University of Colorado Law Review

Volume 84 | Issue 3 Article 3

Summer 2013

Patience is an Economic Virtue: Real Options, Natural Resources, and Offshore Oil

Michael A. Livermore

PATIENCE IS AN ECONOMIC VIRTUE: REAL OPTIONS, NATURAL RESOURCES, AND OFFSHORE OIL

MICHAEL A. LIVERMORE*

The financial concept of real options has important consequences in areas of environmental and natural resources law where irreversible decisions are made in the face of uncertainty. This article argues that consideration of real options is necessary to maximize economic returns from nonrenewable natural resource extraction, using offshore oil drilling as a case study. Because decisions over drilling are often framed as a now-or-never choice, the option to wait (or the "real option" value) is improperly treated in administrative processes that determine whether, when, and how offshore oil resources will be tapped. The value associated with the option to delay can be large, especially when there is a high degree of uncertainty about price, extraction costs, or the social costs imposed by drilling. The value of the information generated during a period of delay can outweigh the value of immediate extraction. Failure to consider option value leads to over-early exploitation of nonrenewable resources, and socially undesirable environmental damage. In the case of offshore drilling, the governing statute requires the Department of Interior, the administrative agency charged with overseeing the leasing of offshore lands, to consider the economic consequences of its choices, a charge it has implemented through detailed cost-benefit analysis of its planning decisions and through a

* Executive Director, Institute for Policy Integrity (Policy Integrity) and adjunct professor, New York University School of Law. J.D., New York University School of Law. Many thanks for extremely helpful comments from Matthew D. Adler, Oren Bar-Gill, Scott Farrow, Barry Friedman, Robert Hahn, J. Scott Holladay, Alan Krupnick, Lucija Muehlenbachs, Richard L. Revesz, Jason Schwartz, Richard B. Steward, Katrina Wyman, and participants in the Furman Academic Scholars program at NYU Law and the Society for Environmental Law and Economics 2012 Annual Meeting. Excellent research and editorial support was provided by Gaia Larsen, Niral Shah, and Monica Rodriguez and the staff at the University of Colorado Law Review. Early versions of the arguments presented here were included in public comments of Policy Integrity to the Department of the Interior concerning its draft offshore drilling plans, and a Policy Integrity report, *The BP Gulf Coast Oil Spill, Option Value, and the Offshore Drilling Debate.*

sophisticated bidding system for lease auctions. But because both the cost-benefit analysis and the bidding system fail to account for real option value, they are fundamentally incomplete, leaving leasing decisions open to litigation risks and failing to maximize the net benefits generated by this public resource.

INTRODUCTION

Offshore oil drilling remains one of the most frequently discussed national environmental issues in the United States.

Largely breaking along predictable political lines, two fundamental camps have become entrenched: on the one hand, a pro-exploitation camp with a rallying cry of "drill, baby, drill,"[1] and on the other, a preservationist group that seeks an indefinite moratorium on all new drilling activities.[2]

There are several misconceptions that influence this discussion. Perhaps most pervasive is the belief that increasing domestic oil production will have a major effect on gasoline prices. In fact, economic analysis of oil markets has shown 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."[3] Because the United States is engaged in global oil markets, even relatively large domestic changes in production lead to only small changes in price.[4]

If increasing domestic oil production is economically justified, it will not be as an effective or efficient tool to save consumers money at the pump.[5] Rather, the criteria will be

---

1. Siobhan Hughes, *Steele Gives GOP Delegates New Cheer: 'Drill, Baby, Drill!'*, WALL ST. J. (Sept. 3, 2008, 10:50 PM), http://blogs.wsj.com/washwire/2008/09/03/steele-gives-gop-delegates-new-cheer-drill-baby-drill/. Enthusiasm for expansive drilling is not a one-party affair. In his 2012 State of the Union Address, President Barack Obama took credit for "open[ing] millions of new acres for oil and gas exploration" and proposed "open[ing] more than 75 percent of our potential offshore oil and gas resources." News Release, Office of the Press Secretary, Remarks by the President in State of the Union Address (Jan. 24, 2012), http://www.whitehouse.gov/the-press-office/2012/01/24/remarks-president-state-union-address.

2. *See, e.g.*, MICHAEL CRAIG & SIMON MAHA, BREAKING THE HABIT: ELIMINATING OUR DEPENDENCE ON OIL FROM THE GULF OF MEXICO BY 2020, THE PERSIAN GULF BY 2023, AND ALL OTHER NATIONS BY 2033 (2011) (advocating twenty-year timeline for United States to eliminate offshore drilling in the Gulf of Mexico).

3. Robert Hahn & Peter Passell, *The Economics of Allowing More U.S. Oil Drilling*, 32 ENERGY ECON. 638, 638 (2010).

4. Analyses by the Department of the Interior do list consumer surplus improvements from very small changes in oil prices as a benefit associated with the development of oil resources in the outer continental shelf ("OCS"). *See* WILLIAM E. KING, U.S. DEPT OF THE INTERIOR MINERAL MGMT. SERV., OCS REPORT MMS 2007-017, ECONOMIC ANALYSIS FOR THE OCS 5-YEAR PROGRAM 2007–2012: THEORY AND METHODOLOGY 7–8, 17 (2007) [hereinafter ECONOMIC ANALYSIS 2007]. From a purely economic perspective, much of the consumer surplus gains from price declines are merely transferred from producers.

5. There are effective steps that can be taken by the federal government to reduce consumer fuel expenditures that have nothing to do with lowering prices. For example, the Environmental Protection Agency ("EPA") estimates that there will be substantial consumer savings from increased fuel efficiency standards. *See, e.g.*, Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards, 75 Fed. Reg. 25323 (May 7, 2010) (to be codified at 40 C.F.R. pts. 85, 86, 600; 49 C.F.R. pts. 531, 533, 536–38).

whether the social benefits of drilling (i.e., the market price of the oil that is extracted) outweigh the costs (including the production costs and the risks of environmental damage from accidents).[6] To make that choice, the full extent of both the benefits and costs of drilling must be examined.[7]

Doing so is easier said than done, but the Department of the Interior ("DOI") has developed sophisticated methods to tackle this task.[8] Cost-benefit analysis of opening new lands for exploration is based on data collected about known and potential oil resources, information about the commercial costs of exploration and exploitation, and research into the environmental risks associated with offshore oil drilling. Given

6. Of course, the use of cost-benefit analysis and economic criteria for making social choices in the environmental arena has both its defenders and critics. *See generally* FRANK ACKERMAN & LISA HEINZERLING, PRICELESS: ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING (2004) (criticizing cost-benefit analysis for, *inter alia*, placing a monetary value on life-saving regulation); MATTHEW D. ADLER & ERIC A. POSNER, NEW FOUNDATIONS OF COST-BENEFIT ANALYSIS 6, 25 (2006) (arguing that cost-benefit analysis can be justified on welfarist grounds); ELIZABETH ANDERSON, VALUE IN ETHICS AND ECONOMICS (1993) (providing ethical critique of cost-benefit analysis); CASS R. SUNSTEIN, RISK AND REASON: SAFETY, LAW, AND THE ENVIRONMENT 291 (2002) (defending cost-benefit analysis as a tool to improve risk regulation). In any case, cost-benefit analysis as a tool for evaluating social policy is likely "here to stay." RICHARD L. REVESZ & MICHAEL A. LIVERMORE, RETAKING RATIONALITY: HOW COST-BENEFIT ANALYSIS CAN BETTER PROTECT THE ENVIRONMENT AND OUR HEALTH 11 (2008). As will be described in more detail below, cost-benefit analysis is particularly deeply ingrained into the process of determining whether offshore areas should be opened for exploration. *See infra* Part III.

7. Empirical examination of the impact that examination of costs and benefits of lease sales has on policy outcomes has shown that there is a statistically significant correlation but that the correlation is not particularly strong. R. SCOTT FARROW, MANAGING THE OUTER CONTINENTAL SHELF LANDS: OCEANS OF CONTROVERSY 110–15 (1990). Farrow notes that, "[t]he planning process and supporting analyses serve several purposes in the determination of the pace of leasing of which informing the secretary is only a part of predictable strategic planning for the legal battle to follow." *Id* at 115.

8. The DOI entity responsible for management of offshore oil reserves has gone through two reorganizations to date in the wake of the BP Gulf Coast Oil Spill in 2010, following criticism that there had been an "overly cozy" relationship with the regulated industry. Press Release, Sen. Dianne Feinstein, Chairman Feinstein Blasts Shoddy Oversight of Offshore Drilling at Minerals Management Service, Criticizes Overly Cozy Relationships Between MMS Regulators and Oil Industry (May 25, 2010). Shortly after the spill, the Minerals Management Service, which was created in 1981 within DOI, was renamed the Bureau of Ocean Energy Management, Regulation and Enforcement ("BOEMRE") and a round of institutional changes were made. On October 1, 2011, BOEMRE was split into two agencies, the Bureau of Ocean Energy Management ("BOEM") and the Bureau of Safety and Environmental Enforcement ("BSEE"), the first charged with resource management. To avoid confusion, this article refers to the Department of the Interior generally, rather than MMS, BOEMRE, and BOEM.

their time and resource constraints, civil servants at DOI have engaged in a laudable effort to provide decisionmakers with a clear picture of the costs and benefits associated with drilling.

But in an extremely important way, these analyses are fundamentally incomplete because DOI fails to adequately account for the value associated with delaying lease sales. If the net revenue derived from exploiting a resource is rising faster than the rate of return of the economy as a whole, delaying extraction is equivalent to achieving an above market interest rate for savings—an obviously attractive proposition.[9] Even where this is not the case, the value of the option to wait can nevertheless be important where future costs and benefits of a project are uncertain and decisions are irreversible.[10] The value associated with delay has been the subject of discussion within the economics field for decades, including in the context of natural resource extraction and petroleum reserves.[11] Models for taking account of option value have been used extensively in the private sector.[12] But, in leasing decisions for

9. *See generally* Harold Hotelling, *The Economics of Exhaustible Resources*, 39 J. POL. ECON. 137 (1931) (describing what has come to be known as "Hotelling's Rule," that along the efficient pathway of consumption of a finite resource, net revenues for the resource owner will increase at the rate of interest); Robert D. Cairns & Graham A. Davis, *Strike When the Force Is with You: Optimal Stopping with Application to Resource Equilibria*, 89 AM. J. AGRIC. ECON. 461 (2007) (discussing optimal stopping rule when rate of increase of a project's value differs from the economy-wide interest rate).

10. *See generally* Graham A. Davis & Robert D. Cains, *Good Timing: The Economics of Optimal Stopping*, 36 J. ECON. DYNAMICS & CONTROL 255 (2012) (distinguishing between the value of waiting due to capital gains and value due to uncertainty). This Article focuses on the information value of delay rather than the potential for price increases in part because DOI projection for price increases are typically below the growth rate of the economy, a decision that the court has left to the agency's discretion. *See infra* notes 176–182 and accompanying text. In its current leasing plan, the agency assumes a 2 percent rate of price growth for analyzing lease timing. BUREAU OF ENERGY MGMT., U.S. DEP'T OF THE INTERIOR, PROPOSED OUTER CONTINENTAL SHELF OIL AND GAS LEASING PROGRAM 2012–2017, at 71 (2010) [hereinafter 2011 DRAFT PROPOSED PROGRAM].

11. *See, e.g.*, James L. Paddock, Daniel R. Siegel & James L. Smith, *Option Valuation of Claims on Real Assets: The Case of Offshore Petroleum Leases*, 103 Q. J. ECON. 479, 479 (1988).

12. Simple calculators for determining option value proliferate online. *See, e.g.*, *Option Calculator*, OPTION-PRICE.COM (last visited Mar. 26, 2013). Indeed, some commentators have argued that over-reliance on sophisticated pricing models for options is a contributing factor to systemic risk in the financial system. *See, e.g.*, Tim Harford, *Black-Scholes: The Math Formula Linked to the Financial Crash*, BBC NEWS MAG., Apr. 27, 2012, http://www.bbc.co.uk/news/magazine-17866646. Note that the solution would not be to ignore option value; the argument is that current models underestimate the degree of risk in financial markets and, therefore, fail to capture the full extent of option value.

the vast offshore oil reserves held by the United States (and in other natural resource contexts), government agencies do not appropriately value these "real options."[13] The nature of real options and their importance for the timing of decisions concerning the exploitation of nonrenewable natural resources is discussed in more detail in Part I. The central conclusion of that Part is that a failure to account for real-option value results in economically inefficient and environmentally wasteful over-early exploitation.

The implications of real options theory for DOI offshore drilling decisions under the Outer Continental Shelf Lands Act (the "OCSLA")[14] have not yet been explored in the environmental law literature. In recent years, real options have been discussed in a range of legal contexts, including entitlements,[15] litigation behavior,[16] patents,[17] bankruptcy,[18] rules concerning the timing of legislative and administrative action,[19] liability and property rights,[20] and regulatory risk.[21]

---

13. The term "real options" describes the right, but not the obligation, to undertake a business initiative (like making a capital investment). Real options can be contrasted with financial options, which are the right to buy or sell financial instruments at reference prices. *See* AVINASH K. DIXIT & ROBERT S. PINDYCK, INVESTMENT UNDER UNCERTAINTY 6–7 (1994).

14. 43 U.S.C. §§ 1331–1356a (2011).

15. IAN AYRES, OPTIONAL LAW: THE STRUCTURE OF LEGAL ENTITLEMENTS (2005).

16. Joseph A. Grundfest & Peter H. Huang, *The Unexpected Value of Litigation: A Real Options Perspective*, 58 STAN. L. REV. 1267, 1267 (2006); Robert J. Rhee, *The Effect of Risk on Legal Valuation*, 78 U. COLO. L. REV. 193, 194 (2007).

17. F. Russell Denton & Paul J. Heald, *Random Walks, Non-Cooperative Games, and the Complex Mathematics of Patent Pricing*, 55 RUTGERS L. REV. 1175, 1175–76 (2003).

18. Douglas G. Baird & Edward R. Morrison, *Bankruptcy Decision Making*, 17 J.L. ECON. & ORG. 356, 358–66 (2001).

19. Jacob E. Gersen & Eric A. Posner, *Timing Rules and Legal Institutions*, 121 HARV. L. REV. 543, 544–46 (2007).

20. *See* Lee Anne Fennell, *Revealing Options*, 118 HARV. L. REV. 1399 (2005).

21. Justin Gundlach, *What's the Cost of a New Nuclear Power Plant? The Answer's Gonna Cost You: A Risk-Based Approach to Estimating the Cost of New Nuclear Plants*, 18 N.Y.U. ENVTL. L.J. 600, 601–03 (2011); Lynne Holt, Paul Sotkiewicz & Sanford Berg, *(When) to Build or Not to Build?: The Role of Uncertainty in Nuclear Power Expansion*, 3 TEX. J. OIL GAS & ENERGY L. 174, 174–75 (2008); *see also* Christopher J. Koschnitzky, *Refining Regulation: The Oil Refinery Regulatory Framework After the Energy Policy Act of 2005*, 15 MO. ENVTL. L. & POL'Y REV. 89, 104–05 (2007) (mentioning real options in passing and citing Eli Berman & Linda T.M. Bui, *Environmental Regulation and Productivity: Evidence from Oil Refineries*, 83 REV. ECON. & STAT. 498, 498 (2001)); David Zilberman, Gal Hochman & Deepak Rajagopal, *On the Inclusion of Indirect Land Use in Biofuel Regulations*, 2011 U. ILL. L. REV. 413, 430 (arguing that consideration of indirect land use effects from biofuels development "incorporates

How real options relate to environmental questions has received some attention from legal scholars,[22] and given the broad applicability of real options to environmental and natural resource issues, the attention indicates that interest is likely to grow. Jody Freeman and Adrian Vermeule note that option value can help explain some of the hesitancy of agencies to move forward with regulation when the value of additional information associated with delay is high.[23] Jeff Strnad examines how real options theory can inform tax policy concerning oil extraction.[24] Cass Sunstein provides the most detailed treatment, examining how real options theory can justify elements of the precautionary principle and discussing how concern about irreversibility is manifested in both international and domestic environmental regimes.[25] Scholarship in the wake of the BP Gulf Coast Oil Spill, however, has tended to track the traditional environmental topics such as the role of National Environmental Policy Act and other statutes in preventing catastrophic harms,[26] how criminal prosecution should fit within an appropriate environmental enforcement regime,[27] corporate social

---

a new layer of uncertainty" that affects option value for technological adoption).

22. *E.g.*, Dexter Samida & David A. Weisbach, *Paretian Intergenerational Discounting*, 74 U. CHI. L. REV. 145, 168–69 (2007) (mentioning real options as appropriate treatment for irreversibility in climate change context); *see also* Richard L. Revesz & Matthew R. Shahabian, *Climate Change and Future Generations*, 84 S. CAL. L. REV. 1097, 1149 n.236 (2011) (responding to Samida & Weisbach). In a recent article, Daniel Farber mentions real options as an "emerging possibility" for understanding catastrophic risk situations. Daniel A. Farber, *Uncertainty*, 99 GEO. L.J. 901, 927 n.113 (2011) (citing Jon Anda, Alexander Golub & Elena Strukova, *Economics of Climate Change Under Uncertainty: Benefits of Flexibility*, 37 ENERGY POL'Y 1345, 1354 (2009)). Not all scholarship that attempts to move beyond the traditional framing of "precaution versus science" and now-or-never decisionmaking explicitly invokes real option value, although many of the concerns are similar. *See, e.g.*, Holly Doremus, *Precaution, Science, and Learning While Doing in Natural Resource Management*, 82 WASH. L. REV. 547, 549 (2007); *see also* Steven Shavell, *On Optimal Legal Change, Past Behavior, and Grandfathering*, 37 J. LEGAL STUD. 37, 58 n.25 (2008) (noting similarity of model developed to examine grandfathering with real options analysis).

23. Jody Freeman & Adrian Vermeule, *Massachusetts v. EPA: From Politics to Expertise*, 2007 SUP. CT. REV. 51, 81.

24. *See* Jeff Strnad, *Taxes and Nonrenewable Resources: The Impact on Exploration and Development*, 55 SMU L. REV. 1683, 1683 (2002) (discussing the importance of real option value for setting optimal tax policy for extraction).

25. Cass R. Sunstein, *Irreversible and Catastrophic*, 91 CORNELL L. REV. 841, 843–44, 856–60 (2006).

26. Oliver A. Houck, *Worst Case and the Deepwater Horizon Blowout: There Ought to Be a Law*, 24 TUL. ENVTL. L.J. 1, 1 (2010).

27. David M. Uhlmann, *After the Spill is Gone: The Gulf of Mexico,*

responsibility,[28] and liability regimes.[29] The importance of delay for government leasing decisions concerning offshore oil exploration has largely escaped notice. The contribution of this Article is to focus specifically on the special costs and benefits associated with making irreversible decisions when facing uncertainty in the offshore drilling context and to examine how real options should be taken into consideration by DOI under the OCSLA.

Real options theory has important implications for government decisionmaking in the natural resource area. These issues are not merely conceptual, but affect natural resources worth many billions of dollars. For governments to maximize the value of nonrenewable resources and provide sensible levels of environmental protection, they must integrate option value into their administrative processes. Failure to do so leads to over-early exploitation of these resources, reduces economic returns for the American public, and exposes agency decisions to litigation risk.

In the offshore oil context, the government can incorporate option value at two stages of its decisionmaking process. First, when evaluating the costs and benefits of opening lands for leasing, the value of delay can be estimated and included. This value will be calculated as a cost of opening new lands for leasing. Second, during the bid adequacy process, the government can set a higher reservation price, reflecting the option value of the land, both to ensure that the private benefits of extraction exceed the public benefits of delay, and to secure adequate compensation for the American public for the right that is being transferred.

The following discussion examines the economic, environmental, and legal consequences of real option value in the natural resource context, focusing on offshore oil drilling. Part I provides general background on option value and its

---

Environmental Crime, and the Criminal Law, 109 MICH. L. REV. 1413, 1413 (2011).

28. Miriam A. Cherry & Judd F. Sneirson, *Beyond Profit: Rethinking Corporate Social Responsibility and Greenwashing After the BP Oil Disaster*, 85 TUL. L. REV. 983, 983 (2011).

29. Craig H. Allen, *Proving Natural Resource Damage under OPA 90: Out with the Rebuttable Presumption, in with APA-Style Judicial Review?*, 85 TUL. L. REV. 1039, 1039 (2011); John W. deGravelles & J. Neale deGravelles, *The Deepwater Horizon Rig Disaster: Issues of Personal Injury and Death*, 85 TUL. L. REV. 1075, 1075 (2011); Kenneth M. Murchison, *Liability Under the Oil Pollution Act: Current Law and Needed Revisions*, 71 LA. L. REV. 917, 917 (2011).

relevance to nonrenewable resource extraction. Part II examines the types of uncertainty that are most relevant in the offshore drilling context. Part III discusses the legal regime in the United States governing resource extraction and examines how Congress, the courts, and the executive have created requirements that economic factors be considered by DOI when making leasing decisions. Part IV details the failure of DOI to consider option value despite the otherwise sophisticated cost-benefit analysis undertaken to evaluate offshore oil drilling decisions. Part V argues that this failure exposes DOI to litigation risk and proposes a set of reforms to the DOI decisionmaking process.

I. UNCERTAINTY, IRREVERSIBILITY, AND RESOURCE EXTRACTION

The option to wait is valuable in situations where future costs and benefits of a project are uncertain, decisions are irreversible, and delaying action will generate additional information. Investment must be made on the basis of expected outcomes. In contexts where additional time generates information about the benefits and costs of a project, there is a value associated with waiting to act. The value of this information is called the "real option value." This value is distinct from risk aversion, which is a potential additional factor for decisionmakers to take into account when making decisions under uncertain conditions (but is not the focus of this Article). Even fully risk-neutral actors seeking to maximize expected value will, when acting rationally, account for real option value.

This Part will provide a general discussion of real option value, with a particular focus on natural resources. The first section provides a very general introduction to the concept of real options. The second section applies the concept to the context of offshore oil drilling. The third section clears up some conceptual confusion surrounding real option value in environmental law and discusses techniques for assigning a monetary value to the option to wait.

A. The Value of Options

Imagine two young entrepreneurs who need to determine whether to invest their money in creating a lemonade stand

over the weekend. The materials for the stand (pitcher, glasses, lemons, sugar, and time) will cost $45. If it is sunny, they will make $7.50 on Saturday and $50 on Sunday (due to a nearby ballgame); if it is rainy, they will make $5 on Saturday and $10 on Sunday. It takes a day to set up the stand. Assume that the next day's weather can be predicted with 100 percent accuracy and that there is a 75 percent chance of consistency of weather between two consecutive days.

On Friday, the friends view the weather prediction and see that it will be sunny on Saturday, which means a 75 percent chance it will also be sunny on Sunday. If they conducted a standard now-or-never cost-benefit analysis on this problem, they would decide to set up the lemonade stand:

> Net Present Value = (Saturday's Revenue, $7.50) + (Sunday's Expected Revenue, 75% x $50 + 25% x $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% x $10 + 25% x $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 a 75 percent 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% x $50) – (Expected Costs, 75% x $45) = $3.75

On Saturday, they need only make the investment if they

know that it will be sunny on Sunday. If they learn that it is going to rain on Sunday, they can save their money. As a result, the expected value is the profit on a sunny Sunday—$5 ($50 Revenue – $45 Costs)—times the chance that it will be sunny—75 percent—which is $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% x $50) – (Expected Costs, 25% x $45) = $1.25

So even bad news on Friday does not mean that our entrepreneurs need to give up. They can wait until Saturday to see if it will be sunny on Sunday, in which case they should invest. So, even if they learn that it will rain on Saturday, there is a 25 percent chance they can make their $5 profit. That chance has an expected value to our young entrepreneurs of $1.25.

A similar, albeit more complex, situation arises in the context of natural resources. The owner of resources often faces uncertainty over the costs and benefits of development. These uncertainties can be due to fluctuations in commodity prices, the unknown effects of development on complex ecosystems, or gaps in scientific understanding about human health. The impact of any development that increases (or decreases) greenhouse gas concentrations in the atmosphere is subject to large degrees of uncertainty.

In many cases, the decision to develop a resource will also be irreversible, or at least very costly to reverse.[30] Once a nonrenewable resource has been extracted and used, it is gone forever. The decision to convert forested land into a suburban housing complex is largely irreversible. If a wetland is drained or critical species habitat is destroyed, there may be no way to undo it. Carbon dioxide, once released into the atmosphere, can remain stable and trap heat for hundreds of years.

Examples concerning the importance of real options for

30. *See* Sunstein, *supra* note 25, at 860–65 (examining nature of irreversibility and noting that economic view equates irreversibility with sunk costs).

environmental decisionmaking abound. In their pioneering piece on option value, Kenneth Arrow and Anthony Fisher discuss the decision of whether to protect "a virgin redwood forest for wilderness recreation" or open it "to clear-cut logging."[31] If the benefits of development are uncertain, and development is effectively irreversible, then the form is similar to the price uncertainty faced by the lemonade stand entrepreneurs. Taking a similar two-period model, where uncertainty in the first period would be resolved in the second, it may make sense to wait until the uncertainty is resolved. For example, if the value of the development only exceeds the value of the preserved land if a road is built nearby, and there is a chance that the road may not be built, it may make sense to purchase the land but wait to develop, forgoing some amount of profits in the short term in exchange for information about the value of developing.

Climate change, with its attendant scientific uncertainty and risk of irreversible harm, has been examined as an area where option value may be important.[32] For example, the expected value of a project to mine methane hydrates from the ocean floor may be positive, but there may be a small risk that the mining operation could accidently release large amounts of methane—a potent greenhouse gas—directly into the atmosphere.[33] If this were the case, a government requirement to delay the project to collect more information about that risk may be worthwhile from a social perspective, even if the delay results in some lost opportunities for extraction in the short term.

Decisionmaking in the natural resource context is replete with uncertainty and irreversibility.[34] In all of these cases, delay can have value. That does not mean that every natural resource decision should be delayed indefinitely—delay has

31. Kenneth J. Arrow & Anthony C. Fisher, *Environmental Preservation, Uncertainty, and Irreversibility*, 88 Q. J. ECON. 312, 314 (1974).

32. *See, e.g.*, Anthony C. Fisher & Urvashi Narain, *Global Warming, Endogenous Risk, and Irreversibility*, 25 ENVTL. & RESOURCE ECON. 395 (2003).

33. Michael Fitzpatrick, *Japan to Drill for Controversial "Fire Ice,"* THE GUARDIAN, (Sept. 27, 2010), http://www.guardian.co.uk/business/2010/sep/27/energy-industry-energy; Bryan M. Maybee, Daniel J. Packey & Ronald D. Ripple, *Climate Change Policy: The Effect of Real Options Valuation on the Optimal Mitigation-Adaptation Balance*, 31 ECON. PAPERS 216, 220–24 (2012).

34. *See generally* Robert S. Pindyck, *Uncertainty in Environmental Economics*, 1 REV. ENVTL. ECON. & POL'Y 45 (2007) (for an overview). Pindyck also notes that environmental protection can involve uncertainty and irreversibility—for example, the sunk costs associated with pollution control technology. *Id.* at 47.

costs as well as benefits. But real option value captures both the costs and the benefits of delay and leads to more rational decisionmaking than the current now-or-never approach.

B. Options in Offshore Leasing

The U.S. government's decision to lease offshore lands for oil extraction provides a particularly compelling case for the use of real option value. Oil drilling involves a host of uncertainties.[35] The price of the underlying asset (oil) varies considerably. Production costs decline with the development of new technology, but at an unknown rate. As the BP Gulf Coast Oil Spill demonstrated in an extremely salient way, the environmental risks involved in drilling are subject to high degrees of variability and uncertainty.

A decision by DOI to open an area for leasing is also irreversible or nearly so. Leases are designed to encourage drilling within a fixed period of time: if leaseholders delay too long, they risk losing the lease.[36] While many leases are held for some time, and even allowed to expire,[37] leaseholders can move forward with immediate drilling preparations and will do so if it is profitable.[38] Though the Secretary of the Interior

35. These uncertainties are discussed in more detail *infra* Part II.

36. Initial leases are generally granted for a period of five years and can run to ten years if "necessary to encourage exploration and development in areas because of unusually deep water or other unusually adverse conditions." 30 C.F.R § 556.37(a)(1) (2012). For water depths between four hundred and eight hundred meters, an eight-year lease is granted, but leaseholders "must begin an exploratory well within the first [five] years of the term to avoid lease cancellation." *Id.* § 556.37(a)(3). As noted by DOI, "[b]ecause OCS leases have fixed lease terms, as long as exploration and development is privately profitable, lessees will explore and develop within that initial period." 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 68.

37. Indeed, there have been complaints that oil companies are holding leases for too long, leading to calls for "'use it or lose it' legislation." Andrew Restuccia & Ben Geman, *Battle Over 'Use It or Lose It' Heats Up*, THE HILL (Mar. 24, 2011, 6:43 PM), http://thehill.com/blogs/e2-wire/e2-wire/151801-overnight-energy.

38. There are several steps that fall between the purchasing of a lease and actual drilling. *See* 30 C.F.R. §§ 550.200–550.299 (2012) (formerly at 30 C.F.R. § 250.00 (2011)); Reorganization of Title 30: Bureaus of Safety and Environmental Enforcement and Ocean Energy Management, 76 Fed. Reg. 64,432–64,780 (Oct. 18, 2011) (BOEMRE reorganization). Once a lease is procured, firms must prepare exploration plans for specific projects and development plans for specific platforms, both of which are subject to government oversight. 30 C.F.R. § 550.201. There are specific criteria explained in the relevant regulations that govern approval of these plans. *Id.* §§ 550.211–550.285. The government process, and regulatory risks associated with it, can be thought of as one of the sources of uncertainty facing leaseholders, similar to uncertainty about the extent of oil at a

maintains some discretion to suspend or even cancel leases,[39] that power is used only in unusual circumstances[40] and compensation is necessary.[41] Once oil is extracted, the process cannot easily be reversed.[42]

Because of the structure of lease sales, the government's choice can be understood as the selling of an option to allow the private sector to undertake drilling activities. Moving forward with a lease auction does not necessarily mean that a tract will be leased, and even if it is leased, that does not mean that any oil will be extracted. Private firms must show interest in leasing the tract, and the leaseholder will undertake exploratory efforts before moving forward with drilling operations. Indeed, private parties themselves can be understood as purchasing a set of options when they become leaseholders. As Strnad notes:

> Each of three phases—exploration, development, and production—involve an option. Exploration is an option. The mineral owner may explore a property now or may put off exploring it until later. Exploring a property reveals its development potential, but the owner does not have to develop immediately. Exercising the development option will result in wells or mines that the owner may produce, but the owner need not produce these wells or mines immediately.[43]

From the government's perspective, however, what matters is the decision to lease the land—once a firm purchases a lease, the decision of when or whether to move forward with drilling is largely out of the government's hands. The question facing the government is whether to offer a lease for sale at this time or to wait for more information. In this way the government's decision is structurally similar to the decision

---

site or price uncertainty. This uncertainty can be expected to be priced into the amount paid for the lease, but it does not particularly affect the option value that is being given up by the government—it just creates some risk and delay for leaseholders that reduces their willingness to pay during the initial auction.

39. 43 U.S.C. §§ 1334(a)(2)(A)–(C) (2011).

40. Lease cancelations are sufficiently rare that when they do occur, it can be national news. *See* John M. Broder, *U.S. Blocks Oil Drilling at 60 Sites in Utah*, N.Y. TIMES, Oct. 8, 2009, at A12.

41. 43 U.S.C. § 1334(a)(2)(C).

42. *See infra* note 75.

43. Strnad, *supra* note 24, at 1696.

faced by the lemonade entrepreneurs discussed above, in that uncertainty and irreversibility create real option value.

The leaseholder's option to gradually explore, develop, and produce oil, albeit time-constrained, increases the value of the leases themselves. If purchasing a lease obligated the lessee to engage in immediate production, the price paid by private parties for that contract would be lower than the lease price, and firms may even demand upfront compensation to cover their losses if production turned out to be unprofitable.[44] But, because there is not perfect symmetry between the options that are purchased by the private firm and the option held by the government, there is no guarantee that even a competitive bidding process would provide adequate compensation for the lease sale.

A correct cost-benefit analysis of the government's leasing decision would take the value of delay into consideration. The real option character of resource extraction has been recognized by economists for decades.[45] 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."[46] An economic analysis that ignores real option value overvalues the net benefits of immediate exploitation and will systematically lead to inefficient overexploitation.

There is an asymmetry between the decision to extract a resource and the decision to preserve a resource that causes the failure to consider real option value to almost universally point in the direction of overexploitation. If an irreversible preservation decision could be made, there could be real option value associated with delaying that decision, even if the now-or-never expected value of the preservation measure was greater than the costs. But this scenario is unlikely because preservation measures are rarely irreversible. Almost by definition, preservation allows for the possibility of future exploitation. On the other hand, exploitation is almost always costly to reverse. For this reason, consideration of real option

44. The relationship between the purchase price of leases and real option value and how the government can incorporate real option value into its bidding process is discussed in more detail below. *See infra* Parts IV.B, V.C.

45. *See* Arrow & Fisher, *supra* note 31, at 312–14; Paddock, Siegel & Smith, *supra* note 11, at 479.

46. DIXIT & PINDYCK, *supra* note 13, at 136.

value will nearly universally tend to favor preservation, and failure to consider real option value will systematically lead to the undesirable overexploitation of resources.

Real options can be positive even in cases where the value of the underlying asset is declining on average over time and even where the expected value of an asset is less than its current purchase price. In these cases, so long as there is some probability that the asset's value in the future will exceed its current price, a rational investor should be willing to pay some amount to gain the opportunity to take advantage of that potential upside.

A simplified framework that ignores real 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*. Option value can be important where there is uncertainty over future costs and benefits and investors are unable to easily recoup sunk costs. 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.[47]

It is worth emphasizing that real option value is different from risk aversion. Risk aversion refers to a preference for risk-free payoffs over risky payoffs. A person who is risk averse would prefer a guaranteed payoff of $10 to a 50 percent chance of being paid $20. In many contexts, consumers and investors exhibit risk aversion.[48] Option value applies even to a fully risk-neutral actor.[49] Stated another way, even an economic decisionmaker who was neutral with respect to risk, and thus was indifferent as to a certain payment of $10 or a 50 percent chance of a payment of $20, would still take real option value into consideration if presented with the opportunity to delay a decision under conditions of uncertainty and irreversibility.

C. Determining Real Option Value

This section describes how real option value is calculated, first clarifying the distinction between real options and other

47. *Id.* at 175–212.

48. *See generally* John W. Pratt, *Risk Aversion in the Small and in the Large*, 32 ECONOMETRICA 122 (1964) (discussing risk aversion).

49. Arrow & Fisher, *supra* note 31, at 313–14.

types of values that are generated by natural resources and then discussing some of the work in financial economics that has allowed a monetary estimate to be assigned to real option value.

1. Options in Environmental Law

There has been some confusion among commentators concerning different type of option values and non-use values. This sub-section explains and seeks to clarify these concepts.

a. Non-Use Value

Although they have sometimes been conflated, option value and non-use value are distinct concepts.

An important research question in environmental economics, which gained increasing prominence after the Exxon Valdez Oil Spill, is whether and how non-use values, which are not associated with use or consumption of a resource, should inform conservation policies.[50] As a legal matter, this question was settled to some degree in *Ohio v. Department of the Interior* where the D.C. Circuit found that "non-consumptive values" should be used for determining natural resource damages under the Superfund law.[51] Unfortunately, the court (like some federal agencies,[52] legal commentators,[53]

50. As stated by a longtime researcher in the area, "[p]rior to the Exxon Valdez oil spill, the estimate of passive use value or as it has often been previously termed, nonuse or existence value, was an area of economic research not well known to many economists working outside the area of benefit cost analysis . . . . However, based on a belief that the State of Alaska and the Federal Government intended to litigate a natural resource damage claim for lost passive use value, the attention paid to the conceptual underpinnings and estimate techniques . . . changed rather abruptly." Richard T. Carson et al., *Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill*, 25 ENVTL. & RESOURCE ECON. 257, 257–58 (2003) (citation omitted).

51. Ohio v. U.S. Dep't. of the Interior, 880 F.2d 432, 464 (D.C. Cir. 1989) ("[W]e instruct DOI that its decision to limit the role of non-consumptive values, such as option and existence values, in the calculation of use values rests on an erroneous construction of [the Comprehensive Environmental Response, Compensation, and Liability Act].").

52. Fish and Wildlife Service, Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for the Mexican Spotted Owl, 60 Fed. Reg. 29,914, 29,928 (June 6, 1995) (discussing option value within category of "[n]onmarket [b]enefits and [c]osts" associated with designation of critical habitat for the spotted owl); Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Metal Products and Machinery, 60 Fed. Reg. 28,210–28,286 (May 30, 1995) (discussing option value as a non-monetized

and economic researchers[54]) lumped option value into the group of non-use values that can be considered when setting environmental policy. This was a mistake.

Consideration of non-use values represented an attempt to acknowledge that natural resources have value beyond their market returns. The basic observation is that even if a private owner of the Grand Canyon were able to charge all park visitors their full willingness to pay, the net present value of all future entrance fees would not capture the entire social value of protecting that natural resource from alternative incompatible uses, like strip mining.

Stated another way, the net present *use value* of a resource is the discounted stream of payments that could be elicited from all future users of a natural resource. Where there is some uncertainty about those future payments, from an ex ante position, that net present value is expressed as an expected value that accounts for the different probabilities of future payments.[55]

b. The Origins of Option Value

In the 1960s, economists introduced the idea that there would also be a "willingness to pay for retaining an option to use an area or facility" such as a national park.[56] This option value was understood to be based on the "need [to] recognize the existence of people who anticipate purchasing the commodity (visiting the park) at some time in the future, but who, in fact, never will purchase (visit) it."[57] This description spurred a substantial line of research in environmental

---

benefit of effluent limitations).

53. Frank B. Cross, *Natural Resource Damage Valuation*, 42 VAND. L. REV. 269, 285–87 (1989); Daniel S. Levy & David Friedman, *The Revenge of the Redwoods?: Reconsidering Property Rights and the Economic Allocation of Natural Resources*, 61 U. CHI. L. REV. 493, 500–01 (1994).

54. Douglas A. Greenley, Richard G. Walsh & Robert A. Young, *Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality*, 96 Q. J. ECON. 657, 657 (1981).

55. The best way to translate uncertain future payments into a present value in the face of risk aversion is through certainty equivalents. K.J. Arrow et al., *Intertemporal Equity, Discounting, and Economic Efficiency*, *in* CLIMATE CHANGE 1995: ECONOMIC AND SOCIAL DIMENSIONS OF CLIMATE CHANGE 130, 136–37 (James P. Bruce, Hoesung Lee & Erik F. Haites eds., 1996).

56. John V. Krutilla, *Conservation Reconsidered*, 57 AM. ECON. REV. 777, 780 (1967).

57. Burton A. Weisbrod, *Collective-Consumption Services of Individual-Consumption Goods*, 78 Q. J. ECON. 471, 472 (1964).

economics.[58]

This research has found that option value associated with demand uncertainty is not always positive (i.e., higher than zero).[59] For example, "if an individual was uncertain about future income and the demand for the good in question was a positive function of income," then that demand uncertainty option value is "unambiguously negative for risk-averse individuals."[60] This would mean that uncertainty about demand would decrease an individual's willingness to pay to preserve access to a site below his or her ex ante (risk-neutral) expected consumer surplus from enjoyment of the site.

Option value understood in this way is a particular way of expressing consumption value given a certain kind of uncertainty. It, therefore, is not a form of non-use value, nor does it have "any particular claim as a superior welfare measure" compared to a more straightforward calculation of expected consumer surplus.[61]

c. *Three Distinct Values*

Option value that derives from demand uncertainty is different from non-use value because it is ultimately connected to use of the site. Non-use values, on the other hand, are unconnected to any consumption experience. An example is existence value, which is "the value from knowing that some good exists."[62] Non-use values can be taken into account when

58. A. MYRICK FREEMAN III, THE MEASUREMENT OF ENVIRONMENTAL AND RESOURCE VALUES: THEORY AND METHODS 247–50 (2d ed. 2003).

59. *Id.*

60. *Id.* at 248.

61. *Id.* at 249. The EPA has accepted the conclusion that option value is not properly understood as a form of non-use value. National Pollutant Discharge Elimination System—Proposed Regulations to Establish Requirements for Cooling Water Intake Structures at Phase III Facilities, 69 Fed. Reg. 68,444, 68,514 n.51 (Nov. 24, 2004); GUIDELINES FOR PREPARING ECONOMIC ANALYSIS, NAT'L CTR. FOR ENVTL. ECON. xiv (2010), http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf [hereinafter EPA GUIDELINES] (defining non-use value as including bequest value, existence value, and paternalistic altruism).

62. ADLER & POSNER, *supra* note 6, at 126. Posner and Adler argue that existence value does not bear on welfare, and should therefore not be considered in cost-benefit analysis of environmental policy. *Id.* They specifically differentiate existence value from "nonuse value [which] also is understood to include the option value of having some good in the future" and which they see, presumably, as potentially being important for human welfare. *Id.* Despite criticisms, existence value, and the most common technique used to measure it, was endorsed in 1993 by a peer review committee of distinguished economists established by National

setting environmental policy,[63] but they are something different from option value. The court's interpretation in *Ohio v. Department of the Interior*[64] that demand uncertainty option value is a type of non-use value was mistaken and has led to substantial confusion.

Real options represent a third type of value that is distinct from both demand uncertainty option value and non-use value. Real options (also referred to as planners' uncertainty or quasi-options[65]) occur "when policymakers are uncertain about the magnitude of the benefits or the costs of alternative courses of action."[66] Real option value occurs when the overall benefits and costs of a particular choice are unclear, unlike in the case of demand uncertainty option value where it is the preferences of the decisionmaker that are uncertain. Where real options exist, there are benefits associated with delaying an irreversible decision. Real option value can never be negative. The option to wait is at worst useless: it is never harmful because it only adds alternatives to the decisionmaker's choice set. Nor are real option values contingent on risk-aversion: a completely risk neutral actor will assign value to real options.

To sum up, expected value is the net present value of an uncertain future revenue stream. This revenue stream is equal to the use value. Real option value is the value of a right, but not the obligation, to purchase that revenue stream.[67] There is a difference between the value of a right to purchase a stream of revenue at a fixed price and the expected value when the purchase price, and, therefore, the expected value, can change in light of future information.

Oceanic and Atmospheric Administration. Report of the NOAA Panel on Contingent Valuation, 58 Fed. Reg. 4,601 app. 1, at 4,602–4,611 (Jan. 15, 1993).

63. *See generally* EPA GUIDELINES, *supra* note 61, at 7–18.

64. 880 F.2d 432, 476 (D.C. Cir. 1989).

65. As discussed *infra* notes 76–78 and accompanying text, real options are closely related to "quasi-options," which is the word used within the field of environmental economics to differentiate planners' uncertainty from option-to-use value.

66. FREEMAN, *supra* note 58, at 250–51.

67. An easy way to think of real option value is where the option-holder has the right to purchase an asset at a fixed price. This is equivalent to a standard call option in the financial context where, for example, a certain amount of stock can be purchased at a fixed price. But there can also be value for an option to purchase an asset at a variable price. For example, the option to purchase an ounce of gold for the price of ten barrels of oil could have some value even if oil was worth over $100 a barrel and gold worth less than $1000 an ounce because those prices are not perfectly coordinated and at a future date the transaction could be profitable.

It is perhaps not surprising that some confusion has arisen in this area, and even thoughtful commentators have conflated some of these concepts.[68] Overall, it is helpful to remember the two important distinguishing features of real option value: real option value (which is associated with the option to delay) exists when expected value can change in light of new information and the purchase price is sunk. Restated, real option value arises in circumstances of uncertainty (i.e., when expected value can change), and irreversibility (i.e., when there are sunk costs associated with a course of action). Real option value exists irrespective of risk aversion. Demand uncertainty option value, which has received considerable attention in the environmental law literature, is a measure of expected value. It is neither a non-use value like existence value nor the same as real option value.

2. The Mechanics of Option Value

To consider real options in any cost-benefit analysis, a value must be calculated. The classic work on options valuation in the financial context was published nearly four decades ago.[69] The concept of real options, which imported concepts from finance to analyze "real" decisions like construction or real estate development, was popularized by a group of scholars writing from the late 1980s through the 1990s.[70] The

68. REVESZ & LIVERMORE, *supra* note 6, at 122 (describing demand uncertainty option value as a non-use value and making a confusing analogy with executive compensation options); CASS R. SUNSTEIN, WORST-CASE SCENARIOS 179–97 (2007) (discussing option value literature but failing to make a clean distinction between demand uncertainty option value and real option value).

69. Fischer Black & Myron Scholes, *The Pricing of Options and Corporate Liabilities*, 81 J. POL. ECON. 637, 637 (1973).

70. *See generally* TOM E. COPELAND ET AL., VALUATION—MEASURING AND MANAGING THE VALUE OF COMPANIES (1990); GORDON SICK, SALOMON CTR., MONOGRAPH SERIES IN FINANCE AND ECONOMICS NO. 3, CAPITAL BUDGETING WITH REAL OPTIONS (1989); STOCHASTIC MODELS AND OPTIONS VALUES (Diderik Lund & Berbt Øksendal eds., 1991); LENOS TRIGEORGIS, REAL OPTIONS IN CAPITAL INVESTMENT: MODELS, STRATEGIES & APPLICATIONS (1995); Petter Bjerksund & Steinar Ekern, *Managing Investment Opportunities under Price Uncertainty: From Last Chance to Wait and See Strategies*, 19 FIN. MGMT. 65 (1990); J.S. Busby & C.G.C. Pitts, *Real Options in Practice: An Exploratory Survey of How Finance Officers Deal with Flexibility in Capital Appraisal*, 8 MGMT. ACCT. RES. 169 (1997); Dennis Capozza & Yuming Li, *The Intensity and Timing of Investment: The Case of Land*, 84 AM. ECON. REV. 889 (1994); Paul D. Childs et al., *Capital Budgeting for Interrelated Projects: A Real Options Approach*, 33 J. FIN. QUANTITATIVE ANAL. 305 (1998); Avinash K. Dixit, *Entry and Exit Decisions Under Uncertainty*, 97 J. POL. ECON. 620 (1989); Steven R. Grenadier, *Valuing*

field has developed to the point where there is now a broad range of guides for practitioners.[71] 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,[72] remediation of brownfield properties,[73] and the development of real estate.[74] There are also a number of cases where real options have been used to examine decisions about the development of petroleum reserves,[75] and real options have been proposed as a way to

---

Lease Contracts: A Real-Options Approach, 38 J. FIN. ECON. 297 (1995); Angelien G.Z. Kemna, *Case Studies on Real Options*, 22 FIN. MGMT. 259 (1993); Diane M. Lander & George E. Pinches, *Challenges to the Practical Implementation of Modeling and Valuing Real Options*, 38 Q. REV. ECON. & FIN. 537 (1998); Saman Majd & Robert S. Pindyck, *The Learning Curve and Optimal Production Under Uncertainty*, 20 RAND J. ECON. 331 (1989); Robert S. Pindyck, *Irreversibility, Uncertainty, and Investment*, 29 J. ECON. LITERATURE 1110 (1991); Laura Quigg, *Empirical Testing of Real Option-Pricing Models*, 48 J. FIN. 621 (1993); Han T.J. Smit & L.A. Ankum, *A Real Options and Game-Theoretic Approach to Corporate Investment Strategy Under Competition*, 22 FIN. MGMT. 241 (1993); Lenos Trigeorgis, *Real Options and Interactions with Financial Flexibility*, 22 FIN. MGMT. 202 (1993).

71. *See, e.g.*, PRASAD KODUKULA & CHANDRA PAPUDESU, PROJECT VALUATION USING REAL OPTIONS: A PRACTITIONER'S GUIDE (2006); JOHNATHAN MUN, REAL OPTIONS ANALYSIS: TOOLS AND TECHNIQUES FOR VALUING STRATEGIC INVESTMENT AND DECISIONS (2d ed. 2006); TOM E. COPELAND & VLADIMIR ANTIKAROV, REAL OPTIONS: A PRACTITIONER'S GUIDE (2003).

72. *See* S.E. Fleten, K.M. Maribu & I. Wangensteen, *Optimal Investment Strategies in Decentralized Renewable Power Generation Under Uncertainty*, 32 ENERGY 803, 803 (2007); Gürkan Kumbaroğlu et al., *A Real Options Evaluation Model for the Diffusion Prospects of New Renewable Power Generation Technologies*, 30 ENERGY ECON. 1882, 1882 (2008); R. Madlener et al., *Modeling Technology Adoption as an Irreversible Investment Under Uncertainty: The Case of the Turkish Electricity Supply Industry*, 27 ENERGY ECON. 139, 139 (2005); G. Rothwell, *A Real Options Approach to Evaluating New Nuclear Power Plants*, 27 ENERGY J. 37, 37 (2006).

73. *See* R.D. Espinoza & L.X. Luccioni, *An Approximate Solution for Perpetual American Option with Time to Build: The Value of Environmental Remediation Investment Projects*, 12 INT'L J. BUS. 291, 291 (2007).

74. *See* Laarni Bulan, Christopher Mayer & C. Tsuriel Somerville, *Irreversible Investment, Real Options, and Competition: Evidence from Real Estate Development*, 65 J. URB. ECON. 237, 237 (2009); Steven R. Grenadier, *The Strategic Exercise of Options: Development Cascades and Overbuilding in Real Estate Markets*, 51 J. FIN. 1653, 1653 (1996); David Geltner, Timothy J. Riddiough & Srdjan Stojanovic, *Insights on the Effect of Land Use Choice: The Perpetual Option on the Best of Two Underlying Assets*, 39 J. URB. ECON. 20, 20 (1996).

75. Anthony C. Fisher, *Investment under Uncertainty And Option Value in Environmental Economics*, 22 RESOURCE & ENERGY ECON. 197, 197 (2000); Ramón Yepes Rodriguez, *Real Option Valuation of Free Destination in Long-Term Liquefied Natural Gas Supplies*, 30 ENERGY ECON. 1909, 1909 (2008); Paddock, Siegel & Smith, *supra* note 11, at 479; *see also* Han T.J. Smit, *Investment Analysis of Offshore Concessions in the Netherlands*, 26 FIN. MGMT. 5, 5 (1997).

formalize discussion of the precautionary principal.[76]

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.[77] In the offshore drilling context, it is the point at which it is reasonable for the government to lease access to the resource. 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).[78] This model, sometimes referred to as quasi-options, has key similarities to the Dixit and Pindyck real options model[79] and seeks to correct an antipreservation 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.[80]

There are several inputs into the real options model developed by Dixit and Pindyck, all of which can be defined in the natural resource extraction context. Projected benefits are assumed to vary randomly over time.[81] The value of immediate

---

76. Scott Farrow, *Using Risk Assessment, Benefit-Cost Analysis and Real Options to Implement a Precautionary Principle*, 24 RISK ANAL. 727, 728 (2004). *But see* DOUGLAS A. KYSAR, REGULATING FROM NOWHERE: ENVIRONMENTAL LAW AND THE SEARCH FOR OBJECTIVITY 92 (2010) ("Proponents of the precautionary approach . . . would not agree . . . that the option value of [ ] precaution should simply be priced and incorporated into the optimization calculus . . . .").

77. DIXIT & PINDYCK, *supra* note 13, at 34–35.

78. For a succinct overview of the model, see Fisher, *supra* note 75, at 198–201. *See also* W. Michael Hanemann, *Information and the Concept of Option Value*, 16 J. ENVTL. ECON & MGMT. 23, 34 (1989). *But see* KYSAR, *supra* note 76, at 92.

79. The relationship between these models is complicated, but both incorporate the value of information. For a series of papers discussing similarities and differences between the models, see generally Fisher, *supra* note 75. *See also* Paul Mensink & Till Requate, *The Dixit-Pindyck and the Arrow-Fisher-Hanemann-Henry Option Values are Not Equivalent: A Note on Fisher (2000)*, 27 RESOURCE & ENERGY ECON. 83 (2005); Iulie Aslaksen & Terje Synnestvedt, *Are the Dixit-Pindyck and Arrow-Fisher-Henry-Hanemann Option Values Equivalent?* (Statistics Nor., Discussion Paper No. 390, 2004).

80. On the "antipreservation bias" of the standard now-or-never framework, see Rüdiger Pethig, *Optimal Pollution Control, Irreversibilities, and the Value of Future Information*, 54 ANNALS OPERATIONS RES. 217, 219 (1994). For the sake of simplicity, the Dixit and Pindyck model and their terminology (real options) is used throughout this Article.

81. The standard real options model includes a continuous time stochastic process, either geometric Brownian with drift or mean reverting. *See* DIXIT & PINDYCK, *supra* note 13, at 135–74.

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."[82] The cost of extracting the resource, current prices, and discount rate in the overall economy also help set the threshold price. Although models typically focus on uncertainty concerning the evolution of prices over time, the same models can be used to account for uncertainty about the costs (both private and public) associated with drilling in very deep water. 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 situation faced by the owner of a resource is similar in form 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 (the "strike price"). In the oil drilling context, there is an option to extract a certain amount of oil at a strike price that is set by the fixed costs of extraction. In the real world, this option is divided into several stages: the option to sell the lease (held by the government) and the options to explore, develop, and produce oil (held by private leaseholders). Because of the similarity of real options to financial options, the same mathematical models that are used in financial markets can be used to inform the decision of when and whether to drill.

One difficulty associated with using the more complex option value formula, rather than the more straightforward calculations that the government has used in the past, is disagreement about input values in the real options model. 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.[83] There is likely to be controversy about the path of future technological development as well as uncertainty about environmental risks. 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, actors in financial markets value options on a daily basis, and the

82. *Id.* at 115.
83. *See infra* Part II.B.

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."[84]

II. DIMENSIONS OF UNCERTAINTY

Uncertainty is at the heart of option value. In the natural resource context, the decision to extract can pose a host of uncertainties, but there are three areas that are of particular concern: environmental and social costs; price; and extraction costs. In each of these areas, waiting to take advantage of an extraction opportunity can provide additional information that can inform the often irreversible (or costly to reverse) decisions facing the government and private actors. The greater the uncertainty in these areas, the higher the real option value of waiting.

This Part will describe the three primary sources of uncertainty in natural resource decisionmaking: environmental and social costs; fluctuations in future prices; and technological development that can reduce the private cost of extraction.

A. Environmental and Social Costs

Environmental and social costs associated with oil drilling constitute a major category of uncertainty in offshore drilling. Those costs can be catastrophic—as in the case of a major oil spill—but can also include the more mundane disruptions to ecosystems associated with day-to-day exploration and drilling operations. Whether or not environmental and social costs appear as costs external to the operator or are internalized due to regulation, their presence adds substantial cost uncertainty. The BP Gulf Coast Oil Spill incident demonstrates with extreme clarity the high level of risk associated with these activities and the difficulties business or governmental actors face in anticipating and characterizing that risk.

There are at least four aspects of uncertainty about environmental costs that are important drivers of option value.

84. DIXIT & PINDYCK, *supra* note 13, at 396.

First is the potential extent of catastrophic oil spills. Prior to the BP Spill, the risks associated with deep water drilling in the Gulf Coast were severely underestimated.[85] Before that incident, a catastrophe of that magnitude was not anticipated, and experts in the field predicted that existing controls would be sufficient to substantially limit the damage associated with a mechanical failure at the drilling site.[86] Because catastrophic failures are by definition rare, the outer boundaries of risk exposure will remain hidden for long periods of time.[87] These unknown risks add substantial amounts of environmental uncertainty to offshore drilling.

The second important aspect of uncertainty in environmental costs is the sensitivity of environmental resources to threats associated with drilling.[88] The existence of endangered species, relationships within and between ecosystems, and the toxicity of petroleum releases (or the chemicals that are used to control petroleum spills) are all amenable to scientific inquiry, and information about these factors can be expected to be continually generated. Damage associated with a spill depends on the extent of the release and the sensitivity of exposed resources. Lack of knowledge about the complex set of factors that influence environmental sensitivity is another form of uncertainty that is important in the drilling context. As time passes and research is conducted, knowledge tends to grow about the true environmental costs of

85. *But see* West Engineering Services, Inc., *Evaluation of Secondary Intervention Methods in Well Control* 84–85 (MMS Solicitation 1435-01-01-RP-31174, Mar. 2003) (discussing risks associated with blowout prevention systems and recommending best practices).

86. In the exploration plan prepared by BP for the drilling site, the company stated, "In the event of an unanticipated blowout resulting in an oil spill, it is unlikely to have an impact based on the industry wide standards for using proven equipment and technologies for such responses . . . [and] techniques for containment and recovery and removal of the oil spill." BRITISH PETROLEUM, INITIAL EXPLORATION PLAN, MISSISSIPPI CANYON BLOCK 252 14.4–14.5 (OCS-G 32306) (on file with author). The underestimation of the risk from a blowout was due in part to a failure to "develop[] an oil spill plan for the low probability, high-consequence event when everything fails." Carl Hoffman, *Investigative Report: How the BP Oil Rig Blowout Happened,* POPULAR MECHANICS (2010), http://www.popularmechanics.com/science/energy/coal-oil-gas/how-the-bp-oil-rig-blowout-happened (quoting Greg McCormack, director of the Petroleum Extension Service at the University of Texas).

87. *See generally* Martin L. Weitzman, *On Modeling and Interpreting the Economics of Catastrophic Climate Change*, 91 REV. ECON. & STATS. 1 (2009).

88. *Cf.* Anke D. Leroux, Vance L. Martin & Timo Goeschl, *Optimal Conservation, Extinction Debt, and the Augmented Quasi-Option Value*, 58 J. ENVTL. ECON. & MGMT. 43 (2009).

an action. There are many examples of products or activities once thought to be harmless that turn out to have significant environmental costs.[89] Fears about other products subside.[90] The offshore drilling industry is no exception. For instance, significant uncertainty still surrounds the effect of large-scale oil spills in sensitive areas. Waiting for future information regarding these costs holds value.

The third source of uncertainty concerning environmental costs is the potential for future reductions in environmental and social costs because of technological development.[91] Better safety technology can decrease the risk of an oil spill, while enhanced cleanup technology can lower loss if a spill does occur. Some important technological advances have emerged in recent years in relation to oil spill cleanup. Technological development has improved the ability to gauge the effect of spilled oil.[92] Dispersants used in oil spills today are more sophisticated and less environmentally toxic.[93] Over the past decades booms have been improved to more effectively collect oil in choppy waters and faster currents, and they can better withstand exposure to heat and flame.[94] While technological development in these areas will lead to lower environmental risks, the pace at which new technologies will come online is extremely uncertain.

Valuation is the fourth category of uncertainty in

89. *See, e.g.*, Mario J. Molin & F. Sherwood Roland, *Stratospheric Sink for Chlorofluoromethanes: Chlorine Catalysed Destruction of Ozone*, 249 NATURE 810, 810 (1974) (first study proposing that chlorofluorocarbons pose risk to stratospheric ozone-layer).

90. *See, e.g.*, Torie Bosch, *Leading Environmental Activist's Blunt Confession: I Was Completely Wrong to Oppose GMOs*, SLATE.COM (Jan. 3, 2013, 2:27 PM), http://www.slate.com/blogs/future_tense/2013/01/03/mark_lynas_environmentalist_who_opposed_gmos_admits_he_was_wrong.html (quoting environmentalist Mark Lynas as regretting advocacy against genetically modified organisms ("GMOs")). *But see* Ken Cook, *Another Environmentalist Apologizes Over GMOs*, Environmental Working Group (Jan. 18, 2013), http://www.ewg.org/agmag/2013/01/another-environmentalist-apologizes-over-gmos/ (arguing that science in support of GMO safety remains problematic).

91. *See generally* Gaia J. Larsen, *Skewed Incentives: How Offshore Drilling Policies Fail to Induce Innovation to Reduce Social and Environmental Costs*, 31 STAN. ENVTL. L. J. 139 (noting that the pace of technological development in this area is endogenous to policy decisions).

92. U.S. COAST GUARD RESEARCH & DEV. CTR, REPORT NO. CG-D-07-03, U.S. COAST GUARD OIL SPILL RESPONSE RESEARCH & DEVELOPMENT PROGRAM: A DECADE OF ACHIEVEMENT 9–12 (2003) [hereinafter COAST GUARD REPORT].

93. *See generally* ZEKE LYONA & XOCHITL CASTANEDA, HISTORY OF DISPERSANT DEVELOPMENT: A DISPERSANT TIMELINE (2005).

94. COAST GUARD REPORT, *supra* note 92, at 9–12.

environmental and social costs.[95] While cost-benefit analysis of environmental policies has been conducted for decades, there remains substantial uncertainty about several important technical and conceptual questions. Differences in how environmental or social harms are valued can have substantial effects on estimates of risks from offshore oil drilling.

There are a number of valuation uncertainties. For example, controversies exist about whether willingness-to-pay ("WTP") or willingness-to-accept ("WTA") is the appropriate yardstick for environmental harms.[96] Although, theoretically, WTP and WTA should be relatively similar, in reality, surveys have found large differences between the two measures of individuals' preferences.[97] Because the entitlement to pollute or, on the other hand, to be free from pollution is often disputed, it is not clear in any particular case which is the appropriate measure, leading to large potential uncertainties in valuation.

In the offshore drilling context, existence value can be important because spills often occur in remote areas where use value is minimal, but people nonetheless are willing to pay for conservation efforts. Eliciting individual preferences for existence value, however, is very difficult.[98] In some studies, for example, respondents have not shown sensitivity to scope, so the value assigned to environmental protection is the same regardless of whether a relatively smaller or larger amount of protection is delivered.[99] This result calls into question the intelligibility of existence value surveys. There are also controversies over whether existence value should be included at all in cost-benefit analysis.[100]

For long-lasting environmental harms, uncertainty concerning discount rates is also important. Were a spill to cause permanent damage to an environmental resource, much

95. Thanks are due to Professor Matthew Adler for this point.

96. *See generally* Elizabeth Hoffman & Matthew L. Spitzer, *Willingness to Pay vs. Willingness to Accept: Legal and Economic Implications*, 71 WASH. U.L.Q. 59 (1993) (discussing differences between the two measures).

97. *See generally* John K. Horowitz & Kenneth E. McConnel, *A Review of WTA/WTP Studies*, 44 J. ENVTL. ECON. & MGMT. 426 (2002).

98. Report of the NOAA Panel on Contingent Valuation, *supra* note 62, 4603–08.

99. Richard T. Carson, *Contingent Valuation Surveys and Tests of Insensitivity to Scope*, *in* DETERMINING THE VALUE OF NON-MARKETED GOODS: ECONOMIC, PSYCHOLOGICAL, AND POLICY RELEVANT ASPECTS OF CONTINGENT VALUATION METHODS 127 (R.J. Kopp, W. Pommerhene & N. Schwartz eds., 1997).

100. *See, e.g.*, ADLER & POSNER, *supra* note 6, at 126.

of the loss would be experienced by future generations. While some have argued that a positive discount rate is appropriate in these contexts, others have challenged those claims.[101] Even if there was agreement that some discounting is necessary, there is substantial uncertainty around the appropriate rate to use.[102]

Uncertainty around environmental costs can have important consequences for decisionmaking. Conrad and Kotani focus on environmental costs in an option-based examination of the choice of whether and when to open the Arctic National Wildlife Refuge to drilling.[103] These authors model the relationship between lost "amenity value" of the wildlife reserve—a concept roughly equivalent to existence value—and threshold price to determine how sensitive option value is to changes in the estimate of amenity value.[104] They find that a $100 million change in amenity value altered the threshold price by a few dollars.[105] Were that analysis to take into account uncertainty around amenity value or the risk of environmental exposure, the increase in threshold price would be even greater.

---

101. *See generally* Revesz & Shahabian, *supra* note 22 (discussing and criticizing arguments in favor of a pure rate of time preference applied to future generations).

102. *See generally* Richard G. Newell & William A. Pizer, *Uncertain Discount Rates in Climate Policy Analysis*, 32 ENERGY POL'Y 519 (2004).

103. Jon M. Conrad & Koji Kotani, *When to Drill? Trigger Prices for the Arctic National Wildlife Refuge*, 27 RES. & ENERGY ECON. 273, 273 (2005). For a critique of Conrad and Kotani's article, including their choice of discount value, see generally Paul L. Fackler, *Comment on Conrad and Kotani*, 29 RES. & ENERGY ECON. 159 (2007).

104. Conrad & Kotani, *supra* note 103, at 274. The authors choose this method over a contingent value approach in order to avoid the necessity of calculating a convenience yield. However, it instead requires the determination of an appropriate risk-adjusted discount rate. Conrad and Kotani set that rate at 0.1 to reflect a social rate of time preference of 0.025 and a risk premium of 0.075. *Id.* at 275 n.3.

105. Holding the cost of production constant at $15 per barrel, Conrad and Kotani estimate that under geometric Brownian motion, changing the amenity value of ANWR from $200 million to $300 million per year resulted in the trigger price moving from $27.96 per barrel to $29.96 per barrel. *Id.* Under the mean reverting model, the $100 million per year change in amenity value made the trigger price shift from $27.99 per barrel to $34.41 per barrel. Jon M. Conrad & Koji Kotani, *Erratum to "Where to Drill? Trigger Prices for the Arctic National Wildlife Refuge,"* 29 RES. & ENERGY ECON. 244, 244–45 (2007) (updating calculations from original article). The Conrad and Kotani analysis did not focus on uncertainty about environmental costs. Had uncertainty associated with environmental costs been included, the threshold price would have been higher.

B. Price

The most common type of uncertainty for options analysis concerns the price of the underlying asset. In the context of standard financial instruments, uncertainty is largely confined to price. The cost of exercising the option is generally set, and the investor only cares about the variance of the price of the underlying asset.

One of the important questions that often arises around price uncertainty in the context of natural resources is whether prices follow a purely random walk pattern, drift either upward or downward, or are mean reverting. A mean reverting price process would imply that, over time, prices will tend to converge in the long run.[106] While at any given time a price may be very far away from that mean (depending on the degree of variance), the further a price is above the mean, the more likely that the price will decline in the next time period. A mean reverting price structure will tend to reduce the value of options because there is less uncertainty about future prices.[107] For these types of processes, if you know the mean, then in the long run you will generally know the neighborhood of future prices.

The alternative is a pure random walk pattern (also known as Brownian motion[108]) in which "the past history of the series

106. *See generally* Helyette Geman, *Mean Reversion Versus Random Walk in Oil and Natural Gas Prices*, *in* ADVANCES IN MATHEMATICAL FINANCE 219 (Michael C. Fu et al. eds., 2007).

107. DIXIT & PINDYCK, *supra* note 13, at 403–05.

108. The term "Brownian motion" has its origins in the scientific investigation of random motion, most typically the movements of a grain of pollen suspended in water, which, when magnified, can be seen to vibrate and move about even in perfectly still water. JAMES TREFIL, THE NATURE OF SCIENCE: AN A-Z GUIDE TO THE LAWS AND PRINCIPLES GOVERNING OUR UNIVERSE 59–60 (2003). As it turns out, that motion is attributable to the pollen grain being bumped into by large numbers of water molecules. *Id.*; ALBERT EINSTEIN, INVESTIGATIONS ON THE THEORY OF THE BROWNIAN MOVEMENT 1–18 (R. Furth ed., A.D. Cowper trans., reprint 1956) (1926) (English translation of the 1905 paper that appeared in Annalen der Physik describing "the movement of small particles suspended in stationary liquid" and relating it to "the molecular-kinetic theory of heat"). While, on average, the bumps tend to cancel out, at any given moment, the bumps on one side may be slightly larger than on the other, causing a slight movement. JAMES TREFIL, THE NATURE OF SCIENCE: AN A-Z GUIDE TO THE LAWS AND PRINCIPLES GOVERNING OUR UNIVERSE 59–60 (2003). Once the grain has moved, the same process simply occurs again, so that the new position becomes the starting point. *Id.* At any point in time, the fact that the pollen had recently moved a bit to the north has no bearing on whether it is likely to move a bit to the south in the future. *Id.*

cannot be used to predict the future in any meaningful way."[109] The current price is the best indicator of future prices, and no matter what the price in relationship to past prices, the likelihood of a price increase or a price decrease in the next time period is exactly the same. Brownian motion with drift implies that the movement of prices will be biased in one direction or the other. If the value of an asset is growing over some period of time, but is also influenced by some set of random factors, then it can be described as exhibiting Brownian motion with upward drift.[110]

There is a substantial amount of disagreement over whether the price of extractable resources, and most importantly oil, are mean reverting or random walk and whether they have upward (or downward) drift.[111] A recurring difficulty is that past price behavior is not necessarily predictive of future prices. There could be fundamental changes in technology or some other factor that changes the basic price dynamic. In addition, there are competing, but similarly compelling, theoretical stories that can be told about why prices follow one or the other pattern.[112] A proponent of the mean reverting position might refer to the tendency for new exploration technologies to come online or for substitutes to be found as prices increase due to scarcity, a process that tends to keep prices in the same general neighborhood. Alternatively, a proponent of upward drift in prices can point to the ultimately finite nature of any nonrenewable natural resource, which should tend to push prices upward over time.[113]

Certainly, these are important questions that must be considered when determining the value of extraction options. But regardless of the specific process that determines future price movements, we know that there is a large degree of

109. Eugene F. Fama, *Random Walks in Stock Market Prices*, FIN. ANALYSTS J., Sept.–Oct. 1965, at 55–56.

110. DIXIT & PINDYCK, *supra* note 13, at 65–67.

111. *See* Geman, *supra* note 107, at 219; *see also* Delson Chikobvu & Knowledge Chinhamu, Random Walk or Mean Reversion? Empirical Evidence from the Crude Oil Market (unpublished manuscript) (on file with the Journal of Turkish Statistical Association), http://jtsa.ieu.edu.tr/files/journals/1/articles_in_press/1.pdf (noting controversy over random walk versus mean-reversion and stating that "[f]orecasting crude oil future prices remains one of the biggest challenges facing econometricians and statisticians").

112. *See, e.g.*, DIXIT & PINDYCK, *supra* note 13, at 403–05.

113. *See* William D. Nordhaus, *Resources as a Constraint on Growth*, 64 AM. ECON. REV. 22, 22 (1974) (discussing model showing slow increase in energy prices over time as fossil fuel resources are depleted).

uncertainty. Whether that uncertainty is cabined by a mean reverting tendency or not, it generates some value associated with the option to wait to extract. As discussed in more detail below, DOI currently assumes away price uncertainty.[114]

C. Extraction Costs and Technological Development

The other category of costs associated with offshore drilling is the direct cost to the 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. With regard to this risk, waiting has little value because no significant level of information will emerge. 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."[115]

Changes in technology can have a huge effect on the production costs associated with oil drilling, but there is a high degree of uncertainty about the pace and direction of future technological development. The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling gave this account of the early days of offshore drilling at the turn of the century in California:

> Closely resembling boardwalks in appearance, rows of narrow wooden piers extended up to 1,350 feet from the shoreline, their piles reaching 35 feet to the floor of the

114. *See* King, *supra* note 4, at 108 (noting that the agency "has chosen to base its estimates of anticipated production, exploration and development scenarios, and economic analysis on an oil price of $46 per barrel").

115. DIXIT & PINDYCK, *supra* note 13, at 47.

> Pacific. Using the same techniques as then used on land, steep pipes were pounded 455 feet below the seabed. The hunt for oil ultimately produced only a modest yield. The field's production peaked in 1902, and the wells were abandoned several years later. The project left behind a beach blackened by oil and marred by rotting piers and derricks . . . .[116]

From these perhaps inauspicious beginnings, the industry has grown substantially with more than fifty thousand wells now having been drilled in the Gulf of Mexico alone.[117] The first deepwater well (defined as a well drilling at a depth of one thousand feet of water or more) came online in 1979, and in 1986 the first ultra-deepwater well (defined as a well drilling at a depth of five thousand feet of water or more) became operational.[118] Today there are approximately 3,600 drilling structures in the Gulf and seven thousand active leases. Over half of these leases are for deepwater drilling.[119]

The progression over time to wells farther from the shore and deeper under water was largely the result of technological advances. Firms shifted to more sophisticated drilling technologies and began using steel rather than wood to construct drilling structures.[120] By the late 1940s, oil companies had successfully built platforms beyond sight from shore, ultimately "ushering in the great and enduring oil bonanza that the Gulf of Mexico has provided."[121] Today, deepwater drilling relies on highly sophisticated technology, which continues to improve the efficiency of extraction. 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.

---

116. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, A Brief History of Offshore Oil Drilling 1 (Staff Working Paper No. 1, 2010) [hereinafter A Brief History].

117. DEP'T OF THE INTERIOR, INCREASED SAFETY MEASURES FOR ENERGY DEVELOPMENT ON THE OUTER CONTINENTAL SHELF 3 (2010).

118. MINERALS MGMT. SERV., DEEPWATER GULF OF MEXICO 2009: INTERIM REPORT OF 2008 HIGHLIGHTS 10 (2009).

119. *Id.*

120. A Brief History, *supra* note 116, at 2.

121. WILLIAM L. LEFFLER, RICHARD PATTAROZZI & GORDON STERLING, DEEPWATER: PETROLEUM EXPLORATION & PRODUCTION: A NONTECHNICAL GUIDE 6 (2003).

But predicting the rate and direction of technological change is a difficult task.[122] 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. Perhaps one of the clearest benefits of waiting to exploit a natural resource is greater information about the performance of different extraction technologies. Especially because oil development is a global phenomenon, with different technologies constantly being developed and deployed, there is a great deal of information to be had about the cost of exploration by waiting to see how well new technologies work. The real options framework, which accounts for the value of this information, can therefore provide a more complete analysis of the costs and benefits of drilling today.

III. ECONOMIC CONSIDERATIONS IN OFFSHORE DEVELOPMENT LAW

Offshore drilling has been a controversial issue in the United States for many years. As a consequence, Congress and the President have taken different positions at different times on the desirability of drilling, where it should take place, and how different social goals, such as environmental protection and energy independence, should be reconciled. But although the specific balance of priorities have differed by institution and over time, there is a consistent commitment among the three branches that DOI should consider the economic consequences of leasing decisions before proceeding.

This Part will examine economic rationality standards for offshore drilling. The first Section examines congressional requirements under the governing statute. The second Section describes how the courts have interpreted those standards. The final Section discusses the presidential requirement that agencies conduct cost-benefit analysis prior to major administrative actions and how that requirement should be applied in the offshore drilling context. The requirement of economically informed decisionmaking discussed in this Part, which has been placed on DOI by all three branches, cannot be

122. Many factors influence the direction and speed of innovation. *See generally* LAWRENCE H. GOULDER, PEW CTR. FOR GLOBAL CLIMATE CHANGE, INDUCED TECHNOLOGICAL CHANGE AND CLIMATE POLICY (2004).

adequately fulfilled unless the Agency incorporates option value into its analysis.

A. Statutory and Regulatory Priorities

This Section discusses the requirement in the OCSLA and that statute's implementing regulations that DOI examine and consider the economic consequences of leasing decisions.

Moratoria imposed by Congress and the executive have at different times provided an important part of the legal backdrop to offshore oil development. In 1982, Congress began issuing a series of moratoria in DOI appropriations measures prohibiting new leases in several areas.[123] Then, in June 1990,[124] President George H.W. Bush exercised his authority under the OCSLA[125] to remove a number of areas from potential leasing, and in 1998 President Clinton extended this order through 2012.[126] In the run-up to the 2008 election, as gasoline prices spiked, President George W. Bush rescinded those orders,[127] and a Democratic Congress allowed the legislative moratorium to expire.[128]

The federal government exercises control over the outer continental shelf through several federal statutes. The primary federal law governing mineral development offshore is the OCSLA, which was substantially amended in 1978 into its current form in the wake of the 1969 offshore oil well blowout in the Santa Barbara Channel and the oil embargo organized by the Organization of Arab Petroleum Exporting Countries in 1973.[129] While the Santa Barbara Oil Spill (and other similar

123. CURRY L. HAGERTY, CONG. RESEARCH SERV., R41132, OUTER CONTINENTAL SHELF MORATORIA ON OIL AND GAS DEVELOPMENT 5–6 (2011).

124. Statement on Outer Continental Shelf Oil and Gas Development, 26 Weekly Comp. Pres. Doc. 1006 (June 26, 1990).

125. 43 U.S.C. § 1341(a) (2006).

126. Memorandum on Withdrawal of Certain Areas of the United States Outer Continental Shelf from Leasing Disposition, 34 Weekly Comp. Pres. Doc. 1111 (June 12, 1998).

127. Memorandum on Modification of the Withdrawal of Areas of the United States Outer Continental Shelf from Leasing Disposition, 44 Weekly Comp. Pres. Doc. 986 (July 14, 2008).

128. HAGERTY, *supra* note 123, at 7. Shortly before the BP Gulf Coast Oil Spill, President Obama proposed opening substantial new areas to development. Juliet Eilperin & Anne E. Komblut, *President Obama Opens New Areas to Offshore Drilling*, WASH. POST., Apr. 1 2010, http://www.washingtonpost.com/wp-dyn/content/article/2010/03/31/AR2010033100024.html.

129. Judge Wald describes:

> several cross-currents [that] generated support for revising

incidents) raised public awareness of the environmental sensitivity of marine and coastal resources, the oil embargo also created substantial demand for expanded domestic oil production.[130] These conflicting impulses were embodied in the 1978 amendments, which were intended to facilitate the "expeditious and orderly development [of the Outer Continental Shelf] subject to environmental safeguards."[131] The OCSLA establishes a comprehensive leasing process, administered by the Secretary of the Interior. Regulations implementing the Act require the Agency to "preserve, protect, and develop mineral resources" to help "meet the Nation's energy needs; [b]alance orderly energy resource development with protection of the human, marine, and coastal environments; [and] [e]nsure the public receives a fair and equitable return on the resources of the OCS."[132]

Among DOI's duties is a requirement to prepare a leasing program "to implement the policies of [the] Act."[133] Section 18 of the Act describes four basic principles according to which the leasing program "shall be prepared and maintained"[134]:

- First, in Section 18(a)(1), "[m]anagement of the outer Continental Shelf shall be conducted in a manner which *considers economic, social, and environmental values* of . . . renewable and nonrenewable resources."[135]
- Second, in Section 18(a)(2), "[t]iming and location of exploration, development, and production . . .

> [the] OCSLA. The onset of the energy crisis, dramatized by the oil embargo of 1973, heightened the attractiveness of the uncertain OCS resources . . . [while] [a]t the same time, local governments, environmental and citizens organizations, commercial and recreational fishing interests, and other groups expressed increasing concern over possible deleterious effects of rapid OCS development.

Energy Action Educ. Found. v. Andrus, 654 F.2d 735, 739 (D.C. Cir. 1980) (citing legislative history) (citations omitted); *see also* U.S. GOV'T ACCOUNTABILITY OFFICE, COAST GUARD RESPONSE TO OIL SPILLS—TRYING TO DO TOO MUCH WITH TOO LITTLE 1 (1978) (documenting oil spills and government responses in 1975 and 1976).

130. *See generally* Rick S. Curtz, *Coastal Oil Pollution: Spills, Crisis, and Policy Change*, 21 REV. POL'Y RES. 201 (2004).

131. 43 U.S.C. § 1332(3) (2006); *see also* S. REP. NO. 284, at 42–43 (1977).

132. 30 C.F.R. § 550.101(b) (2012).

133. Outer Continental Shelf Lands Act Amendment of 1978, Pub. L. No 95-372 § 18(a) (codified at 43 U.S.C. § 1344(a) (2006)).

134. *Id.*

135. 43 U.S.C. § 1344(a)(1) (emphasis added).

shall be *based on consideration* of" eight enumerated factors, such as "an equitable sharing of developmental benefits and environmental risks," and "the relative environmental sensitivity . . . of different areas."[136]

- Third, in Section 18(a)(3), "timing and location of leasing, to the maximum extent practicable, [shall be selected] so as to *obtain a proper balance* between the potential for environmental damage, the potential for the discovery of oil and gas, and the potential for adverse impact on the coastal zone."[137]
- Fourth, in section 18(a)(4), "[l]easing activities shall be conducted to assure receipt of *fair market value*."[138]

The leasing program that governs through 2012 was published in December 2010 and is entitled *Revised Program Outer Continental Shelf Oil and Gas Leasing Program 2007–2012*.[139] This document lays out DOI's considerations and calculations regarding off-shore drilling leases and responds to the statutory directives laid out in Section 18. DOI has initiated a process to adopt a leasing program for 2012 through 2017 and released a proposed leasing plan in November 2011.[140]

The Agency's internal manual describes its fair market value process and bid adequacy procedures as having the objective of "ensur[ing] . . . the public receives a fair return for OCS oil and gas leases."[141] Fair market value is defined in the same document as "the amount in cash . . . for which, in all probability, the property would be sold by a knowledgeable owner willing but not obligated to sell to a knowledgeable purchaser who desired but is not obligated to buy," and, that this value "is not merely theoretical or hypothetical but it represents, insofar as it is possible to estimate it, the actual

136. *Id.* § 1344(a)(2) (emphasis added).
137. *Id.* § 1344(a)(3) (emphasis added).
138. *Id.* § 1344(a)(4) (emphasis added).
139. BUREAU OF ENERGY MGMT., REGULATION AND ENFORCEMENT, REVISED PROGRAM OUTER CONTINENTAL SHELF OIL AND GAS LEASING PROGRAM 2007–2012 1 (2010) [hereinafter 2010 REVISED PROGRAM].
140. *See* 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 1.
141. BUREAU OF OCEAN ENERGY MGMT., REGULATION AND ENFORCEMENT MANUAL, 610.1 § 2 (2010).

selling price at the time of the transaction."[142]

OCS regulations require a bidding system that promotes the goals of "[p]roviding a fair return to the Federal Government; [i]ncreasing competition; [e]nsuring competent and safe operations; [a]voiding undue speculation . . . [d]iscovering and recovering oil and gas; [and] [d]eveloping new oil and gas resources in an efficient and timely manner."[143] This return is achieved through rental fees at the price reached in bidding, a fixed royalty rate of at least 12.5 percent, and at the Agency's discretion, a fixed cashed bonus or other variations on the rate or calculation of the royalty.[144] For recovery from marginal or nonproducing tracts, or from deep-water tracts, royalty payments may be reduced or suspended provided that production would not be economic without such relief.[145]

Both the statute and DOI's regulation state that the Agency should base leasing decisions after consideration of their economic impact, a charge which, as discussed in Parts I and II, DOI cannot fulfill without examining real option value.

B. Judicial Review

Where it is legally permissible for DOI to open up areas for leasing, those decisions are subject to judicial scrutiny according to the governing statute, as well as general administrative law principles. In *Motor Vehicles Manufacturers Association. v. State Farm Mutual*, the Supreme Court held that an agency's decision would be "arbitrary and capricious" unless it was "based on . . . consideration of the relevant factors" and the agency had not "relied on factors which Congress has not intended it to consider, [or] entirely failed to consider an important aspect of the problem."[146] Administrative law standards have been applied to agency decisions concerning leasing of offshore lands most extensively in the context of the lease planning process. The "policies and purposes" of the OCSLA provide the standards by which the court "may determine whether the Secretary's decision was arbitrary, irrational, or contrary to the requirements of the

142. *Id.* § 5C.
143. 30 C.F.R. § 560.130(a)–(d), (f)–(g) (2012).
144. *Id.* §§ 560.110–560.111.
145. 43 U.S.C. § 1337(a)(3) (2006).
146. 463 U.S. 29, 43 (1983) (citations omitted).

Act."[147]

Courts have examined the Secretary's decisionmaking process in several cases over the past thirty years.[148] Although judges have shown an understandable hesitancy to engage in overly probing review of expert-based agency decisions, in several instances courts have found DOI's economic analysis lacking, especially where whole categories of effects were excluded. A wholesale failure to consider real option value is similar to the types of deficiencies that courts have found sufficient to warrant judicial intervention. The most important of these cases has involved the lease planning program adopted by the Agency.[149] In general, the D.C. Circuit, which has jurisdiction over challenges to the leasing program,[150] has granted a substantial degree of deference to the Agency, especially where there are technical or scientific issues where DOI has special expertise or where the predictive nature of the planning enterprise necessarily involves a substantial amount of discretion. At the same time, the court has carefully policed DOI's interpretation of the statute and, in particular, has emphasized the need to examine and account for all of the factors that the statute states must bear on agency leasing decisions.[151]

147. California v. Watt (*Watt I*), 668 F.2d 1290, 1317 (D.C. Cir. 1981).

148. The first case to examine a lease sale decision under the current law is *Massachusetts v. Andrus*, 594 F.2d 872 (1st Cir. 1979) (largely focusing on environmental impact statement associated with offering lease sales in Georges Bank). For a lengthy treatment of the history of litigation in this area, see generally EDWARD A. FITZGERALD, THE SEAWEED REBELLION: FEDERAL-STATE CONFLICTS OVER OFFSHORE ENERGY DEVELOPMENT (2001).

149. In addition to reviewing the leasing schedule proposed by DOI, courts have also examined the bidding procedure established by the agency, in light of the statutory mandate to ensure that the American public is compensated with a "fair market value" in exchange for private access to OCS. *E.g.*, Watt v. Energy Action Educ. Found., 454 U.S. 151, 153 (1981) (overturning appellate court decision that DOI must experiment with particular types of bidding systems). Bid adequacy was also discussed directly in *Natural Resources Defense Council, Inc. v. Hodel*. 865 F.2d 288, 312–16 (D.C. Cir 1988). In *Hodel*, the court found that the "competitive bidding process and elaborate post-bid evaluation of bids on those tracts most susceptible to market failure" were adequate and an across the board minimum bid was not "a crucial element of the measures designed to assure receipt of fair market value." *Id.* at 313–14. Because the necessary contours of the "post-bid evaluation" procedure have not been given detailed discussion by the court, this Article focuses on the lease planning process. Nevertheless, the requirement for fair market value does create the potential to challenge the bid adequacy process on the basis of its failure to account for real option value.

150. 43 U.S.C. § 1349(c)(1) (2006).

151. The relationship of DOI's current failure to account for option value and the oversight regime discussed in this section will be discussed in detail *infra* Part

The first five-year leasing program in 1980 was successfully challenged by several coastal states in *California v. Watt (Watt I)*.[152] The court found flaws in the Agency's decisionmaking under the OCSLA, including a failure to define potential lease sales "as precisely as possible" in its leasing program[153] and remanded the program for reconsideration. The court provided detailed discussion of how the Agency was to make decisions under the Section 18 framework. Under the statute, the Agency is to "consider all of the factors listed in [S]ection 18(a)(2)" and "must base the leasing program upon the result of [the] consideration of these factors."[154] Reviewing the Agency's decision, the court found that DOI failed to consider some of the enumerated factors, including the "need to share . . . benefits and . . . risks" and "relative environmental sensitivity."[155] The court also found that the Agency had failed to base the lease program on consideration of these factors.

The court found that the Section 18(a)(3) requirement that the Agency strike the "proper balance" between competing factors requires DOI to "evaluate oil and gas potential, which can be quantified in monetary terms, in conjunction with environmental and social costs, which do not always lend themselves to direct measurement."[156] This "difficult burden [that] the [Agency] must shoulder" creates "broad" but "not unreviewable" discretion.[157] In exercising its power of review, the court looked to the "policies and purposes of the Act [to] provide [the] standards by which we may determine whether the Secretary's decision was arbitrary, irrational, or contrary to the requirements of the Act."[158]

The court endorsed the Agency's interpretation that the Section 18(a)(3) requirement could be met through a cost-benefit analysis.[159] Quoting from the Agency's determination that "[i]f the anticipated benefits outweigh the anticipated costs[,] . . . then the proper balance . . . is to schedule the area for leasing consideration" and that the basis for "declining to proceed with planning activities . . . is that the costs in that

---

V.B.

152. 668 F.2d 1290, 1317 (D.C. Cir. 1981).
153. *Id.* at 1305.
154. *Id.*
155. *Id.* at 1325.
156. *Id.* at 1317.
157. *Id.*
158. California v. Watt (*Watt I*), 668 F.2d 1290, 1317 (D.C. Cir. 1981).
159. *Id.* at 1318.

area outweigh the benefits."[160] The court found it "reasonable to conclude that within the section's proper balance there is some notion of 'costs' and 'benefits.'"[161] The court also "agree[d] with the [Agency's] view that an area should be included . . . when its potential 'benefits' exceed its potential 'costs.'"[162]

Ultimately, although it was happy with DOI's "general interpretation" of the Section 18(a)(3) requirement, the court was not satisfied with the Agency's "actual approach."[163] Among the problems mentioned, the court was "left uncertain as to whether the [Agency] properly considered the economic effect of delaying lease sales."[164] The court quoted the Agency's determination that

> it is worthwhile finding and producing any OCS oil and gas that is less costly than [world oil prices] as soon as possible unless extraordinary increases in future world oil prices are expected. Otherwise "banking" oil in the ground will deprive the American people of present consumption and investment without sufficient future gains to offset the income they would forego.[165]

The court noted that the Agency had developed "a model of attributing a cost to delay" that the court was "reluctant to interfere with . . . so long as it is not irrational."[166] The court did, however, question the finding that world oil prices would increase at a 2 percent rate, given recent history. The failure to "adequately explain [the Agency's] determination of net economic value, particularly the economic effects of delaying leasing," was one of seven grounds on which the court based its decision to remand the plan back to the Agency.[167]

The Agency responded to the court's decision by making several revisions to the planning documents and then adopting an updated version of the plan.[168] Again, a group of petitioners raised several challenges to the plan. In *California v. Watt*

160 *Id.* at 1317–18.
161. *Id.* at 1318 (internal quotations omitted).
162. *Id.*
163. *Id.* at 1319.
164. California v. Watt (*Watt I*), 668 F.2d 1290, 1320 (D.C. Cir. 1981).
165. *Id.*
166. *Id.*
167. *Id.* at 1325.
168. California v. Watt (*Watt II*), 712 F.2d 584, 589–90 (D.C. Cir. 1983) (discussing procedural history).

(Watt II), the court upheld the revised plan.[169] Relying on its earlier decision, the court utilized a similar framework for enumerating the duties of the Agency and defining the appropriate role for a reviewing court.[170] Unlike in *Watt I*, the court found that the challengers' complaints with agency decisionmaking were insufficiently persuasive to support a finding that the Agency had acted in an arbitrary or capricious manner.[171]

In discussing the challenge raised by petitioners that the cost-benefit analysis under Section 18(a)(3) was flawed, the court went to special pains to establish the "great deference afforded to [DOI] in these areas."[172] The court found that "petitioners challenge the factual basis and the methodology used . . . in various aspects of the cost benefit analysis" and noted that these "aspects of the analysis" fell at "the frontiers of scientific knowledge"[173] with facts that were "largely predictive in nature" and methodologies that were "necessarily novel."[174] The court also emphasized that Congress did not want "analysis . . . [to] go on forever" but instead insisted on prompt deadlines, and that "the final decision as to how much analysis is necessary in view of the available data must be the [A]gency's subject to judicial review only for obviously incorrect results or methodology."[175]

There were three bases for the petitioner's argument that the cost-benefit analysis was deficient. The first was that the Agency "failed to reflect the costs and benefits of delaying lease sales."[176] The court disagreed, finding that the Agency's "initial calculation . . . as if all oil in all areas would be leased and developed in the first year of the program" was "reasonable."[177] The court so found "because the [Agency] was trying to calculate the *relative* ranking of each of the planning areas, in addition to determining whether each of the planning areas should be leased."[178] The court disagreed with the challengers'

167. *Id.* at 611.
170. *Id.* at 590–91, 594.
171. *Id.* at 611.
172. *Id.* at 599–600.
173. California v. Watt (*Watt II*), 712 F.2d 584, 600 (D.C. Cir. 1983) (quoting *Watt I*).
174. *Id.*
175. *Id.* (quoting Massachusetts v. Andrus, 594 F.2d 872, 886 (1st Cir. 1979)).
176. *Id.* at 601.
177. *Id.*
178. *Id.*

alternative, whereby the Agency would "initially determine the timing of each lease sale in order to determine when the oil would be developed and then calculate the costs and benefits of leasing at that time in order to determine whether and when each planning area should be leased."[179] The court found this proposition "illogical."[180] The petitioners raised two other challenges to the calculation of net economic value, the first concerning the rate of increase of world oil prices and the second concerning an assumption of constant production costs over the course of the planning period.[181] The court "reject[ed] both of these arguments," finding that the Agency's determinations on these points were reasonable.[182]

Watt I and *Watt II* thus developed a framework for evaluating the leasing program based on how well the Agency's cost-benefit analysis was conducted. While granting the Agency wide discretion, the court was not shy about challenging some key assumptions that it viewed as being inadequately supported, such as the rate of oil price growth.[183] The court also carefully attempted to distinguish between statutory issues, on the one hand, and factual or "methodological" issues, where Agency discretion was particularly pronounced, on the other hand.[184] The court also reserved the power to set aside decisions based on "obviously incorrect results or methodology."[185]

The reviewing framework developed in *Watt I* and *Watt II* was applied several times in the subsequent decades. *Natural Resources Defense Council v. Hodel* was the first challenge to a leasing plan under the standard announced in *Chevron v. Natural Resources Defense Council.*[186] There were several questions at issue in *Hodel.* Petitioners again challenged the planning area designations by DOI.[187] Under the statute, the

179. California v. Watt (*Watt II*), 712 F.2d 584, 601 (D.C. Cir. 1983).

180. *Id.*

181. *Id.* at 601–02.

182. *Id.*

183. At least one roughly contemporaneous commentator argued that the court was overly deferential to the Agency, undermining congressional intent for environmental issues to receive greater weight. *See* Edward Fitzgerald, *California v. Watt: Congressional Intent Bows to Judicial Restraint*, 11 HARVARD ENV. L. REV. 147, 147 (1987).

184. *Watt II*, 712 F. 2d at 600.

185. California v. Watt (*Watt II*), 712 F.2d 584, 601 (D.C. Cir. 1983).

186. Natural Res. Def. Council v. Hodel, 865 F.2d 288, 288 (D.C. Cir. 1988) (citing Chevron v. Nat. Res. Def. Council, 467 U.S. 837 (1984)).

187. *Id.* at 300–06.

Secretary has to determine which areas were "oil- and gas-bearing physiographic regions of the outer Continental Shelf" and then make the comparative analysis of regions required by Section 18(a)(2).[188] The petitioners alleged that the Secretary skewed the analysis by placing high- and low-potential fields within the same planning areas and comparing these planning areas, not the oil-bearing regions.[189] The court found that the statutory terminology "oil- and gas-bearing physiographic regions" was ambiguous, and, therefore, the Agency's definition was subject only to review for reasonableness.[190] Upon reviewing the alternatives proposed by petitioners, the court found that DOI's choice of planning areas was "eminently reasonable."[191]

Petitioners also alleged that the Secretary had selected for drilling low-potential areas that were not justified on cost-benefit grounds, focusing on the relatively high price of oil used by DOI in its analysis.[192] They noted that there were several areas where, had the current price of oil been used, the "economic value" would have been zero or negative, and that, necessarily, the "net social value" would be zero.[193] Petitioners argued that the Secretary's decision to go forward, despite the questionable value of the lease sales, violated the statutory requirement that a "proper balance" be struck between the costs and benefits of exploiting offshore oil resources.[194]

The court disagreed, pointing to several rationales, two of which are especially relevant.[195] First, the court endorsed DOI's argument that it could use its cost-benefit analysis for "comparative purposes—to compare the relative benefits among the various areas—and not for the purpose of determining the absolute economic values of oil and gas that might exist."[196] Second, DOI was permitted to "weigh . . . qualitative as well as quantitative factors," when making its decision.[197] These qualitative factors included "national security, industry interest, and equitable sharing of

188. *Id.* at 300.
189. *Id.*
190. *Id.* at 301.
191. *Id.*
192. Natural Res. Def. Council v. Hodel, 865 F.2d 288, 306–07 (D.C. Cir. 1988).
193. *Id.*
194. *Id.* at 306 (quoting 43 U.S.C. § 1344(a)(3)).
195. *Id.* at 307.
196. *Id.*
197. *Id.*

developmental costs and benefits."[198] The court further found that "[t]aking qualitative factors into account implies that the inclusion of areas with a calculated net social value of zero may nonetheless be compatible with" the statute.[199] The court's analysis has drawn some criticism from commentators for allowing DOI to hold inconsistent positions and ignore its own analysis.[200] Petitioners also challenged the reduction of the minimum bid from $150 to $25 per acre as violating Section 18(a)(4), which requires the receipt of fair market value in leases.[201] The court deferred to the Secretary's discretion, holding that fair market value is primarily obtained through competitive bidding and post-bid evaluation procedures, that minimum bids were not particularly important in securing the fair market value, and that the methodology employed in determining minimum bids and fair market value served to "amply fulfill" the statutory mandate.[202]

Center for Biological Diversity v. Department of Interior[203] was a challenge that led to revision of the 2007–2012 leasing plan. Petitioners raised two main arguments. The first, which was rejected by the court, was that DOI had an obligation to examine the greenhouse gas consequences of consumption of OCS resources.[204] The court found that the structure of the statute that "instructs Interior to ensure that oil and gas are extracted *from the OCS* in an expeditious manner" implies that the DOI "simply lacks the discretion to consider any global effects that oil and gas consumption may bring about."[205]

The second challenge, which was successful, involved the measure of environmental sensitivity used by DOI in its analysis.[206] The Agency, noting that there was some statutory ambiguity, argued that its choice to use the environmental sensitivity of the shoreline associated with planning area as a proxy for the overall environmental sensitivity of the planning area fell within its discretion.[207] The court disagreed, finding

198. Natural Res. Def. Council v. Hodel, 865 F.2d 288, 307 (D.C. Cir. 1988).
199. *Id.*
200. Edward A. Fitzgerald, Natural Resources Defense Council v. Hodel*: The Evolution of Interior's Five Year Outer Continental Shelf Oil and Gas Leasing Program*, 12 TEMP. ENVTL. L. & TECH. J. 1, 1 (1993).
201. *Id.* at 312.
202. *Hodel*, 865 F.2d at 313–15.
203. 563 F.3d 466 (D.C. Cir. 2009).
204. *Id.* at 484–86.
205. *Id.* at 485.
206. *Id.* at 487–89.
207. *Id.* at 487–88.

that the Agency's interpretation was "irrational" because it was not "based on a consideration of the relevant factors" set forth in the statute.[208] Although prior cases "afforded Interior a great deal of leeway . . . they did not give [DOI] carte blanche to wholly disregard a statutory requirement out of convenience."[209] Because the statute required the Agency to look at the environmental sensitivity of OCS, DOI could not look at onshore effects alone and needed to conduct an independent inquiry into offshore effects.[210] The deficiency in the environmental sensitivity analysis also rendered the cost-benefit analysis conducted under section 18(a)(3) incomplete.[211]

The consequences of this line of cases for DOI decisionmaking will be explored in more detail below. But it is clear that, while the court has granted the Agency some degree of discretion, DOI is not free to simply ignore the factors that Congress has instructed the Agency to consider. Even if the court does not examine methodological minutiae, it has for the past thirty years attempted to ensure that the analysis done by the Agency is well-founded and represents a good-faith and reasonable effort to balance the variety of factors that are relevant for making sound leasing decisions. The implication is that courts may not shy away from requiring the Agency to consider real option value in its analysis.

C. Executive Standards

The Presidential requirement that reasonably complete cost-benefit analysis be undertaken of major agency actions also cannot be fulfilled if DOI continues to fail to account for real option value. While the standards imposed by the President on executive agencies for administrative action cannot be enforced in courts, they inform how agencies should conduct analysis of their decisionmaking. Presidential requirements for agencies to conduct cost-benefit analyses of their regulatory decisions, and subject those analyses to scrutiny by the Office of Information and Regulatory Affairs ("OIRA") in the White House, have been in place since 1981.[212]

208. *Id.* at 488.
209. Ctr. for Bio. Diversity v. Dep't of Interior, 563 F.3d 466, 488 (D.C. Cir. 2009).
210. *Id.*
211. *Id.*
212. *About OIRA*, OFFICE OF MGMT. AND BUDGET, http://www.whitehouse.gov/omb/in

The documents containing these requirements, along with supporting guidance issued by OIRA and best practices developed by administrative agencies when following these directives, provide some direction for how DOI should carry out its duties to conduct thorough analysis of the impact of its decisions. The focus on comprehensive economic examination of the effects of agency action strongly favors examination of option value.

There is no record of DOI submitting its proposed five-year plans for OIRA review, although informal consultation outside the formal review process is possible. Executive Order 12,866, which has governed, with only minor modification, since being adopted in 1993 by President Clinton, defines a "regulatory action" as being "any substantive action by an agency (normally published in the Federal Register) that promulgates or is expected to lead to the promulgation of a final rule or regulation."[213] The order defines "regulation" or "rule" to mean "an agency statement of general applicability and future effect, which the Agency intends to have the force and effect of law, that is designed to implement, interpret, or prescribe law or policy or to describe the procedure or practice requirements of an agency."[214] This definition is similar to the one given for "rule" in the Administrative Procedure Act ("APA") with the primary difference being that the language "which the Agency intends to have the force and effect of law" in the Executive Order is absent in the APA.[215]

The issue of the judicial reviewability of the Agency's adoption of the leasing program is settled quite clearly in the OCSLA, which includes specific language on the point: "Any action of the Secretary to approve a leasing program pursuant to section 1344 of this title shall be subject to judicial review only in the United States Court of Appeal for the District of Columbia."[216] Even without this language, the adoption of a leasing program is the kind of administrative action that is regularly subject to judicial scrutiny based on the definition of agency action in the APA. It is not altogether clear why OIRA has not subjected the leasing program to scrutiny.

---

foreg_administrator (last visited April 4, 2013).

213. Executive Order No. 12,866, Regulatory Planning and Review § 3(e), 58 Fed. Reg. 51,737 (Sept. 30, 1993).

214. *Id.* § 3(d).

215. 5 U.S.C. § 551(4) (2011).

216. 43 U.S.C. § 1349(c)(1) (2011).

Even if the leasing program is never subjected to OIRA review, the principles that inform executive level review nevertheless provide a set of best-practices that should inform DOI as it makes extraction decisions. A reasonable, straightforward reading of these requirements would imply that analysis should be done of the option value that is lost when DOI opens an area for exploration. For important actions, the Executive Order requires agencies to conduct "[a]n assessment . . . of benefits anticipated from the regulatory action (such as, but not limited to, the promotion of the efficient functioning of the economy and private markets . . . [and] the protection of the natural environment . . .) together with, to the extent feasible, a quantification of those benefits."[217] Agencies must also conduct "[a]n assessment, including the underlying analysis, of costs anticipated from the regulatory action (such as, but not limited to . . . any adverse effects on the efficient functioning of the economy, private markets (including productivity, employment, and competitiveness), health, safety, and the natural environment), together with, to the extent feasible, a quantification of those costs."[218] Option value is easily captured in this expansive list of the types of costs and benefits that agencies should consider.

OIRA has also issued guidance that provides more information about best-practices for the cost-benefit analyses that are to be carried out by government agencies.[219] The criteria used in these documents also counsel for consideration of option value. The A-4 Circular, adopted by OIRA in 1993, provides some general criteria to be used by government agencies when carrying out cost-benefit analysis.[220] In general, the Circular advocates the most complete analysis possible, which estimates and monetizes all costs and benefits of a government action, relying on an "opportunity cost" framework.[221] OIRA recommends the "willingness-to-pay [standard, which] captures the notion of opportunity cost by measuring what individuals are willing to forgo to enjoy a particular benefit."[222] OIRA also notes that "[t]he use of any

217. Executive Order No. 12,866 § 6(3)(C)(i), 58 Fed. Reg. 51,741 (Sept. 30, 1993).

218. *Id.* § 6(3)(C)(ii).

219. *E.g.*, OFFICE OF MGMT. & BUDGET, REGULATORY ANALYSIS, MEMORANDUM TO THE HEADS OF EXECUTIVE AGENCIES AND ESTABLISHMENTS 18 (Sept. 9, 2003).

220. *See generally id.*

221. *Id.*

222. *Id.*

resource has an opportunity cost" and that agencies should, "[t]o the extent possible[,] . . . monetize any such forgone benefits" created by the Agency's action.[223] Option value is the measure of the opportunity cost of going forward with a project that could be delayed and, under the A-4 Circular, should be estimated by the Agency if feasible. Indeed, OIRA specifically recommends that real options be taken into account, stating that "[a]s long as taking time will lower uncertainty, either passively or actively through an investment in information gathering, and some costs are irreversible, such as the potential costs of a sunk investment, a benefit can be assigned to the option to delay a decision."[224]

Agencies have also developed their own set of guidance documents concerning cost-benefit analysis of their decisionmaking. The *Guidelines on Economic Analyses of Environmental Regulation* by EPA is the most relevant.[225] In that document, EPA provides a lengthy introduction to cost-benefit analysis and establishes a set of best practices on a variety of methodological issues, ranging from establishing a regulatory baseline to measuring willingness to pay for non-market goods.[226] Throughout the *Guidelines*, EPA places an emphasis on encouraging analysts to provide the most complete accounting, in economic terms, of the benefits and costs of an agency action, providing a range of technical approaches to dealing with values that are difficult to estimate and ensuring that the effects of action are appropriately weighed.[227] There is also an extensive discussion of discounting and appropriate accounting for the timescale when benefits and costs are incurred.[228] Sensitivity to the timing of the impacts of agency actions is one of the hallmarks of EPA's cost-benefit analysis.

The A-4 Circular and EPA's guidance documents provide some information on the best practices that agencies should take into consideration when conducting economic analyses. While these documents do not create legal obligations for DOI,[229] they do provide an indication on how other agencies conduct analyses and the types of factors that are relevant in

223. *Id.* at 19.
224. *Id.* at 39.
225. EPA GUIDELINES, *supra* note 61, at 1-1.
226. *Id.* at 5-1 to 5-16 (discussing baselines); *id.* at 7-21 to 7-44 (discussing measurement techniques).
227. *Id.* at 7-15 to 7-20 (discussing measurement of ecological benefits).
228. *Id.* at 6-1 to 6-20.
229. *See generally* United States v. Mead Corp., 533 U.S. 218, 226–27 (2001).

economic analysis of agency decisionmaking. With their focus on opportunity costs, comprehensive analysis, and accurate examination of all costs and benefits, these documents offer persuasive authority that consideration of option value would be appropriate for DOI.

IV. FAILURE TO ACCOUNT FOR OPTION VALUE

Although DOI has developed sophisticated methodologies for calculating costs and benefits and ensuring bid adequacy, there is no point in the process, from the five-year plan to the lease of individual tracts, at which real option value is considered. The participation of private actors in the auctioning process, even if the auctions are competitive, is not sufficient to ensure that only tracts that should be leased from a social perspective will be leased, or to ensure that the American public is adequately compensated for lost option value.

This Part first discusses the planning process, then describes the bid adequacy process, and finally shows how option value is ignored at both steps.

A. Planning

In managing OCS, DOI places a great deal of emphasis on cost-benefit analysis at every stage, reflecting the requirements under Section 18(a)(3) and the judicial interpretation thereof. The Agency requires that in areas with known resources, leasing should be considered if anticipated benefits "substantially outweigh estimated environmental risks."[230] In addition to pursuing the statutory goals described above, including securing a fair return, the Agency seeks to time future lease sales to "enhance financial return."[231] In making planning decisions, the Agency uses cost-benefit analysis to identify "[t]hose program areas with positive net benefits[, which] are appropriate for inclusion in the leasing program from an economic point of view."[232]

In the case of the lease-scheduling process (the Five-Year

230. 2010 REVISED PROGRAM, *supra* note 139, at 28; 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 17.

231. 2010 REVISED PROGRAM, *supra* note 139, at 29; 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 18.

232. ECONOMIC ANALYSIS 2007, *supra* note 4, at 16 (noting that "decisionmakers can and should bring to their decisions other valid points of view besides economics").

Plan), a broad social concept of value is utilized. Various forms of price, technological, and environmental uncertainty are acknowledged, but this uncertainty is not modeled.[233] The Agency seeks to use the best data available but notes that in areas with low confidence in the ability to avoid harm to resources, the possibility of better information in the next five-year period should influence decisionmaking.[234]

DOI estimates of existing known and undiscovered resources, in terms of location, type, and economic viability of extraction, lay the foundation for both the leasing plan and the economic analysis.[235] These estimates cover "undiscovered, conventionally and economically recoverable oil and natural gas resources located outside of known oil and gas fields."[236] In addition to oil prices, essential input assumptions are those regarding anticipated production, exploration and development scenarios, and production profiles.[237]

Estimates of technically recoverable resources are assessed for economic viability.[238] Recent technological advances affecting exploration and development are taken into account, but despite the acknowledgment that advances "are sure to occur in the future" and likely to increase economic recoverability, "no attempt [is] made to determine an empirical relationship between the future technological advancements and the estimated undiscovered resources."[239]

DOI creates its proposed schedule of leasing in its five-year plans, which are developed through a notice and comment process.[240] The cost-benefit analysis in those plans compares the social value of opening leasing within a given OCS region against a scenario in which the region is not open.[241]

For a given tract, the Agency calculates the net economic value and subtracts the external environmental costs to arrive

233. 2010 REVISED PROGRAM, *supra* note 139, at 27.

234. 2010 REVISED PROGRAM, *supra* note 139, at 28; 2011 DRAFT PROPOSED PROGRAM *supra* note 10, at 18.

235. ECONOMIC ANALYSIS 2007, *supra* note 4, at 9. The estimates are included in periodic assessments produced by DOI. *See, e.g.*, MINERALS MGMT. SERV., ASSESSMENT OF UNDISCOVERED TECHNICALLY RECOVERABLE OIL AND GAS RESOURCES OF THE NATION'S OUTER CONTINENTAL SHELF (2006) [hereinafter OCS ASSESSMENT].

236. ECONOMIC ANALYSIS 2007, *supra* note 4, at 9.

237. *Id.* at 10.

238. OCS ASSESSMENT, *supra* note 235, at 1.

239. OCS ASSESSMENT, *supra* note 235, at 2.

240. 2010 REVISED PROGRAM, *supra* note 139, at 12.

241. 2010 REVISED PROGRAM, *supra* note 139, at 1.

at a net social value, which is added to consumer surplus to arrive at an estimate of net benefits.[242] The net benefits of the leasing program are assumed to extend over a forty-year period.[243] Net economic value is calculated as the market value of anticipated production, less the costs of exploration, development, production, and shipping.[244] In the current leasing plan, the Agency uses a constant real price of oil ($46 bbl) that "represent[s] a realistic estimate of the kind of long-term price assumptions the oil and gas industry will be using for making its development decisions."[245] In the draft program for 2012–2017, DOI uses three estimates for oil prices to "allow . . . decisionmakers to more easily understand net benefits at a mid-range price as well as changes in benefits that may result from major swings in price, either upward or downward."[246] The Market Simulation models are used to estimate effects on prices and, therefore, on consumer surplus. Most of the increase in consumer surplus due to small changes in prices amounts to a transfer of wealth from producers (including foreign producers) to consumers.[247]

The environmental and social costs are estimated using the Offshore Environmental Cost Model.[248] This model covers seven categories: recreation; air quality; property values; subsistence harvests; fiscal impacts; commercial fishing; and ecology.[249] The model is designed to account for "typical oil spills that might occur" but "is not designed to represent impacts from catastrophic events or impacts on unique resources such as endangered species."[250] In its most recent draft plan, DOI released a "proposed methodology to identify information on the range of factors that could influence the severity of impacts from a catastrophic event and the unique resources that could be affected."[251]

242. 2010 REVISED PROGRAM, *supra* note 139, at 110–11; 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 95.

243. 2010 REVISED PROGRAM, *supra* note 139, at 108; 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 96.

244. 2010 REVISED PROGRAM, *supra* note 139, at 110; 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 98–100.

245. 2010 REVISED PROGRAM, *supra* note 139, at 109.

246. 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 96.

247. *Id.* at 103–04.

248. 2010 REVISED PROGRAM, *supra* note 139, at 110–11; 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 100.

249. 2011 DRAFT PROPOSED PROGRAM, *supra* note 10, at 101.

250. *Id.*

251. *Id.*

B. Bid Adequacy and Reservation Price

The Agency interprets the statutory framework in the OCSLA to require that the federal government receive a "fair return for the lease rights granted and the minerals conveyed."[252] At the most general level, the Secretary must "establish royalties, fees, rentals, bonuses, or other payments to ensure a fair return to the United States for any lease, easement, or right-of-way granted under" the statute for energy or related purposes.[253] The Agency fulfills this requirement, first, through a set of regulations designed to establish a competitive bidding process and, second, through a process to determine whether bids pass a reservation price that is adequate to compensate the American public for the rights being sold.

The Notice of OCS Lease Sale, published in the Federal Register, specifies the bidding system to be used, the annual rental fee, and any other provisions.[254] A minimum bidding amount is also specified, and the highest qualified bid is determined on the basis of a "bid variable" in the chosen bidding system, either the level of cash bonus to be paid or the royalty rate.[255] There are a number of possible bidding systems that mix royalties and direct payments.[256]

There are several procedural protections in place. Bids that are "otherwise qualified" may undergo an antitrust review to be conducted by the Attorney General, in consultation with the Federal Trade Commission, before final approval, especially if an unusual bidding pattern suggests uncompetitive practices among companies.[257] Except for certain projects that are exempted under the Energy Policy Act of 2005, all other leases must be granted through competitive bidding, unless it is determined after public notice that no competitive interest exists.[258] Large operators with average

252. MINERALS MGMT. SERV., SUMMARY OF PROCEDURES FOR DETERMINING BID ADEQUACY AT OFFSHORE OIL AND GAS LEASE SALES 1 (1999) [hereinafter BID ADEQUACY PROCEDURES].

253. 43 U.S.C. § 1337(p)(2)(A) (2011).

254. 30 C.F.R. § 560.111 (2012).

255. *Id.*

256. 30 C.F.R. Section 560.110(a)–(g) describe the general forms that these systems can take. Many leave room for discretion regarding the formula, schedule, and/or rate that will be announced.

257. 43 U.S.C. § 1337(c).

258. 43 U.S.C. § 1337(p)(3).

daily production of over 1.6 million barrels in a six-month period prior to leasing are restricted from joint-bidding with other such entities.[259]

The methodology used to determine bid adequacy depends on the type of tract and the number and distribution in the bids received and is evaluated in two phases. For certain types of tracts, bid characteristics alone are sufficient to determine adequacy, with requirements concerning the number of bids, and the variability within bids for the tract and with respect to bids for other similar tracts.[260] For some low viability tracts, bid adequacy is assumed no matter how few bidders or what the bids are.[261] For other types of tracts, with higher prospects, additional evaluation is undertaken, and bid adequacy is determined through a reservation price that is determined through a computational simulation that is meant to "estimate . . . the expected net present value of a tract (or prospect)."[262]

C. Missing Option Value

Despite the extensive attention given to cost-benefit analysis in the planning process and the technical nature of the bid adequacy process, option value is not calculated at either step. While both processes have recognized that DOI can delay lease sales, the value of doing so is not properly estimated.

As part of the most recent planning process, the Agency explicitly recognized that all lands that are currently available need not be immediately released.[263] A 2010 Agency-funded economic analysis of potential leasing-policy changes for the 2010–2060 period examined the possibility of slowing the pace of leasing as well as changes in royalty rates and the bidding process.[264] The report concludes that a "slower pace of leasing significantly increases bidding revenue" but that this is largely offset by a lower discounted value for the other components of

259. 30 C.F.R. § 556.41. An exemption may be provided if extremely high exploration and development costs make it such that production would not occur otherwise. *Id.*

260. Modifications to the Bid Adequacy Procedures, 64 Fed. Reg. 37560-01 (July 12, 1999).

261. *Id.*

262. *Id.*

263. 2010 REVISED PROGRAM, *supra* note 139, at 101–05.

264. ECON. ANALYSIS, INC. & MARINE POLICY CTR., POLICIES TO AFFECT THE PACE OF LEASING AND REVENUES IN THE GULF OF MEXICO TECHNICAL REPORT iv (OCS Study BOEMRE 2011–2014) [hereinafter OCS STUDY].

OCS revenue—royalty payments and area rental.[265] Regarding broader policy goals, the report states that slower leasing "adversely affects the expeditious development of OCS resources and overall social value of OCS resources, while increasing the competition for tracts and reducing environmental risks of OCS development."[266]

But this analysis did not calculate option value—the value of the information that would be revealed during the waiting process. Even though technological change was assumed to exist in the future, the uncertainty about the rate (and nature) of technical change was not taken into account. Even in an analysis that was specially geared towards understanding the economic effects of slowing the leasing process, option value was ignored.

Indeed, DOI has also explicitly rejected a petition to the Agency requesting that it incorporate real option value into its planning decisions.[267] On April 25, 2011, the Institute for Policy Integrity at New York University School of Law submitted a petition to DOI requesting that it examine real options in its next leasing plan.[268] DOI stated that it is "studying option value and how this type of analysis might be considered in the upcoming [five]-year program analysis and in future lease sale timing decisions."[269] However, one month later, the draft leasing plan for 2012–2017 was released, with no new provisions relating to option value.[270]

The bid adequacy process also fails to account for real option value. There is some accounting for future prices during

265. *Id.* (emphasis omitted).

266. *Id.*

267. Letter from Tommy P. Beaudreau, Dir., Bureau of Ocean Energy Mgmt., to Michael A. Livermore, Exec. Dir., Inst. for Policy Integrity (Oct. 19, 2011) http://policyintegrity.org/documents/BOEMRE%20response.pdf.

268. Letter from Michael A. Livermore, Exec. Dir., Inst. for Policy Integrity, to Kenneth Salazar, Sec'y, U.S. Dep't of the Interior (Apr. 25, 2011), http://policyintegrity.org/documents/Petition_to_BOEMRE_on_Option_Value.pdf.

269. Letter from Tommy P. Beaudreau, Dir., Bureau of Ocean Energy Mgmt., to Michael A. Livermore, Exec. Dir., Inst. for Policy Integrity (Oct. 19, 2011) http://policyintegrity.org/documents/BOEMRE%20response.pdf.

270. 2011 DRAFT PROPOSED PROGRAM, *supra* note 10. The final leasing plan was released in June 2012. BUREAU OF OCEAN ENERGY MGMT., PROPOSED FINAL OUTER CONTINENTAL SHELF OIL AND GAS LEASING PLAN 2012–2017 1 (2012). The final plan includes a confusing discussion that may be meant to incorporate some real option value related to price uncertainty. *Id.* at 88. This language, however, is sufficiently vague that it is impossible to know what type of analysis was actually conducted by the agency, and real option value associated with other sources of uncertainty are not mentioned.

the process when the expected value of a tract at the time of the lease sale is compared with the expected value of lease revenue "if the high bid is rejected and the tract resold at the next sale in the area adjusted for changes in value due to potential drainage . . . and to variations in prices."[271] But this calculation is not sufficient to capture option value because it does not take into account uncertainty. Without recognizing the extent of the variance around price or drainage predictions (in addition to potential environmental harm), even this methodology, which at least recognizes the reality that lease sales can be delayed, is inadequate.

Protections within the bid adequacy procedure to ensure competition are not sufficient because, despite DOI's claim, "market forces" alone are not enough to "assure fair market value."[272] It is true that with a competitive bidding process, market actors may compensate the American public for some lost option value during the leasing process. To the extent that lease auctions 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 and the portion of the option value that will be recognized by private parties will be impounded into the lease price.

But there are two problems that interfere with the ability of private lease sales to fully compensate for lost real option value. First, 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, which is for a fixed time period, is less extensive than the perpetual option to wait held by the government that is extinguished when drilling commences. 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.

271. BID ADEQUACY PROCEDURES, *supra* note 252, at 1.
272. *Id.* at 2.

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.[273] 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.

Second, and more importantly, private bidders will only take account of private costs and benefits.[274] Even if value concerning private costs and benefits do affect lease sales, uncertainty concerning environmental harm or the development of cleanup technology will not. The prices in the auction process may account for some uncertainty but will not cover the whole spectrum of uncertainty that is relevant from the public perspective. Because of the social costs associated with drilling, the government cannot simply rely on private market actors to adequately compensate for option value or time drilling activities efficiently—a mechanism is needed to ensure that the value of the benefits of drilling (as indicated by the lease sale price) are higher than the social costs.

In addition to these problems that would exist even if auctions were fully competitive, where auctions are not competitive, DOI does not have a mechanism to ensure that the price that is paid is sufficient to compensate the American public for lost option value. From an efficiency perspective, this is not a problem so long as the lease purchasers would have been willing to pay a sufficiently high price (pure economic efficiency does not require that they actually pay that price). But it does represent an unnecessary transfer of wealth from the American public to lease purchasers.

Ultimately, planning and leasing decisions are being made without estimations of option value, and private market actors do not have incentives to adequately consider several of the central uncertainties that are relevant to society in general. As

273. DIXIT & PINDYCK, *supra* note 13, at 401.

274. The incompleteness of the tort system for large-scale environmental harms is well known. In the offshore oil context, Congress has taken steps to limit liability for large-scale damages, rendering the tort system even more ineffective at internalizing social and environmental harms. *See generally* Larsen, *supra* note 91. One proposal to attempt to internalize some of the externalities associated with the mining process into the leasing process involves opening up participation to include "exgroups" that could bid to delay sales. Scott Farrow, *Lease Delay Rights: Market Value Permits and Offshore Leasing*, 13 RESOURCES POL'Y 113, 113 (1987).

a consequence, leases are currently being made by DOI without any assurance that economic value is being maximized.

V. LEGAL AND POLICY RESPONSES

Given the size of the uncertainties and the large economic value associated with natural resource extraction, option value is not merely an academic curiosity. Rather, where lease sales are made prematurely, the lost option value could substantially exceed whatever revenue is generated, potentially resulting in billions of dollars of lost value for the American people. Failure to take option value into account exposes agencies charged with extraction decisions to legal challenge, which can impose unnecessary costs and delays for both the government and private actors.

There are several steps that can be taken by agencies to incorporate option value into their decisions, reducing this litigation risk and ensuring that a full range of economic factors are adequately examined. From a legal certainty perspective, the most important step that DOI should take is inclusion of real options in the cost-benefit analysis that accompanies the lease plan. Given the case law on DOI's responsibilities under the OCSLA, failure to examine real options subjects the leasing process to substantial litigation risk. In addition, the bid adequacy process should be reformed to account for real options as well. While bid adequacy has been subject to somewhat less judicial scrutiny, the "fair market value" requirement does create a legal hook for challengers. To maximize the economic value of public resources, real options analysis should be undertaken both at the planning stage and, later, to evaluate the lease auction prices at particular tracts.[275]

The first Section in this Part provides some rough estimates of the extent of real options value, which can be quite substantial, especially for tracts that are only marginally

275. The structure of the leasing program with subsequent oversight over individual lease sales is meant to give DOI some "flexibility" while still ensuring that "[t]he Secretary . . . make[s] a good-faith effort to balance environmental and economic interests" during the planning process. Natural Res. Def. Council v. Hodel, 865 F.2d 288, 309 (D.C. Cir. 1988). A similar structure is used under the NEPA when programmatic and site specific analysis is broken into separate tiers. *See* 40 C.F.R. § 1508.28 (2012) (Council on Environmental Quality regulation for implementing NEPA).

profitable at current prices. The Second section discusses litigation risks that DOI faces if it fails to consider option value. The third Section discusses the legal reforms that are necessary to appropriately examine option value and minimize the potential for successful litigation.

A. The Stakes in Option Value

While calculating option value is extremely important for setting economically rational extraction policy, it will not be a trivial task. As described above, there are several controversial choices that must be made (for example, whether to treat prices as mean reverting or random walk), and a substantial amount of data that must be gathered. During the process, there is no doubt that DOI will need to establish some assumptions as well as exercise its professional judgment. But across the government, when economic analysis of regulatory policies is carried out, there are often substantial gaps in data and controversial judgments that must be made—that is simply part of the process for engaging in rigorous analysis. Governments often must choose polices in the face of uncertainty and with less than perfect information, but cost-benefit analysis forces officials to recognize and characterize those uncertainties and data gaps. This is a process that can be uncomfortable but should ultimately lead to better decisionmaking.[276]

This Article does not include a detailed account of how considering option value would alter the calculus for extraction decisions. Nonetheless, the following discussion provides some basic numerical examples that draw on research that has already been conducted on the economic effects of oil drilling to give a flavor of the stakes involved in option value in the offshore oil drilling context. The takeaway is clear: especially in cases of substantial uncertainty, option value can easily switch a decision from "drill baby drill" to wait-and-see. Failing to account for this fact wastes billions of dollars of potential value and unnecessarily exposes the American public to inefficient environmental risks.

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

276. *See* REVESZ & LIVERMORE, *supra* note 6, at 12–13.

areas.[277] The authors 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, inter alia, 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.[278]

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.[279]

A real options analysis can generate significantly different results. 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 option value.[280] When this estimate is applied to the Hahn and Passell analysis, only a small percentage of the net benefits that they predict would exist.[281] 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.

Davis and Schantz developed an illustration of the option

277. Hahn & Passell, *supra* note 3, at 638. The analysis in the article was previewed in an op-ed in the *New York Times* in September of 2008. Robert Hahn & Peter Passell, Op.-Ed., *Save the Environment: Drill, Baby, Drill*, N.Y. TIMES, Sept. 15, 2008, at A25.

278. Hahn & Passell, *supra* note 3, at 643–45.

279. *Id.* at 638–50.

280. DIXIT & PINDYCK, *supra* note 13, at 401.

281. If the cost of drilling were doubled to take account of the option value, the net benefits predicted would be $68 million, rather than $323 million, nearly an 80 percent reduction. *See* Hahn & Passell, *supra* note 3, at 645.

value based only on price uncertainty.[282] Their results were derived in the late 1990s, from a time of somewhat lower price expectations. The authors assume that the per barrel value of a developed reserve is one-third of the price of oil. They then calculate the threshold price based on the (per barrel) sunk costs associated with drilling,[283] finding that, with average sunk cost at $7.32, the threshold price for oil was roughly $37 per barrel—sale of any lease at less than that price represented a loss. The authors also calculate the losses associated with over-early selling of oil leases, given that private lease holders have incentives to drill before the socially optimal date because of the constraints provided in the lease terms. As prices approach the threshold value, this loss moves towards zero because both private actors and the government would manage the resource the same by choosing to exploit. But at prices that are substantially below the threshold value, there is loss of value that fluctuates between 10 percent and 20 percent of the total value.

The 2010 agency-funded analysis of delaying lease sales also provides some illustration of what the effect could be of using an option value framework.[284] The general expectation is that including option value would result in fewer tracts passing a threshold for immediate leasing. The DOI analysis examined the impact of increasing the minimum bid by five times the current levels. This was not based on any options analysis but gives a sense of the scope of how changes in the minimum bid price might impact lease sales. The DOI analysis found the generally modest effect of slightly decreasing revenues by 1.5 percent and reducing social costs by somewhat less than 1 percent.[285]

Overall, existing analyses tend to show that incorporating option value would change some decisions for some marginal tracts. Especially where the costs of drilling are high or uncertain due to location, difficulty of extraction, or the potential for catastrophic environmental damages, use of

282. Graham A. Davis & Radford Schantz, Selling and Managing Offshore Oil Leases: A Real Options Analysis (revised March 3, 2004) (unpublished manuscript) (on file with author). The authors use a random walk model, which provides higher estimates of option value than the mean reversion model, as discussed above. *See supra* Part I.C.1.

283. These sunk costs are referred to in the oil and gas context as "finding costs." Davis & Schantz, *supra* note 282, at 30.

284. *See* OCS STUDY, *supra* note 264, at iii.

285. *Id.* at 164 tbl.IV-5 (estimating effect of "Higher Minimum Bid").

option value would likely slow down the pace of drilling. But for the easy cases, where the price of oil swamps the costs of extraction, there will be little difference because the benefits of moving forward with lease sales exceeds cost even including lost option value. The benefit of calculating option value is, to a large extent, likely to be in separating those easy cases, where drilling should go forward, from the harder cases where delay has substantial social value.

Empirical analysis of the prices paid for offshore oil leases indicates that private firms seem to have found it worthwhile to invest the necessary resources to analyze option value when making decisions about whether to purchase offshore leases and at what price.[286] Option value helps explain behavior by private actors that would otherwise be puzzling, like purchasing leases that are never used.[287] The evidence that private firms are taking real option value into account "impl[ies] that the government should account for the option to delay, since any uncertainty about future spot prices can drastically increase bonus bids, especially for high-cost tracts."[288]

B. Legal Uncertainty

There are two potential scenarios for uncertainty in the DOI planning process brought about by the failure to examine option value. Under the first, OIRA decides that the leasing plan is an appropriate subject for executive review, an interpretation that is consistent with the governing executive order. In this case, the requirement that a methodologically sound cost-benefit analysis accompany major agency action would subject the DOI process to delay while the Agency attempts to include option value. While there is some degree of discretion within the OIRA review process, and incomplete cost-benefit analyses do sometimes pass OIRA review, impartial application of the guidance documents issued by OIRA as well as standard best practices for cost-benefit analysis would require some attempt to account for option

286. *See generally* MICHAEL H. ROTHKOPF, RADFORD SCHANTZ & LEE UPTON, RUTCOR RESEARCH REPORT NO. 22-2006, OPTIMAL MANAGEMENT OF OIL LEASE INVENTORY: OPTION VALUE AND NEW INFORMATION (2006).

287. *Id.*

288. Leo Lunquist, Evaluating Offshore Petroleum Leases Using Real Option Theory: An Application to the Central Mexican Gulf 18–19 (Spring 2003) (unpublished Bachelor's thesis, Stockholm University) (on file with author).

value.

The second, and likely more important scenario, involves litigation by an outside party. As demonstrated by a thirty-year history of litigation, there is ample opportunity for affected parties to subject DOI to suit. Further, despite the extensive litigation over the DOI planning process, the issue of option value has not been raised, and no court has endorsed the Agency's failure to incorporate option value into its administrative processes.

Both the Section 18(a)(3) cost-benefit analysis and the bid adequacy procedures can be litigated. As discussed above, the court has given extensive attention in several cases to the methodology employed by the Agency in its cost-benefit analysis, and in *Hodel*, the court found that the "elaborate post-bid evaluation of bids on those tracts most susceptible to market failure" was important to the Agency's fulfillment of the Section 18(a)(4) requirement of a "fair market value."[289] Flaws in either the cost-benefit analysis or the bid adequacy process, if not remedied, expose the Agency to legal challenge. Given the more substantial litigation history on the five-year leasing plan process (which includes the cost-benefit analysis), it is perhaps more likely to arise in that context.

In that planning process, the Agency has been given substantial deference, a point the court has emphasized many times.[290] But, that deference is not complete, and courts have vacated the Agency's leasing program twice for failures in the administrative process. That history shows the court's willingness to closely examine the methodologies used by the Agency against the statutory standard.

In particular, the court has found that there is wide deference in how the Agency uses the results of its cost-benefit analysis. Were the Agency to calculate option value and then make a decision to move forward with a lease despite substantial option value, a court may decide not to unsettle that choice. In *Hodel*, the fact that the Agency moved forward with tracts that were not justified by its cost-benefit analysis was less important than the fact that the analysis was done. Even though the Agency had included areas in the leasing program "with a calculated net social value of zero," the court found that this decision "may nonetheless be compatible with

289. Natural Res. Def. Council v. Hodel, 865 F.2d 288, 314 (D.C. Cir. 1988).
290. *See supra* Part III.B.

section 18(a)(3)" because the Agency has the discretion to "tak[e] qualitative factors into account."[291] The court also endorsed the Agency's choice to "not rely on the absolute values of [its] estimates [in the cost-benefit analysis,] but [to] use[ ] them relatively or comparatively to rank the planning areas by groups."[292] From this finding it would seem that, were the Agency to estimate option value, it would retain a large degree of discretion over how it used that information.

> In areas of agency decisionmaking that are highly technical, courts have a tradition of granting especially high levels of deference. In Watt II, discussing the Section 18(a)(3) cost-benefit analysis, the court noted that there are aspects of the analysis which fall within . . . the frontiers of scientific knowledge. The facts used by the [Agency] in performing the analysis are largely predictive in nature, and the methodology utilized was necessarily novel because this type of analysis has not been performed extensively in the past. Thus . . . great deference is afforded to the [Agency] in these areas.[293]

A court may be loath to overrule the Agency's decision on questions like the particular option value formula that is used or how best to estimate parameters like prices or the convenience yield. Evaluating choices like these would require detailed professional expertise that most judges do not have. But, in its current practice, the Agency is not using option value at all, a choice that is easier for a court to review.

The issue of evaluating the possibility of delaying leases was specifically discussed in *Watt I*. The planning document at issue in the case had analyzed the issue of delay by discounting future lease sales to the present value to reflect the time value of money and comparing that loss to any additional value that was realized from increasing oil prices, finding that, overall, there was a cost associated with delay.[294]

The court noted that, "[t]he record thus reflects a model for attributing a cost to delay," and that, "[w]e are reluctant to interfere with an agency's choice of methodology so long as it is

---

291. 865 F.2d at 307.
292. *Id.*
293. California v. Watt (*Watt II*), 712 F.2d 584, 600 (D.C. Cir. 1983)
294. California v. Watt (*Watt I*), 668 F.2d 1290, 1320 (D.C. Cir. 1981) (explaining DOI's reasoning).

not irrational."[295] The court nonetheless questioned the 2 percent rate of increase in oil prices, which it found to be suspect in light of the recent history of oil prices, noting that "[h]igher estimates of future [oil] prices would increase the estimate of the benefit of exploit[ation] . . . in the near future . . . but it also appears to make further delay in exploitation more worthwhile."[296] Even though it granted the Agency broad latitude, the court examined whether the Agency had both justified its technical choices and ensured that the benefits and costs of delay were properly counted.

Currently, the Agency's practice is to disregard option value altogether, so that an entire class of benefits is missing from the Agency's model of delay. This is not a matter of uncertainty around technical aspects of how option value should be calculated. Instead, the Agency has chosen neither to examine option value, nor to provide an explanation for why option value can safely be ignored. In this way, the exclusion of option value is similar to *Center for Biological Diversity* where the Agency was faulted for examining only on shore environmental sensitivity.

A rulemaking by the National Highway Traffic Safety Administration ("NHTSA") on fuel-efficiency that was challenged in the Ninth Circuit and eventually overturned is instructive. In that case, NHTSA conducted a cost-benefit analysis of its proposed rule without including a monetary estimate of the benefits of greenhouse gas reductions. The court found that this failure was arbitrary and capricious. In particular, the court rejected NHTSA's reasoning that "the value of reducing emissions of . . . greenhouse gases [is] too uncertain to support their explicit valuation," finding that "while the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero."[297] It further rejected the Agency's "argument that it placed no value on carbon emissions reduction rather than zero value," noting that the court "fail[ed] to see the difference."[298] The court also noted that NHTSA had not justified its finding that there was a large potential range of value, and that it had "monetized

295. *Id.*

296. *Id.* at 1321. In *Watt II*, the court upheld the agency's determination of a 1 percent rate increase in world prices, based on a more extensive record. 712 F.2d at 601–02.

297. Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin., 508 F.3d 508, 532–33 (9th Cir. 2007).

298. *Id.* at 533.

other uncertain benefits."[299]

In its model of the cost of delay in the Section 18(a)(3) cost-benefit analysis, the Agency fails to account for option value—i.e., the informational value of delay—just as NHTSA had failed to account for the benefits of greenhouse gas reduction. While it might be difficult for a court to evaluate a particular methodology of valuing either of these types of benefits, it is much easier for a court to recognize when an entire class of benefits is entirely missing from the analysis.

In accepting the Agency's model of the cost of delay in *Watt I* and *Watt II*, the court was not presented with the issue of option value. This is not surprising. Both cases were decided in the early 1980s, before the major scholarship in the area of option value in the natural resources context was published. At that time, the Agency could not have relied on the substantial body of scholarship that now exists in support of option value, and challengers would not have been in a position to point to that literature when questioning the Agency's choices. That situation has changed—there is now an extensive literature on the topic that can and should inform the Agency's choices.

The discussion of the cost of delay model focused simply on the question of whether anticipated price increases in oil justified "banking" the resource in the ground. The court's observation about higher future oil prices justifying delayed leasing would be correct even if oil prices were known with certainty—if the price of oil was expected to increase faster than the rate of return for the economy as a whole, then there would be a cost associated with early exploitation because the value of the asset would be increasing faster than the discount rate. Such a situation may be unlikely to hold in the long term, but in the short term, the situation that the court foresees is possible. In any case, this analysis of the benefits of delay is not the same as real option value.

DOI's continued failure to include option value in its calculations exposes the Agency to substantial litigation risk, casting a pall of legal uncertainty over its future lease programs. The court has demonstrated a willingness to examine closely the Section 18(a)(3) cost-benefit analysis. The failure to include option value is not the kind of detailed and technical decision that is given broad discretion. Nor is it the kind of policy choice that a court is less inclined to upset. This

299. *Id.* at 534.

failure goes to the heart of rational decisionmaking and directly conflicts with the Agency's statutory obligations—exactly the kind of flaw that the court has seen fit to address in the past.

The following Section discusses what the Agency can do to remedy this situation.

C. Reforms

To resolve legal uncertainty and better fulfill its statutory mandate, DOI must incorporate option value into its decisionmaking process. There are two stages at which this should be done. First, during the preparation of the leasing program, the cost-benefit analysis should be expanded so that lost option value is acknowledged as a cost of making lands available for immediate exploration and exploitation. Second, the bid adequacy process should be revised to ensure that the American people are compensated for the lost option value associated with the lease.

Currently, DOI simplifies its analysis of costs and benefits by assuming either constant prices or a fixed growth path, and treating extraction costs and environmental risks as fixed values, thereby doing away with uncertainty. These assumptions help reduce the analytic requirements of conducting a cost-benefit analysis, but they result in very substantial biases in the results. These assumptions of certainty about costs and benefits are not simply best guesses about a parameter value, an exercise of professional judgment that is often irreducibly part of cost-benefit analysis. Rather, an assumption of zero uncertainty is known to be wrong—there is *definitely* some uncertainty about future costs and benefits. By basing their models on zero price and cost uncertainty, the analysts are making assumptions that they know to be wrong.

True, incorporating option value into its cost-benefit analysis will certainly require additional steps by the Agency. Several parameter values that are not currently estimated (or which are assumed away) will need to be developed. These estimates include variance on future prices, the convenience yield of oil, and a measure of uncertainty concerning future technological development of spill recovery and drilling technology and the magnitude of risks imposed by the threat of catastrophic failure. Some of these terms will be easier to derive than others.

Still, there is an extensive academic literature on option value, and specific studies of the petroleum context that the Agency can draw on.[300] The Agency can help augment this research by providing funding for future studies and undertaking other activities—such as hosting workshops or creating post-doctoral research fellowship positions to further develop the field. As it becomes a customer of research on option value, the Agency will also create incentives for academics interested in informing public policy to undertake research in this area.

Moreover, interest groups with a stake in the outcome of DOI leasing decisions will likely develop into an additional source of information in the future. Of course, the Agency will have to be wary of potential bias in this information, as industry groups and environmentalists will have incentives to promote studies that most favor their causes. But so long as participation in DOI administrative processes is sufficiently robust so that a range of voices are heard, information generated by interest groups on option value can help augment research carried out by the Agency and independent academics.[301]

Determination of bid adequacy is based on a range of factors, including lease sale prices at other similar tracts, and the sufficiency of participation in the auction process. Unfortunately, neither of these factors is sufficient to ensure that the American public is being compensated for lost option value. Even in a robust auction process with a sufficient number of uncoordinated participants, the private value of the leased property may be substantially lower than the public value, especially when the hosts of uncertainties that affect option value from the social perspective are taken into account. Obviously, lease sales on similar tracts cannot guarantee adequate compensation, if they too failed to take account of the full value that is lost from the public perspective by the lease sale.

To ensure an adequate price, some substantive standard that acknowledges risks from the public perspective and

300. *See supra* note 75.

301. There is a persuasive argument that the participation rules and norms under which agencies like DOI operate help to facilitate a relatively level playing field between interest groups, which helps cancel out some of the natural advantages faced by industry groups. *See generally* STEVEN P. CROLEY, REGULATION AND PUBLIC INTERESTS: THE POSSIBILITY OF GOOD REGULATORY GOVERNMENT (2008).

incorporates option value is needed. While procedural protections may be attractive because they do not require independent judgment by the Agency and help leverage competitive factors in the private market to generate information about correct prices, they cannot provide assurance that the American public is being adequately compensated for lease sales. A substantive standard that incorporates the full range of socially relevant factors, including environmental risks and option value, is necessary.

While it may be relatively easy to identify the necessary reforms to the DOI process, it will take substantial commitment on the part of the Agency to carry them out. Resources will need to be devoted to research, and overhauling these two administrative processes will require time and effort on the part of the Agency. For government agencies already strapped for funds, and with a number of important responsibilities that tax those limited resources, this will represent a significant challenge. But the funding constraints do not mitigate DOI's legal duty to examine the economic factors described in its governing statute or engage in the reasoned decisionmaking requirements of administrative law. The appropriate course of action in the face of resource constraints would be to request a budget increase from Congress, rather than attempt to shirk the Agency's legal obligations.

CONCLUSION

Real option value, which occurs when a decisionmaker faces an irreversible choice and uncertainty about the costs and benefits of available options, exists for many natural resources decisions. In the natural resources context, there is often substantial uncertainty about the price of the resource as well as the environmental costs associated with extraction. Therefore, there will often be a benefit associated with delaying a decision. While there are certainly cases where extraction is justified, even where option value is taken into account, there may also be a number of important cases where consideration of option value will counsel for delay.

The current DOI process used to calculate the costs and benefits of opening areas of the Outer Continental Shelf for oil and gas development fails to take real option value into account. This failure means that the net benefits of exploitation

may not be maximized from the perspective of the American public. In addition, under the OCSLA—the statute that governs offshore development—DOI must take a range of economic considerations into account. By failing to estimate option value and incorporate it into its decisionmaking, the Agency subjects itself to substantial legal uncertainty.

The failure of DOI to recognize option value is mirrored in a substantial gap in the environmental and natural resource literature. While real options have been explored in a range of other legal contexts, and there is substantial economics literature linking real options to environmental questions, scholars in environmental law have not yet explored in detail the consequences of real options for environmental and natural resource decisionmaking. This Article is a first step in addressing this gap.