the earnings that the business would have realized but for the spill. Allowing individuals to average income levels over multiple years, as in both the GCCF and the Settlement Program, can average out any cyclical macroeconomic factors or unusual weather events to find a reasonable forecast as to what one could expect to earn in the period of interest, had the oil spill event not occurred.

While the difference between the benchmark period and post-spill income or profits may include elements that are due to external factors, it does capture differences in income or profits that are due to the oil spill. Each individual claim can therefore be viewed as an estimate of that individual claimant's loss, which might be either an under- or an over-estimate of damages. Aggregating the claims paid that were calculated using this method provides a rough estimate of damages to claimants caused by the oil spill.[18]

[18] Hanley et al. (2007, pp. 334-336) discuss the aggregation of damage estimates across affected individuals. One can also think of these individual damages as estimates of an individual's loss; the set of claims can then be used to estimate the average loss suffered by an individual in the set (Asteriou and Hall, 2011; Chou, 1989). Then multiplying by the total population in the Gulf of Mexico would produce an estimate of total damages. Since one cannot know how the set of individuals who did not file claims were impacted, I prefer to use the simper method of summing reported claims.

With this interpretation in mind, each claim payment is a measure of an individual or business's economic harm, either for some past loss or in anticipation of a future stream of losses. As such, the sum of payments reflects an estimate of total harm. This sum would include the payments during the brief period where BP processed claims, and the two more substantial programs associated with the GCCF and the Settlement Program. Table 5 lists all these payment programs. The sum of these payments then defines an estimate of the economic harm from the Macondo oil spill: nearly $14.5 billions.

5 Costs of the New Regulations

As a result of mounting concerns regarding the magnitude of economic and environmental harm resulting from the Macondo blowout mounted, the US government developed new rules for oil and gas operations on the outer continental shelf. In this section I consider the potential cost of the final rules.

A preliminary version of the proposed rules was released on 13 April, 2015, following which release BSEE took public comments.[19] This new rule focused primarily on blowout preventers, as well as reforms in well design, casing, cementing, and real-time well monitoring. The main thrust of these rules was to address conditions that were believed to have contributed to the loss of control in the well.[20] The oil and gas industry responded to these proposed rules vigorously,

[19] The full text of the proposed rule was made available online, at https://www.bsee.gov/sites/bsee.gov/files/safety-alerts/development/bsee-2015-08587-final-fr-04-13-15.pdf.

[20] Cementing and casing are used in oil and gas wells to control the flow of hydrocarbons. It

arguing that they were costly and unnecessary.[21] In response to these concerns, the rules were adjusted, with the final version released on 16 April, 2016.

Shortly before releasing the final rule, BSEE published a regulatory impact analysis – an assessment of the likely economic effects of the new regulation (Bureau of Safety and Environmental Enforcement, 2016). In this assessment, BSEE focused on the 10 years immediately following release of the rule (2016 to 2026), arguing that the likelihood of technological improvements would render forecasts farther into the future unreliable. Their methodology was aimed at characterizing likely costs per well; assuming 320 wells – roughly the number of active wells at the time the rule was released – BSEE then constructed an estimate of aggregate cost in the Gulf of Mexico, for each of the ten years. Finally, they calculated the present discounted value of the flow of costs for two discount rates, 3% and 7%. This process lead to total 10-year cost estimates of $890,309,000, $790,509,000 and $686,023,000 at discount rates of 0, 3% and 7%, respectively (Bureau of Safety and Environmental Enforcement, 2016, Exhibit 3, p. 65). Of these costs, far and away the most significant were real time testing, about 45% of total costs, and BOP control station function testing, about 28% of total costs (Bureau of Safety and Environmental Enforcement, 2016, Exhibit 31, pp. 50-51).

Industry estimated costs to be much larger, on the order of 35 times the size of the BSEE estimates (Quest Offshore, 2015). Part of the discrepancy appears to

is believed that a contributing factor to the blowout was shoddy quality of the cementing in the wellbore.

[21] See, for example, the API press release "Unintended Consequences of the Proposed BSEE Well Control Rule", available at http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Offshore/Unintended-Consequences-of-the-Proposed-BSEE-Well-Control-Rule-vs4.pdf.

come from inclusion of deadweight loss in the the industry estimates, but most of the difference would seem to arise from changes in well design: The undiscounted cost of the regulations is estimated to be $31,830,500,00, of which well design costs are estimated to be more than half.[22]

As I noted above, the industry estimates likely overstate the true costs of the regulation, as they were constructed on the basis of the proposed rule. Nevertheless, for the sake of discussion I base the pursuant discussion on these estimates. That point noted, one would want to use discounted as opposed to undiscounted costs, and so I adjust the industry cost estimates by applying the 3% discount rate. The resultant values, collected in Table 6, indicate an average annual cost of slightly more than $2.788 billions. Assuming 320 wells drilled (Bureau of Safety and Environmental Enforcement, 2016), this estimate translates into an estimated cost of roughly $8.7 million per well.[23]

6 Well Failure Probability

The results articulated above place the damages from a major spill in the billions of US Dollars. Weighing against these large losses are the tangible and large costs associated with the regulatory program promulgated in response to the

[22] See (Quest Offshore, 2015, Table 5, pp. 15-16). The industry analysis points to a sharp reduction in drilling, in the range of 26%; presumably this feeds into the deadweight loss calculations. It is unclear that reduced drilling in one basin would impact market prices, particularly as crude oil prices are based on international markets.

[23] By comparison, the industry report assumes fewer than 200 wells drilled per year. At the time of writing, there are 321 active operations in waters exceeding 1,000 feet – a commonly used definition for deep-water.

spill. These costs have been estimated to lie between \$ 700 million and \$3 billion annually, which corresponds to roughly between \$.25 and \$8.7 millions per well. With prospective damages on the order of 4,000 times the size of the per-well cost, a reduction in the probability of a major oil spill of about .00025 would generate non-negative net benefits.

While evaluating the likely impact of the new regulations upon the probability of a major oil spill is a difficult, perhaps intractable, task, it is possible to characterize the *ex ante* likelihood of a spill. I consider this aspect of the problem in this section. To this end, I collected publicly available data on offshore oil spills. These data, available from the BSEE website, identify all spills exceeding 50 barrels prior to 2013.[24] This information includes the data of the spill, the water depth, the amount spilled, and the cause of the spill. Some spills result from hurricanes or failed pipelines; because the new regulations focus on drilling activities, *i.e.* exploration for and development of new deposits, I exclude these spills from consideration. Other spills are caused by ships such as barges; again, these are not relevant to the inquiry at hand, and so I exclude them. After filtering the observations in this manner, I retain observations on 76 spills.

Figure 2 plots the time and water depth associated with these spills, while Figure 3 shows the average depth and number of wells drilled, for each year between 1990 and 2012. Two patterns are apparent: comparing the period after 2000 to the period before 2000, spills become more common and they occur in deeper water over time. These features are likely the result of the increased drilling

[24] While the data go back to the 1960s, technology facilitating deep water drilling was unavailable prior to 1990. I therefore limit my focus to observations between1990 and 2012.

that occurred after the turn of the century, when oil prices started to rise; this lead to a more attractive economic climate in which to explore, and also accommodated more costly ventures (such as deep water exploration).

Because the volume of drilling is trending upward during the sample period, it is not immediately obvious that spill rates are changing. To get at that issue, I plot the number of spills per well drilled in Figure 4. Here, I split out larger spills – those in excess of 1,000 barrels – from smaller spills. While smaller spills are more common, on the order of five times as likely as larger spills, both are becoming more likely over time. Moreover, the general trends towards increased spill rates are roughly the same.

Because oil spills arising from drilling are relatively infrequent, using ordinary least squares to evaluate patterns is ill-advised. A better approach is to use a "count regression", such as a Poisson model. Evidence from such a regression model is given in Table 7. The left-side variable in this analysis is the number of non-minor oil spills in a given year.[25] The key result here is that spills are more common the deeper are wells, and the more wells are drilled. Indeed, my results indicate that an additional significant spill will occur once every 826 wells drilled, on average; assuming 320 wells drilled per year, this corresponds to one non-minor spill every 2.5 years. The coefficient on water depth indicates that increasing the average water depth by 770 feet will yield an additional non-minor spill. To put this in context, the difference between the average water depths in 2011 and 2012 (1428 and 1936, respectively) was 508 feet. Were this trend to continue, one would

[25] The BSEE data characterizes spills as "minor", "medium" or "major". As there are relatively few major spills I retain medium spills in the inquiry, but do not consider minor spills.

expect to see an additional spill every 1.5 years.[26]

Of course, the events observed in the data have much smaller spill levels than the Macondo event; extrapolating from these occurrences to very large spills is a fraught exercise. That said, I would note that the results illustrated in Figure 4 point to roughly similar trends in spill rates as the size of the spill increases. In particular, the figure indicates the frequency of spills roughly doubled in the period between 2000 and 2009. To extent that pattern extends to very large spills, the results presented in this section have some expository value. Moreover, the results articulated here suggest a general trend toward more common spills as water depths increase. Given the very large damages that are linked to such a spill, the case against the new regulations is suspect.[27]

7 Conclusion

Large numbers of individuals and businesses suffered economic harm as a result of the Macondo oil spill. Many of the losses were direct, in that they reflect reductions in income or profit as a direct result of the spill. There were also indirect losses (the impacts resulting from the change in spending by those who suffered direct effects upon industries that provide goods and services to those in

[26] Muehlenbachs et al. (2013) provides corroborating evidence to these conclusions, though they base their analysis on all spills. Their results point to a sharp increase in spill rates as wells are drilled in deeper water, with a predicted spill rate of about 30% for a well drilled in 5,000 – which is roughly the water depth of the Macondo well. By contrast, I do not consider spills BSEE characterized as "minor". Anderson et al. (2012) find similar results, although their analysis includes spills resulting from Hurricane Rita, while I exclude Hurricane-related spills.

[27] To the extent that society exhibits significant aversion to risk, this argument would be strengthened.

the direct effects cohort) and induced losses (resulting from reduced household income of anyone in the primary or related industries, for example laborers who lose their jobs as a result of the initial direct effect upon their employer). One way to think about the combination of these effects is as a decomposition of payments to factors of production: when a particular firm is adversely impacted, payment to the firm's owner will fall, as will payments to the various factors of production; the first element reflects reduced profits while the second set of elements combine to describe reductions in the firm's costs. Summing these describes the reduction in revenues, which is equivalent to reductions in payments by customers. In this way, the combination of harms to sellers is dual to harms suffered by potential buyers. Altogether, almost $14.5 billion was paid in claims to individuals and businesses.

Using actual claim payments as a measure of economic harm due to the oil spill excludes some damages. Some harms were explicitly excluded from the Settlement Program, including claims of BP shareholders, claims for moratoria losses, claims relating to Menhaden fishing and processing, and claims for economic damage suffered by entities in the banking, gaming, financial, insurance, oil and gas, real estate development, and defense contractor industries, as well as claims from entities selling or marketing BP-branded fuel. Some individuals or businesses who experienced economic losses may have determined that the likely return from filing was not worth the time and cost of filing the claim. The time and cost of filing a claim are examples of transactions costs. There are indications that the transactions costs associated with filing a claim as part of the GCCF and Settlement Programs could be substantial.[28] Any individual or business that suffered damages less than the transaction costs would rationally decide to not file a claim. Others may have overestimated the transaction costs and decided that it was not worthwhile to file, even they would have received more claims money than the true cost associated with filing the claim. Finally, some types of harm were not explicitly excluded from the three claims programs but no claim was available for these harms. For instance, the claims paid do not reflect recreational use losses, or various non-market losses such as losses of ecosystem services. These latter losses have been estimated in the range of $20 billions (Bishop et al., 2017).

Weighing against these large losses are the tangible and large costs associated with the regulatory program promulgated in response to the spill. These costs have been estimated to lie between $ 700 million and $ 3 billion annually, which corresponds to roughly between $.25 and $8.7 millions per well. Thus, a reduction in the probability of a major oil spill of .00025 would generate non-negative net benefits. While evaluating the impact of the regulations upon the risk of a major spill is impractical, one can characterize the nature of oil spill risks prior to the promulgation of the regulations. These risks are rising over time, specifically as a result of drilling in ever deeper waters.

An alternative to invoking new regulations might be to insist that drillers are liable for any damages caused by a spill for which they are responsible. While such an approach is conceptually compelling there are some important practical

[28] Austin et al. (2014, p. 164) reports the GCCF often claimed to have lost the documentation provided by claimants, and "claims adjusters made multiple, new requests for additional financial documents, stretching over weeks and months."

limitations. First, there are litigation costs, which skew incentives away from the claimed efficiency of setting the charge for an offense equal to its expected damage (Shavell, 2014). In the case at hand, the action brought against BP under the Clean Water Act took over three years to litigate, with substantial expenses incurred by all parties. In the end, BP settled the case (along with the prospective case involving natural resource damages, and all cases brought by the five impacted states) for about $18.5 billions. This settlement split payments between the impending resource damages case and the concluded Clean Water Act case by ascribing $5.5 billion to the Clean Water Act case. This is noteworthy, as BP was exposed to a potential finding in excess of $13 billions. Thus, the settled amount fell far short of BP's exposure. The ascribed amount corresponding the natural resource damages was $8.5 billions, far less that the amount estimated by Bishop et al. (2017). The inescapable conclusion is that the settlement probably did not impose the complete costs of the spill upon BP.

A second important caveat to the liability argument , the nature of possible damages is such that the expected value is almost surely much larger than any realized damage (Viscusi and Zeckhauser, 2011).

Finally, relying on liability to induce firms to exercise socially efficient precaution requires risk attitudes be aligned between firms and society, and that the probabilities associated with the underlying events are known and agreed. In general it is difficult to make concrete statements about various risk attitudes.[29]

[29] That said, there is an additional complication that arises in situations where multiple parties are involved in a joint venture that experiences an oil spill, as is commonly true in deepwater ventures. One approach in such circumstances is "to make all firms involved liable for the full costs of an oil spill" (Viscusi and Zeckhauser, 2011, p. 1747). This approach again relies on

Regarding the nature of probabilistic beliefs, not only was the probability of a drilling disaster in deep water unknown, it is highly unlikely that society will be able to learn the true probability in any reasonable period of time (Viscusi and Zeckhauser, 2011). Unlike many examples that use sampling to assess a probability, in the deepwater drilling example disasters are very uncommon, which implies that one would need a very large number of observations, certainly more than the number of wells that have been drilled to date, before a reasonable estimate of the disaster probability could be formed.

common risk attitudes, here across firms involved in the venture, as well as for society generally. With assuming common risk attitudes is likely innocuous when gambles are small, the assumption becomes more problematic in the context of larger gambles, as with deepwater exploration.

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Table 1: Claims and Money Paid under the Gulf Coast Claims Facility, by state

	inland		coastal	
state	claims	money	claims	money
Alabama	100.4	1.732	21353.3	361.368
	(199.4)	(3.791)	(18982.1)	(338.909)
Florida	182.1	3.246	9007.2	125.792
	(347.9)	(5.290)	(11574.)	(165.957)
Louisiana	296.4	7.516	14437.8	190.960
	(654.577)	(13.625)	(21498.2)	(210.246)
Mississippi	54.3	1.856	12738.7	173.082
	(117.1)	(3.172)	(10714.7)	(138.763)
Texas	51.6	2.903	872.7	22.524
	(213.8)	(19.420)	(739.4)	(18.433)
Total	39449	1092.818	456437	6473.731

notes: (i) payments in millions of US Dollars
(ii) standard errors in parentheses

Table 2: Claim Payments under the Settlement Program

Claim Type	Amount Offered	Amount Paid	Unique Claimants Paid
Business Economic Loss	$4,823,992,442	$4,138,333,122	25,468
Seafood Compensation Program	$1,668,618,866	$1,623,142,601	5,107
Wetlands Real Property	$215,209,396	$183,320,081	1,791
Subsistence	$186,235,260	$147,474,466	16,909
Coastal Real Property	$163,875,138	$157,093,781	22,358
Start-Up Business Economic Loss	$147,717,900	$136,184,385	824
Individual Economic Loss	$82,863,827	$76,191,272	6,229
Real Property Sales	$40,478,745	$40,405,448	759
Vessel Physical Damage	$12,497,839	$12,249,222	744
Failed Business Economic Loss	$5,388,575	$3,323,958	38
Individual Periodic Vendor or Festival Vendor Economic Loss	$77,085	$77,085	8
Total	$7,346,955,073	$6,517,795,421	80,235

Table 3: Claims Denied under the Settlement Program

Claim Type	Total Claims	Total Denied	% Denied
Business Economic Loss	114,051	37,464	32.8%
Seafood Compensation Program	30,565	8,820	28.9%
Wetlands Real Property	20,103	7,348	36.6%
Subsistence	58,593	15,081	25.7%
Coastal Real Property	42,296	8,507	20.1%
Start-Up Business Economic Loss	7,292	3,851	52.8%
Individual Economic Loss	58,880	38,209	64.9%
Real Property Sales	3,110	934	30.0%
Vessel Physical Damage	1,553	471	30.3%
Failed Business Economic Loss	5,314	3,601	67.8%
Individual Periodic Vendor or Festival Vendor Economic Loss	473	310	65.5%
Total	342,230	124,596	36.4%

Table 4: Claims Filed, Paid and Appealed under the Settlement Program

	Claims		Appeals	Payments Adjusted	
Claim Type	Filed	Paid	Processed	Higher	Lower
Business Economic Loss	133,076	27,633	7,617	73	1,501
Subsistence	67,691	16,909	44	4	1
Individual Economic Loss	60,781	6,229	470	28	72
Coastal Real Property	42,128	28,478	264	38	1
Wetlands Real Property	27,317	7,016	133	3	10
Seafood Compensation Program	24,953	12,768	444	82	22
Start-Up Business Economic Loss	7,733	874	0	0	0
Failed Business Economic Loss	5,614	38	0	0	0
Real Property Sales	3,065	857	87	0	8
Vessel Physical Damage	1,562	799	105	2	29
Individual Periodic Vendor or Festival Vendor Economic Loss	388	8	3	0	0
Total	374,308	101,609	9,813	256	1,736

Table 5: Gulf of Mexico Oil Spill Payments (millions of US Dollars)

Claims Program	Amount
BP Claims Program	$395.620
Gulf Coast Claims Facility	$7,566.549
Court Supervised Settlement Program	$6,517.795
Total Claims Paid	$14,479.964

Table 6: API Estimates of Well Control Rule Costs

year	nominal cost	discounted cost (3%)
0	2421	2421.000
1	2800	2718.447
2	3402	3206.711
3	3547	3246.007
4	3589	3188.780
5	3606	3110.567
6	3378	2829.022
7	2753	2238.441
8	3050	2407.698
9	3284	2516.913
10 year total	31830	27883.586
annual average	3183	2788.359

Note: costs reported in millions of US Dollars

Table 7: Impact of Water Depth on Number of Oil Spills

Average Water Depth	0.00130**
	(0.000518)
Number of Wells Drilled	0.00121*
	(0.000707)
constant	-2.419**
	(1.104)
χ^2	6.455

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: BP/Gulf Coast Claims Facility Payment History.

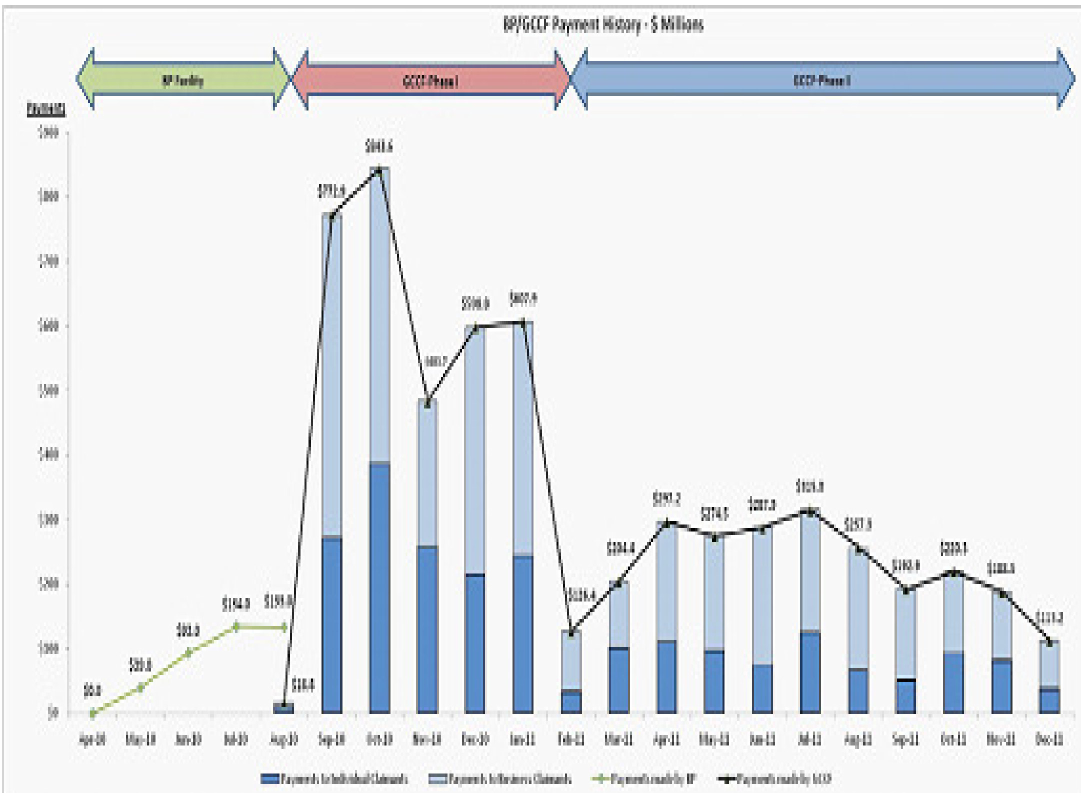

Figure 2: Oil Spills, 1990-2012, by Water Depth.

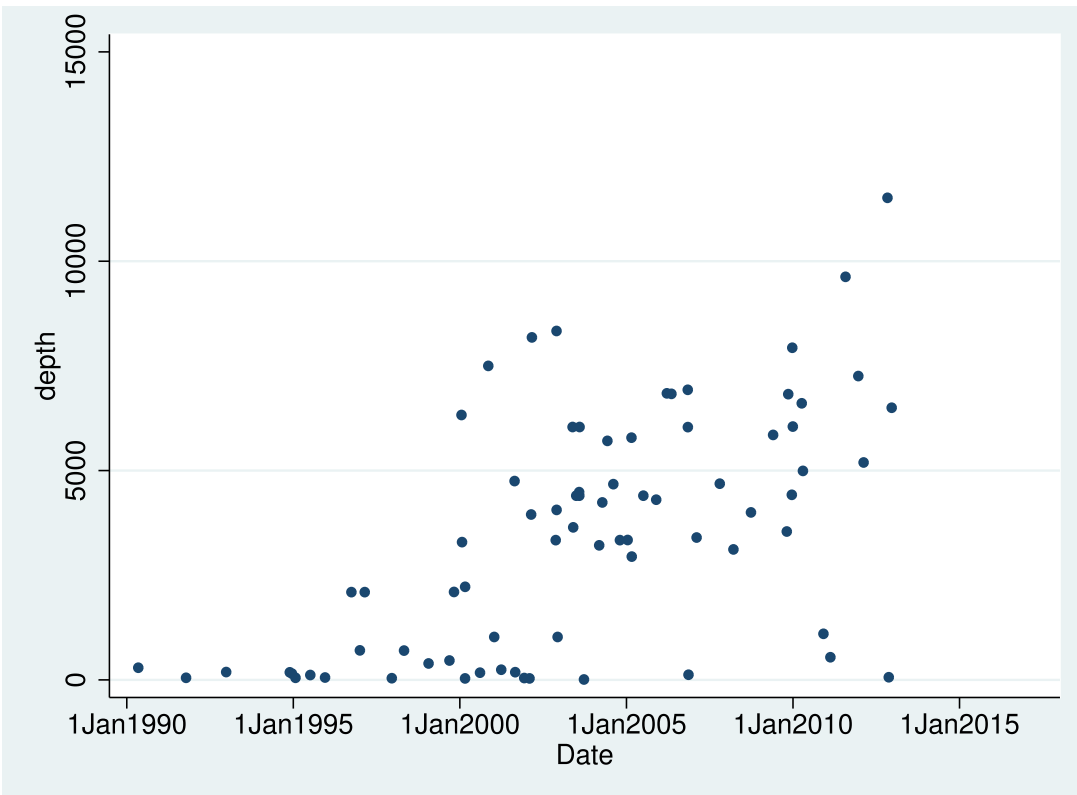

Figure 3: Average Depth and Number of Wells Drilled, 1990-2012.

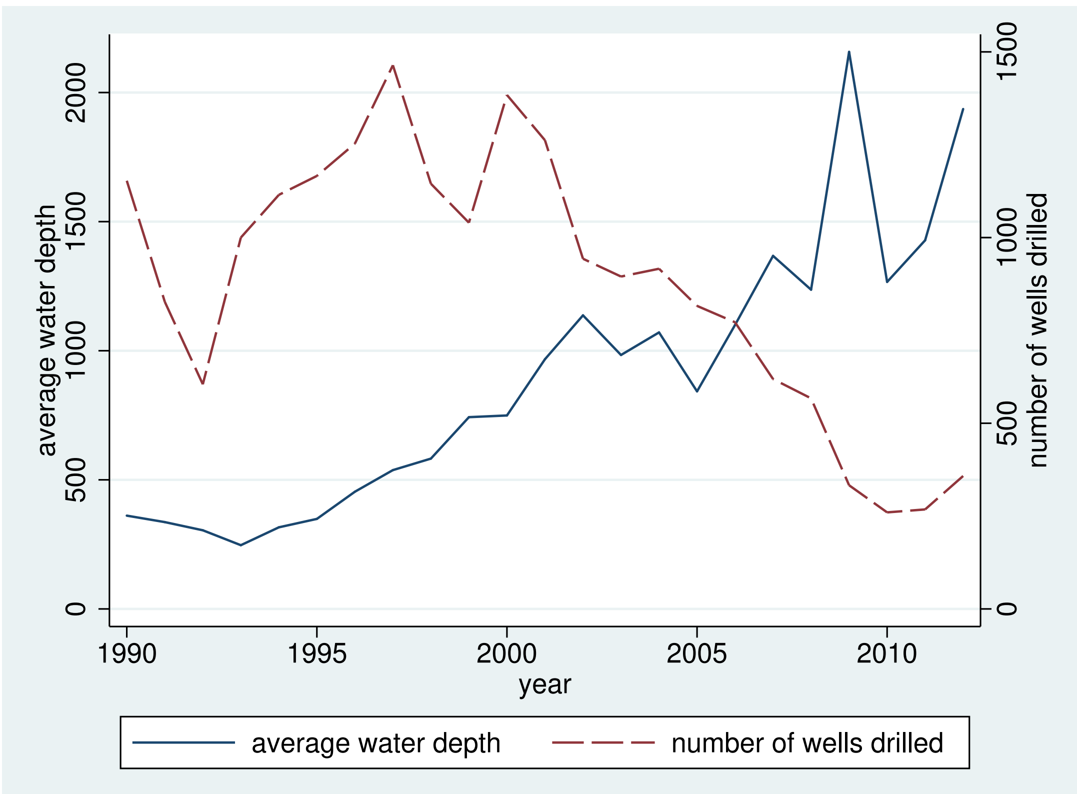

Figure 4: Frequency of Oil Spills: More vs. Less than 1,000 Barrels.