Regulatory Report

The BP Gulf Coast Oil Spill, Option Value, and the Offshore Drilling Debate

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Executive Summary

In the wake of recent unrest in the Middle East, rising gasoline prices have politicians from both parties scrambling to ramp up domestic oil production. Perhaps ironically, this scramble coincides with the one year anniversary of the BP Gulf Coast Oil Spill, the single largest offshore oil spill in history.

This regulatory report examines the economics of increased domestic oil drilling, in light of large uncertainties associated with this activity. Many of the most important factors for making smart choices about oil drilling are uncertain: future oil prices cannot be perfectly forecasted; science has a limited understanding of the scope and consequence of environmental damages from oil exploration, production, and accidents; and the rates of technological innovation for both production improvements and cleanup technologies are difficult to predict.

The primary finding of this report is that, unless uncertainty is incorporated into the economic models used to determine whether oil drilling is appropriate, the United States will allow too much drilling, too soon, and with too much risk. This reality should be reflected in how the Department of the Interior structures the sale of leases to extract offshore oil—but presently, it is not.

A major flaw with the rhetoric currently dominating both sides of the political debate over domestic oil drilling is the focus on gasoline prices. In fact, expanding domestic drilling will have practically no effect on, and so should not be motivated by, gasoline prices. Economic analysis of oil markets shows that expanding domestic oil production is "not likely [to] have a significant impact on prices that consumers pay at the gasoline pump now or in the future."[1] Because the United States is engaged in global oil markets, even relatively large domestic changes in production will be swallowed by the larger global supply and demand, leading to only negligible changes in price.

If increasing domestic oil production is economically justified, it will not be as an effective or efficient response to rising gasoline prices. Rather, the choice would only be justified because the benefits of drilling (namely, revenue from the operation) outweigh the costs (like the production costs and the risks of environmental damage from accidents). Consequently, to make that choice, the full extent of both the benefits and costs of drilling must be examined.

It's All about Timing

The Department of the Interior bears the responsibility to examine the costs and benefits of drilling. In the past, the agency met this requirement by carrying out a traditional cost-benefit analysis. While cost-benefit analysis itself is a useful framework for informing these kinds of decisions, the agency's analysis is flawed because it treats oil drilling as a now-or-never decision.

Once the decision to drill has been made, it cannot easily be unmade. But that does not mean the only choices are either to drill now or never: waiting to decide is also an option. Because safer drilling techniques and more effective cleanup technologies continue to be developed, the costs associated with drilling should decline over time—perhaps in fits and starts, but following a generally downward trend. Meanwhile, future market prices for the extracted oil are uncertain, jumping one day and falling the next. Given this uncertainly, it only makes sense for the American public to wait to cash in the value of their finite oil reserves until the price is right: when the oil can be sold high, but environmental costs are low.

Unfortunately, the government's analysis has consistently failed to take into account the option value associated with waiting to drill, even though the methodology to do so has existed for decades. Because of this analytical failure, the government risks the possibility of selling the American public short to the tune of hundreds of billions of dollars. In addition, because the laws that govern offshore oil drilling require consideration of all costs and benefits of drilling, if the Department of the Interior continues ignoring the option value associated with domestic oil reserves, it risks a legal challenge to its leasing decisions.

More complete economic models may have helped prevent the BP Gulf Coast Oil Spill. The value of waiting is greater for relatively more risky drilling activities, like the deep sea operations at the center of the BP spill. Such techniques are relatively newer, and inexperience increases the uncertainty about the extent of risks, the robustness of safety technologies, and the ability of cleanup and containment efforts to reduce harm. If the agency had used an adequate model of costs and benefits when evaluating this kind of deep sea operation, the benefits of waiting for better technologies might have exceeded the short-term costs of delay, leading to smarter use of our offshore resources and fewer risks imposed on the public.

Recommendations for Reform

Calculate the option value related to oil prices. In order to more accurately take into consideration the uncertain path of oil prices, the government should use a model based on the real options framework that has been developed by economists over the past several decades.

Calculate the option value related to costs. Uncertainty about the environmental effects of spills and the path of technological development that reduces both private and social costs should likewise be incorporated using the options framework.

Use the option value when establishing leasing schedules and setting auction reserve prices. When the government makes leasing decisions and determines whether auctions to industry actors are generating a fair price, it should calculate the option value to ensure that the American public is receiving the highest value for the depletion of this finite resource.

Analysis

Uncertainty, Irreversibility, and Non-Renewable Resources

The government has the responsibility to allow for extraction of resources only when it provides a net benefit to the American public. As a result, the federal statute governing offshore oil drilling requires that the Secretary of the Interior take all relevant "environment, social, and economic considerations" into account when managing the exploitation of the nation's natural resources.[2] To fulfill this responsibility, the Interior Department, formerly through the Minerals Management Service (MMS) and now at the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), conducts a broad economic and environmental analysis of the costs and benefits of moving forward with oil extraction in different areas.

Unfortunately, these analyses are inadequate. They treat the government's choice as a one-off, now-or-never decision, when in fact the government has the choice to wait and drill in the future.[3] As a result of this blind spot, the decisions made by these agencies potentially waste billions of dollars in option value owned by the American public. This leads to too much drilling, too soon, and with too much risk.

How Decisions over Offshore Oil Are Made

The federal government exercises control over the outer continental shelf through several federal statutes. The primary federal law governing mineral development offshore is the Outer Continental Shelf Lands Act (OCSLA). A stated purpose of the OCSLA is the "expeditious and orderly development" of resources, "subject to environmental safeguards, in a manner which is consistent with the maintenance of competition and other national needs."[4] The OCSLA establishes a comprehensive leasing process, administered by the Secretary of the Interior through BOEMRE. BOEMRE, in turn, promulgates regulations with specific requirements to guide the leasing program.[5]

State governments control the area within three geographical miles from the state's coastline, as spelled out in the Submerged Lands Act (SLA) of 1953.[6] States have a variety of substantive laws on the books concerning offshore oil development, and some restrict development absolutely.[7]

The Value of Options

In situations where future costs and benefits of a project are uncertain, decisions are irreversible, and the opportunity to delay action until a future date is available, cost-benefit analysis that fails to account for option value can generate inaccurate results. This occurs because, under conditions of uncertainty, investment must be made on the basis of expected outcomes. The expected net present value of a project is the mean of the distribution of probable benefits, minus the mean of the distribution of probable costs. In contexts where additional time generates information about the benefits and costs of the project, there is a value associated with waiting to act. The value of this information is the option value.

A simple numerical example can help illustrate the point. Two friends need to determine whether to invest their money in creating a lemonade stand over the weekend. The materials for the stand, the pitcher, glasses, lemons, and sugar, and their time will cost $45. If it is sunny, they will make $7.50 on Saturday and $50 on Sunday; if it is rainy, they will make $5 on Saturday and $10 on Sunday. It takes a day to set up the stand. Assume tomorrow's weather can be predicted with 100% accuracy, and there is a 75% chance that the weather will be exactly the same on the subsequent day.

On Friday afternoon, the friends view the weather prediction and see that it will be sunny on Saturday, which means a 75% chance it will also be sunny on Sunday. If they conducted a standard cost-benefit analysis on this problem, they would decide to invest in the lemonade stand:

Net Present Value = Saturday's Revenue ($7.50) +
Sunday's Expected Revenue (.75*$50 + .25*$10) - Costs ($45) = $2.50.

If they had learned that it will rain on Saturday, they would have arrived at the opposite conclusion:

Net Present Value = Saturday's Revenue ($5) +
Sunday's Expected Revenue (.75*$10 + .25*$50) – Costs ($45) = -$20.

But, they could also wait for a day and make their decision on Saturday, rather than Friday. They would have to forgo their returns from the first day, but the information they gained would be worth it. If on Friday they learn it will be sunny the next day but they decide to wait to build, there is still a 75% chance the weather will hold and they can open their stand in time for Sunday's profits. But by waiting, they can confirm the weather prediction before incurring any costs, and if they learn it will instead rain on Sunday, they can avoid the investment. As a result, the net present value of waiting a day to make the decision is higher than immediately investing in the lemonade stand:

Net Present Value = Saturday's Revenue ($0) +
Sunday's Expected Revenue (.75*$50) – Expected Costs (.75*$45) = $3.75

The option framework also shows why the friends should not abandon their plans even if they learn on Friday that it would rain on Saturday: because there is some chance the weather will clear up. Upon learning on Friday of rain the next day, the value of waiting an extra day to decide is:

Net Present Value = Saturday's Revenue ($0) +
Sunday's Expected Revenue (.25*$50) - Expected Costs (.25*$45) = $1.25

A similar, albeit more complex, situation arises in the drilling context. The price of the underlying asset (in this case, oil) and the environmental risks involved in drilling are subject to high degrees of variability and uncertainty. Leases are designed to encourage commencement of drilling as soon as possible—if there are delays in drilling the oil company risks losing the lease. While many leases are not immediately used, immediate drilling is allowed and is likely to be undertaken if it is profitable. Though the Secretary of the Interior maintains some discretion to suspend or even cancel leases,[8] that power is used only in unusual circumstances.[9] Once oil is extracted, the process cannot easily be reversed.[10] Finally, the agency does have the choice to delay action. If it so wishes, it can choose to refrain from leasing until a future date.

In this context, a correct cost-benefit analysis would take "option value" into consideration. The option character of resource extraction has been recognized by economists for decades,[11] and has been discussed in the academic legal literature.[12]

Calculations that fail to take into account option value are overly simplistic to the point of being misleading. As Dixit and Pindyck stated in their early textbook on the subject, failing to account for option value "is not just wrong; it is often *very* wrong."[13] An economic analysis that ignores the option value of waiting overvalues the net benefits of immediate exploitation and will systematically lead to inefficient overexploitation.

A simplified framework that ignores option value is sufficient when a decisionmaker is faced with a single one-off choice of whether a project should be pursued or not. However, in the oil drilling context, the U.S. government is not faced with such a simple question. The question is not only whether to lease drilling rights, but whether it should be done *now*. In such situations, the option to act later may have important value. This option value arises in cases of uncertainty and irreversibility. In such cases, where there is uncertainty over future costs and benefits, and investors are unable to easily recoup sunk costs, option value can be important. Drilling today will be cost-justified only if the expected benefits of a project are larger than the total expected costs *plus* the foregone option value.[14]

The Mechanics of Option Value

Calculating Option Value for Price Uncertainty

To consider options in a cost-benefit analysis, a value must be calculated. The classic work on options valuation in the financial context was published nearly four decades ago.[15] The concept of real options was popularized by a set of scholars writing from the late 1980s through the 1990s.[16] The field has developed to the point where there is a broad range of guides for practitioners in the field.[17] Financial mathematicians and economists have developed a variety of models to deal with the specific situations presented by diverse real options contexts: alternative energy investment,[18] remediation of brownfield properties,[19] and the development of real estate.[20] There are also a number of cases where real options have been used to examine decisions about the development of petroleum reserves.[21]

The standard real options model, as given by Dixit and Pindyck, derives a "threshold price" indicating when it is rational to cash in a perpetual option. The threshold price represents the point at which the value of continuing to hold the option is equal to the value arising from exercising that option. In the offshore drilling context, it is the point at which it is reasonable for the government to lease access to the resource.

Prices are assumed to vary over time.[22] The value of immediate exploitation is determined by an estimate that mirrors the rate of return on a traditional investment, referred to in the real options context as a "convenience yield." The cost of extracting the resource, current prices, and discount rate in the overall economy also help set the threshold price. Together, these values determine whether the current price is sufficiently high to exercise the option to extract the resource, and therefore forfeit the option value.

The real options framework can be applied to the case of oil extraction. The situation faced by the government is formally similar to a simple stock call option. These stock options, familiar elements of executive compensation packages, give holders the right to purchase a specific amount of stock at a given price (referred to as the "strike price"). In the oil drilling context, the option is the ability extract a certain amount of oil (however much is available at the lease site) at a strike price that is set by the costs of extraction. Because of the formal similarity of real options to financial options, the same mathematical models that are used in financial markets can be imported to understand the decision of when and whether to drill.

There are some difficulties associated with using the more complex option value formula, rather than the more straightforward calculations that the government has used in the past. For example, there is controversy over whether the price of oil is drifting upward because the global supply of oil is finite, or whether the development of new technology will tend to push the price of oil toward some average value. Other inputs, such as the social discount rate, the degree of price volatility, and the convenience yield are also subject to disagreement, and some work would have to be done to develop adequate estimates for these values.

However, sophisticated actors in financial markets value options on a daily basis, and the methodologies for option valuation have existed for decades. The amount of value that is at stake is sufficiently large that, even if the decisionmaking task is somewhat more difficult, it is reasonable for the agency to expend the additional analytic resources to make sure the estimates are done accurately. Failure to account for options in the context of an oil reserve can lead to "serious errors in valuation."[23]

The Stakes in Real Options

The difference between an analysis that recognizes option value and one that does not is merely academic: in the context of offshore oil drilling, it can lead to drastically different consequences. While a full real options analysis of the offshore oil drilling decisions is outside the scope of this paper, this point is demonstrated by examining a recent analysis of offshore drilling to determine how consideration of option value could affect the outcome of a decision based on these two alternative modes of calculating costs and benefits.

Hahn and Passell provide a calculation for drilling in two areas currently off-limits to oil exploration, the Arctic National Wildlife Refuge in Alaska and certain sensitive offshore areas.[24] This analysis is part of a broader examination of drilling policy, in which the authors argue that cost-benefit analysis, rather than examination of effects on gasoline prices, should be the economic basis for social policy.

Hahn and Passell consider three types of benefits: revenues to producers from drilling for oil; consumer surplus; and reduction in disruption costs associated with variance in world oil prices. On the other side of the balance sheet, they incorporate seven categories of costs including: direct production costs borne by producers, including taxes and other payments; indirect "use" costs, or the loss of opportunity to use the resource for other ends such as photography or fishing; the "non-use" or existence value of untouched natural resources; pollution costs associated with oil consumption, including greenhouse gas emissions and local air pollution; and other negative externalities related to traffic.[25]

With an assumed $50 per barrel price, Hahn and Passell find that the benefits of drilling approach $578 billion as compared with costs of $255 billion. Given these considerable net benefits, they find that expanded drilling is justified, under all but the most implausible assumptions. Based on their analysis, the authors find that expansion is the correct choice in the offshore drilling context at any price over $10-12 per barrel, the break-even point for such drilling.[26]

A real options analysis, using plausible values for the convenience yield, interest rate, and volatility, can generate significantly different results from those found using only a traditional cost-benefit analysis. For example, Dixit and Pindyck find that the price of oil would need to be two times the per-unit costs, under plausible values for the interest rate, convenience yield, and price volatility, to justify drilling now and destroying the option value.[27] Under this framework, even small errors in benefits or cost estimates would flip the decision from "drill" to "wait" in the Hahn and Passell analysis, as would increases in the interest rate, decreases in the convenience yield, or increases in the variance. Regardless of the parameter values used, Hahn and Passel's breakeven price of $10-12 is likely to be an underestimate.

The Importance of Costs

Estimates of option value and threshold prices that take into account price volatility are an improvement. Even these figures, however, fail to provide a full estimate of option value in the context of offshore oil drilling. Volatility and uncertainty exist on both sides of the equation—with respect to costs as well as benefits. There are key uncertainties about both the private costs of oil extraction and the broader social and environmental costs. A complete accounting of costs and benefits would examine the value of the option to wait for more information about direct extraction costs as well as broader social costs, and methods for reducing these expenses.

Extraction Costs

One category of cost associated with offshore drilling is the direct cost to industry of extracting oil. Extraction costs (sometimes termed "lifting costs") include the price of exploring new areas, drilling for oil if exploration is successful, transporting the extracted oil to refineries located on land, and shutting down completed wells.

The direct costs of offshore extraction are not set. Certain questions surrounding production costs may be reduced by the investment itself. For instance, information regarding the presence of oil in a specific tract will not emerge on its own, but will be obtained only if investment is made into exploration and development. In such cases, option value is minimal: no significant level of information will emerge if the choice is made to wait. Many other cost fluctuations are external to the investment itself, such as changes in the price of inputs like steel or labor, or the effectiveness of new technology. Since the choice to drill is irreversible, this uncertainty, write Dixit and Pindyck, "has the same effect on the investment decision as uncertainty over the future value of the payoff from the investment. . . . [I]t creates an opportunity cost of investing now rather than waiting for new information."[28]

Changes in technology can have a huge effect on the production costs associated with oil drilling. The first accounts of oil drilling in ocean waters come from the late nineteenth century, when citizens in California placed drilling rigs on wharfs extending from the beach.[29] Over the following decades drilling experiments were conducted farther and farther from shore.[30] Since that time more than 50,000 wells have been drilled in the Gulf of Mexico alone.[31] The first deepwater well (defined as a depth of 1,000 feet or more of water) came online in 1979, and in 1986 the first ultra-deepwater well (defined as 5,000 feet or more of water) became operational.[32] Today there are approximately 3,600 structures in the Gulf and 7,000 active leases. Over half of these leases are for deepwater drilling.[33]

The progression over time to wells farther from the shore and deeper under water was largely the result of significant technological advances. In early days, technological development focused on improving predictions of tides and currents, enhancing weather forecasts, and enabling adequate communication.[34] Today, deepwater drilling relies on highly sophisticated technology, which continues to improve the efficiency of extraction.

A few examples of the many technological developments related offshore oil drilling that have emerged in recent decades include:

> *Advanced Seismic Surveys.* Safe and efficient exploration and recovery of oil requires accurate readings of the sea bed. The earliest seismic surveys, made during the 1920s, produced two-dimensional (2-D) analog recordings.[35] Commercial use of three-dimensional (3-D) technology began slowly in the 1980s, and by 1996 nearly 80 percent of wells drilled were based on 3-D seismic surveys. The advances in seismic technologies helped improve well placement and reduced the number of exploratory wells drilled, resulting in increased productivity and decreased costs per unit of output.[36] Four-dimensional (4-D) seismic data imaging (interpreting several 3-D surveys from different times) is now being introduced to further enhance efficiency and accuracy.[37]
>
> *Horizontal/Directional Drilling.* Drilling for oil previously meant drilling a borehole straight down into the ground. Today, new technology allows horizontal or directional drilling, which enables greater flexibility and efficiency. Directional drilling allows drill bits to be steered laterally over several kilometers.[38] With this new flexibility, oil under vulnerable or inaccessible areas can be reached by drilling from a less sensitive locale.[39] Directional or horizontal drilling is particularly valuable offshore, where the cost of drilling rigs can make it uneconomical to drill a single well. With this new type of drilling,

twenty or more wells can be drilled from a single rig.[40]

Measurement-While-Drilling (MWD). As drilling has become more complex, obtaining and logging information from inside a well has become increasingly challenging. First introduced in the 1980s, MWD technology today allows attachment to the drilling apparatus itself measurement equipment calculating wellbore position, drillbit information, directional data and real-time drilling information.[41] Research is currently underway to transform the drill pipe into a high speed Local Area Network (LAN) that can support high-speed communications from multiple "downhole" drilling devices.[42] The precise real-time information enhances decisionmaking during the drilling process and enables safer deep drilling.

Enhanced Oil Recovery (EOR). Conventional oil recovery operations often leave two thirds of the oil in the reservoir. Enhanced Oil Recovery (EOR) processes involve injecting a gas or fluid into the reservoir to increase pressure or reduce oil viscosity to enable more easy recovery.[43] Developments in EOR technology in recent decades have allowed increasingly efficient extraction of oil from known reservoirs unreachable by previous technology.[44] In the 1970s, initial experiments were conducted using carbon dioxide as injection material for EOR.[45] Today this technology is receiving increased attention in light of growing interest in carbon capture and sequestration.[46]

These changes in technology have lowered the cost of offshore oil drilling, making drilling profitable in areas and at depths previously prohibited by high costs. These cost reductions are likely to continue and must therefore be included in any analysis of the value of drilling for oil today. Predicting the rate and direction of technological change is a difficult task, however.[47] While a simple cost-benefit analysis can include predictions of future cost reductions, these predictions are often mere guesses. The option value framework incorporates not only what is known about the direction of technological change, but uncertainty about what we do and do not know. It can therefore provide a more complete framework for analysis.

Environmental and Social Costs

Costs include not only the price of production but also broader environmental and social costs associated with oil drilling. Option value emerges in relation to these broader sets of value. Conrad and Kotani[48] focus on environmental costs in an examination of the choice of whether and when to open the Arctic National Wildlife Refuge to drilling. These authors model the relationship between lost "amenity value"[49] of the wildlife reserve—a concept roughly equivalent to existence value or non-use value—and threshold price, to determine how sensitive option value is to changes in the estimate of amenity value. They find that a $100 million change in amenity value altered the threshold price by a few dollars, and concluded that this was not a significant change.[50] Uncertainty about those costs would also affect the threshold price. While their analysis has been critiqued for, among other things, applying too high a discount rate to environmental amenity values,[51] it is useful as a demonstration that the option value framework is flexible enough to take into account broader social costs in the oil drilling context.

Future reductions in environmental and social cost will, like extraction costs, be associated with technological development. Technological advances do not only reduce the cost of extraction as noted above. They are also important in efforts to reduce environmental harm. Better safety technology can, for instance, decrease the harm associated with drilling itself and the risk of an oil spill, while enhanced cleanup technology can lower loss if a spill does occur. Some enhanced technology has emerged in recent years in relation to oil spill cleanup, including:

Sensing and Measuring Technology. A main challenge in oil spill cleanup is accurately measuring the scope and nature of spilled oil. Technological development over time has enhanced our ability to map and gauge the effect of spilled oil. Several types of radar and infrared imagers are now available, for instance, to help locate oil at night and during adverse weather condition.[52] During the Deep Horizon spill, a Multi-Angle Imaging Spectro Radiometer (MISR) instrument aboard NASA's Terra spacecraft helped show the movement of oil in the Gulf of Mexico.[53] Computer models have been developed as well to better find sunken masses of oil.[54]

Dispersants. Dispersants used in oil spills today are a combination of surfactants and solvents, which reduce the surface tension of water allowing oil to disperse into smaller droplets in the water column.[55] These droplets are then more easily broken down by bacteria and other underwater microbes. Early dispersants, used in the 1970s, were originally developed to clean tankers and engine rooms and were often more toxic than the oil itself, which meant that their use wreaked havoc on fish and other wildlife.[56] Although the exact environmental effects of dispersants remain unclear, present-day products are an improvement over earlier varieties. Improved delivery systems have also enhanced levels of efficiency and safety associated with their use.[57]

Booms. Preventing spilled oil from reaching the most ecologically vulnerable areas, such as coastal areas and wetlands, is of great importance in oil spill cleanup. Booms are a key tool in collecting and controlling oil at the water surface. Over the past decades booms have been improved to more effectively collect oil in choppy waters and faster currents. They have also been improved to better withstand exposure to heat and flame, thus enabling in situ burning of oil collected on the water as appropriate.[58]

The advances in oil spill cleanup and other technologies targeted at reducing environmental harm have not been as drastic as those aimed at increasing drilling speed and capacity. But there is a real opportunity for future changes to occur. These uncertain but possible cost reductions must be calculated in an evaluation of the cost of drilling.

A model that specifically focuses on the value of waiting to gain greater information about environmental costs was developed by Arrow, Fisher, Hanemann, and Henry ("the AFHH formula").[59] This model, which has key similarities to the Dixit-Pindyck formulation,[60] seeks to correct an anti-preservation bias in decisionmaking based on models that do not take into account the possibility of increasing knowledge about the natural world and the environmental effects of development.[61]

In the AFHH formula, option value is contingent upon information becoming available in the future. In the environmental context, the emergence of such future information is likely, since as time passes and research is conducted, knowledge tends to grow about the true environmental costs of an action. Examples of such changes in information are seen repeatedly through history as products and activity once thought to be harmless turn out to have significant environmental costs, and other products that are thought to be harmful turn out to be safe. The offshore drilling industry is no exception. Significant uncertainty still surrounds the effect of large-scale oil spills in sensitive areas for instance, or the true cost of greenhouse gas emissions resulting from the extracted oil. Waiting for future information regarding these costs holds value.

A recent report written by Krupnick et al. and published by Resources for the Future (RFF) provides an additional analysis of the value of offshore drilling in light of the potential costs.[62] In certain respects, the analysis from the RFF team shares similarities with an options value framework because it examines intermediate policy alternatives between a complete ban on oil extraction and unhindered exploitation. Specifically, the report compares the net benefits of a total ban on drilling with those associated with an increase in regulation. The framework used includes several variables, such as environmental impacts and damages from spills, effects on energy security, changes in overall oil consumption, and regulatory costs.

Krupnick et al. find that a complete ban would not be cost justified, while a partial ban would be justified, depending on the strength of the regulations and estimates of resulting benefits of that ban.[63] They estimate that a regulation increasing the cost to industry by 20% would entail an annual cost of $22 billion, while regulations increasing costs by 10% would entail $11 billion in costs annually. The authors estimate benefits from reduced spills to be between $16.1 and $25.9 billion per year. They calculate the stronger regulation is efficient only under the higher benefit scenario. The weaker regulation is indicated as beneficial under both scenarios.[64]

A full accounting of the costs and benefits of oil extraction should examine the full range of social effects, and not only effects on private investors; the real options framework can be expanded to include all the variables a social decisionmaker should care about.[65]

Legal Requirement to Take Account of Option Value

According to the legal framework surrounding offshore oil drilling in the United States, any grant of a license to drill must be preceded by an accurate analysis of the costs and benefits of such drilling. Today it is generally accepted that for such a cost-benefit analysis to be accurate, it must include a calculation of option value when a decision is uncertain, irreversible, and need not be taken immediately. Extraction of a non-renewable resource such as oil, which is surrounded by uncertainty and cannot be undone, exactly fits this description. The value of the option to wait until a future date to drill is thus central to any accurate calculation of the costs and benefits of oil drilling. BOEMRE, as the agency in charge of calculating the value of specific oil leases, is thus mandated to include estimates of option value in their analyses.

Interior's Legal Duties

According to both its statutorily described duty to examine a broad range of economic, social, and environmental effects, and general administrative law principles governing the exercise of agency discretion, BOEMRE is required to examine option value when making leasing decisions for offshore lands.

The OCSLA requires the Secretary of the Interior to consider the full costs and benefits of drilling. Section 18(a)(1) of the OCSLA directs the Secretary to prepare an oil and gas leasing program to implement the policies of the act.[66] The program is to include a five-year schedule for leasing that indicates "as precisely as possible, the size, *timing*, and location of leasing activity which [the Secretary] determines will best meet national energy needs."[67] The leasing schedule is to be prepared and maintained in a manner "which considers economic, social, and environmental values of the renewable and nonrenewable resources contained in the outer Continental Shelf, and the potential impact of oil and gas exploration on other resource values of the outer Continental Shelf and the marine, coastal, and human environments."[68]

The Secretary must accurately consider both economic benefits and social and environmental costs when setting the leasing agenda, and he is to take into consideration not only *if* but also *when* to drill. In so doing the Secretary must weigh several variables, including "relevant environmental and predictive information."[69] In addition, section 18(a)(4) directs the Secretary to ensure that lease purchasers pay a "fair market value" for the lease in question.[70]

In addition to the direct statutory language requiring the agency to taking into account "economic, social and environmental values," general principles of administrative law set a standard of reasoned decisionmaking that demand that agencies consider all "relevant factors" when exercising their discretion.[71] Where agencies fail to examine these types of factors, their decisions will be set aside as "arbitrary or capricious" under the Administrative Procedure Act.[72]

In *Motor Vehicles Manufacturers Assoc. v. State Farm Mutual*, the Supreme Court held that an agency's decision would be "arbitrary and capricious" if: "the agency has [1] relied on factors which Congress has not intended it to consider, [2] entirely failed to consider an important aspect of the problem, [3] offered an explanation for its decision that runs counter to the evidence before the agency, or [4] is so implausible that it could not be ascribed to a difference in view or the product of agency expertise."[73] The agency is also to consider alternatives presented in the record.[74]

In relation to offshore drilling specifically, the U.S. Court of Appeals for the District of Columbia Circuit has held that the Secretary's discretion regarding leasing is "not unreviewable," and that the "policies and purposes" of the OCSLA provide standards by which the court "may determine whether the Secretary's decision was arbitrary, irrational, or contrary to the requirements of the Act."[75] In order to determine the Secretary's compliance with the law, the court considers "whether the decision was based on a consideration of the relevant factors and whether there has been a clear error of judgment."[76]

Option value meets the requirement of a relevant factor under *State Farm* and the arbitrary and capricious standard. As discussed above, there is significant consensus that an options framework is appropriate in this context. The lease planning process is an appropriate time to consider option value: the emphasis on timing in section 18 of OCSLA indicates that the agency has the choice to drill in the future instead of today; the benefits in the form of oil revenue are uncertain, as are the direct and indirect costs of drilling; and the choice to drill is essentially irreversible. In addition, private actors will not have incentives, when making lease purchasing decisions, to take into account social costs and benefits—if these values are to be considered at all, it must be during the process of opening lands for leasing, and approving leasing allocations. The choice not to use an options framework can have an important impact on the ultimate decision.

Unfortunately, the agency does not use this framework, or provide an adequate justification for its decision.

The Current Failure to Account for Option Value

BOEMRE's current program for offshore leasing consists of four stages: a five-year planning program; preleasing activity and lease sales; exploration of potential drilling areas; and development and production. In addition, the Secretary can suspend or cancel leases, but only under limited circumstances, as noted above. A lease granted by BOEMRE today gives the holder the right to use land as necessary to develop oil and gas reserves, including exploring, drilling, extracting, removal, and disposal, subject to relevant environmental laws and regulations. Leases can be held for five to ten years (depending on the lease) with no exploration. After that time, if no commercially viable amount of oil or gas is being extracted, the lease is relinquished back to the federal government.[77] From the perspective of the government, there is only one significant choice related to timing: whether and when to lease the tract.

The current BOEMRE framework for making these decisions is explained in agency documents outlining the current five-year leasing program. The most recent such document, published in December 2010, is entitled *Revised Program Outer Continental Shelf Oil and Gas Leasing Program 2007-2012* (hereinafter "RP").[78] This document lays out BOEMRE's considerations and calculations regarding offshore drilling leases and is a response to a remand order from the U.S. Court of Appeals for the District of Columbia requiring the agency to revise its environmental sensitivity analysis and improve its balancing of potential environmental impacts.[79]

The RP outlines methods used by BOEMRE to calculate the net benefits of drilling for oil offshore. Much of the modeling done by the agency is to determine the consumer and producer surplus associated with the extraction of oil, in part using the MarketSim model. This information is then used to determine a "net economic value" of the oil, which is gross revenues minus private costs, and a "net social value" which is the gross revenues minus both private and public costs.[80]

BOEMRE bases its current leasing decisions on the net social value and any benefits related to consumer surplus.[81] From these calculations the agency recently estimates the net benefits of drilling in the OCS to be around $166 billion.[82]

The agency does recognize that there is significant uncertainty concerning key parameters. In calculating gross revenue, BOEMRE assumes a constant inflation-adjusted oil price of $46 per barrel.[83] The agency justifies its use of one set price largely on the "uncertainty of future price levels," and the associated difficulty involved in accurately predicting future price paths. The agency reasons that a set price reduces inaccuracies arising from incorrect price forecasts and eases analysis of comparative benefits.[84]

The agency also recognizes the potential for future environmental information. The agency uses a nine-sector model (the Offshore Environmental Cost Model) in order to estimate environmental impacts.[85] The RP reports as a guiding principle the notion that the agency is to "use best available data when committing additional acreage to leasing, especially where there is insufficient confidence in the ability to avoid or mitigate harm to valuable resources and human uses, and enhanced information will allow for better decisionmaking in the next 5-year program."[86]

Despite its recognition of the uncertainties that affect its decisionmaking, the agency has not provided any justification for its decision not to use the superior real options model. While there are greater information collection and computation demands associated with the real options framework, failure to use the model can lead to significantly misleading estimates of costs and benefits, and ultimately incorrect decisions. For the agency to defend its choice, it would need to show that the additional decisionmaking benefits of the superior real options model are outweighed by greater analytic costs. This will be difficult to do, given the large economic and environmental values that are at stake.

The Role of the Leasing Process

Some of the concerns over the failure of BOEMRE to account for option value may be alleviated if the private market nevertheless compensated the American public for any lost option value during the leasing process. Leases are allocated generally through an auction process. To the extent that leases are genuinely competitive, the price of the lease should equal the economic value of the drilling rights, with a risk-adjusted rate of return for the lease holder. With adequate auction participation, and a lack of collusion, there should be no excess returns available.

The option held by the American public is infinitely long—there is no expiration date on when that option will lapse. During the auction process, the leases being purchased amount to fixed-time options: the purchasers need not immediately exploit the resource, but cannot wait indefinitely. This difference alone can, in theory, lead to under-compensation even with a fair and well-functioning auction process, because the right being purchased is less extensive than the right being sold. If the option value of a fixed-term lease is substantially lower than the perpetual option held by the American public, then the price paid by the lessee is not a good proxy for the right being given up.

This problem may not be very grave in practice. Over the relevant time scales, the option value for a fixed-term lease approaches the option value on the perpetual lease.[87] If auctions worked perfectly, and only private costs and benefits (and associated uncertainty) were the focus of concern, then the auction process would generally ensure rough compensation for the option value being transferred.

There are important problems, however, with relying on the auction process to ensure that option values are protected. First, the leasing process takes into account only private costs and benefits, and therefore does not impound all of the uncertainty concerning environmental harm or the development of cleanup technology. The prices in the auction process may account for some uncertainty, but will not cover the whole spectrum of uncertainty that is relevant in the leasing context.

Second, the reliability of the auctioning process is subject to some concern. In particular, the mechanism that the agency has in place to determine that the auction process is fair (through the setting of a reservation price) does not take into account option value. As a result, this reservation price will not adequately protect against auction failures that generate a price below the threshold value for a lease.

To ensure that the American public receives a fair value for the oil leases that are sold, option value should be used when setting the reservation price during the lease auction process. Without this option value, there is no guarantee that the price reflects uncertainty with respect to both private and public risks.

Conclusion

America's oil reserves represent a massive asset. Wise management of this resource can lead to billions of benefits—primarily in the form of government revenue, but also in secondary economic benefits such as job creation.

At the same time, accessing these resources is a dangerous and costly process: the BP Gulf Coast Oil Spill serves as a stark reminder of the risks involved. There are a host of uncertainties associated with oil drilling. These uncertainties cover everyday business concerns like the costs of oil and lifting costs, but also involve matters like the risk of catastrophic breakdown and the ability of spill response to contain and minimize the negative economic and environmental consequences of such failures.

The fitful growth in technology, both production technology and spill response technology, only adds complexity and uncertainty to the equation. The rate of technological development is unknown and affected by a range of factors, including government policy. This uncertainty provides additional reason for caution when deciding when to exploit these natural resources.

In order to appropriately account for option value, and fulfill its legal obligations under the OCLSA and general principles of administrative law, there are several steps that the Department of the Interior must take:

Calculate the option value related to oil prices. Over the past four decades, economists have developed sophisticated models to estimate how rational market actors would take account of uncertainty about future prices when making investment decisions. The options framework, which is employed on a regular basis by sophisticated participants in financial markets, can be used by the Department of the Interior to ensure that exploitation of natural resources generates the maximum amount of net benefits for the American public.

Calculate the option value related to costs. Uncertainty about the environmental effects of spills and the path of technological development that reduces both private and social costs can likewise be incorporated into an options framework. Just as price volatility can affect investment choices, uncertainty about the private and public costs associated with oil exploitation means that delaying a decision can generate informational benefits. Option value models can incorporate the wide range of costs and benefits associated with oil drilling decisions.

Use the option value when establishing leasing schedules and setting auction reserve prices. The process to auction off oil drilling leases should be designed to protect the American public. Flawed auctions can result in a sub-optimal price, which transfers wealth from the broader public to private actors. In addition, the full range of uncertainty about the costs and benefits of oil drilling will not necessarily be impounded into the price of even a fully competitive auction; there is therefore need to set a reservation price, based on option value, to ensure an adequate price is paid for the right to exploit oil resources.

Notes

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2 Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. § 1344(a)(1) (2010).

3 For an overview of other problems with cost-benefit analyses of offshore drilling, see Alan Krupnick et al., Understanding the Costs and Benefits of Deepwater Oil Drilling Regulation (Resources for the Future, Discussion Paper, 2011).

4 43 U.S.C. § 1332(3).

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6 43 U.S.C. §§ 1301 et seq (2010). Under the SLA, exceptions are made for Texas and Florida, giving them larger areas of control in the Gulf of Mexico—up to nine miles.

7 See, e.g., Alaska Stat. §§ 38.05.140(f), 38.05.184; Cal. Pub. Res. Code § 6243; Fla. Stat. Ann. §377.242; Md. Code, Envt. §14-107; Miss. Code. Ann. § 29-7-3; Wash. Rev. Code Ann. §§ 43.143.005 et seq.

8 Under the OCSLA, the Secretary of the Interior promulgates rules on suspension and cancellation of leases. The Secretary's discretion is limited; generally, a suspension occurs either at request of lessee or of relevant BOEMRE Regional Supervisor. Upon cancellation, the lessee is entitled to damages. 43 U.S.C. §§ 1334(a)(2)(A)-(C).

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84 Id.

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