Is the Deadweight Actually Dead? Real Option Value and Taxation of Oil and Gas

Adi Libson[*]

And both that morning equally lay / In leaves no step had trodden black/
Oh, I kept the first for another day!
-Robert Frost, The Road Not Taken, 1916

ABSTRACT

Analysis of tax policy overlooks an important element—the real option value of the tax. If a tax causes a company to defer an activity with a high probability that the activity will occur in the future when its costs are lower, the tax will provide an economic benefit. Taking into account this real option value will have a substantial impact on one of the key issues shaping tax policy—the analysis of the deadweight loss caused by a given tax. This Article will focus on the taxation of oil and gas, an area where real option value is especially relevant. The Article shows that the optimal tax rate on oil and gas should be higher than under conventional analysis. The Article also sheds light on how this observation about the deadweight loss of taxation is connected to two developing strands in legal scholarship: increasing attentiveness to real option value, and incorporation of dynamic economic analysis into legal policy.

[*] Lecturer, Bar-Ilan University; Ph.D., Bar-Ilan University; LL.M., New York University School of Law; LL.B., Hebrew University; B.A., Hebrew University. I would like to thank Avi Bell, Tsilly Dagan, David Kamin, Michael Livermore, Yoram Margalioth, Jacob Nussim, Gideon Parchomovsky, Arden Rowell, Daniel Shaviro, Eytan Sheshinski, and participants in the Law, Economics and Business Workshop at the Bar-Ilan Law Faculty for their valuable comments. I would like especially to thank Matthew Muma for excellent research assistance. Responsibility for all errors is mine.

I. INTRODUCTION

Most taxes prevent some economic activity from occurring. This effect is viewed solely as a negative effect of taxation,[1] and given an appropriate label—"the deadweight loss of taxation." In this Article I expose how this effect is not necessarily as negative as it would first seem. Preventing an economic activity from taking place may have an inconspicuous positive effect: the possibility that the economic activity will take place in the future under better conditions. I will refer to this beneficial deferral of economic activity as "real option value." A "real option" in this context is the company's ability to control whether to engage in an economic activity now or defer that activity to the future. The term "real option value" was coined by the economists Avinash Dixit and Robert Pindyck, and refers to the value of the ability to wait with an irreversible investment decision due to the expectancy that better information will be obtained in the future.[2]

This observation regarding the value that stems from postponing an investment decision has significant legal policy implications. Although real option value is relevant to the analysis of tax policy in general, it is especially important to the taxation of natural resources, and particularly to the taxation of oil and gas extractions. The constant decrease in the extraction costs of these resources as a result of technological innovation. The expectancy of such a future decrease in costs endows the real option with significant positive value. This Article will thus focus on the taxation of oil and gas, for which there is extensive data showing a constant decrease in costs, but it may equally apply to other types of natural resources.

[1] By "taxation" here I mean taxes aimed at revenue raising. In the case of taxes with a regulatory goal, preventing an activity from occurring is not necessarily a negative effect of a tax; it might be the tax's primary objective. Regarding these two distinctive functions of taxation, see Reuven S. Avi-Yonah, *The Three Goals of Taxation*, 60 TAX L. REV. 1, 3 (2006).

[2] AVINASH K. DIXIT & ROBERT S. PINDYCK, INVESTMENT UNDER UNCERTAINTY 6 (1994).

I will illustrate this point through a numerical example. Suppose that in the state of Resourcia certain indications of oil deposits have been discovered. As a result, the government decides that it is time to determine the proper tax rate on revenue from oil fields to ensure that the state benefits from these discoveries. The government is facing a choice between two tax regimes: in one there is a 50% tax rate, and in the other there is an 80% tax rate. There are two potential oil fields—Field A and Field B. In Field A there is a 90% chance of yielding a net value $800 million; exploring, developing, and producing the oil is projected to cost $50 million. In Field B there is a 50% chance of yielding a net value of $1 billion, and the investment needed to explore, develop, and produce the oil is estimated at $220 million. All of the prospective oil companies are large risk-neutral corporations. Under a 50% tax rate regime on profits, the companies will explore both fields because both have positive expected net value. The expected net value of Field A under such a tax regime is $355 million:

$$(0.9*0.5*800) - (0.1*50)$$

And the expected net value of Field B under such a tax regime is $140 million:

$$(0.5*0.5*1{,}000) - (0.5*220)$$

In contrast, under an 80% tax rate, while Field A will still be exploited due to its positive value of $139 million:

$$(0.9*0.2*800) - (0.1*50)$$

Field B will not be exploited, due to its negative expected value of $10 million:

$$(0.5*0.2*1{,}000) - (0.5*220)$$

The effect of the 80% tax rate on the non-exploration of Field B is the tax's deadweight loss. The consequence of such a tax system is that society loses out on a beneficial economic activity that would have generated an expected net social value of $390 million. Thus the "price" the government is facing for collecting additional expected revenue of $366 million under an 80% rate tax (in comparison to a 50% tax rate)[3] is a social cost of $390 million in deadweight loss. Resourcia's government has two options if it is not willing to bear such costs in exchange for the additional revenue. The first option would be to opt for an alternative tax mechanism capable of raising the same

[3] Under an 80% tax rate the government's take increases to $976 million, from $610 million under a 50% tax rate. *See infra* Table 1. I assume in this example that the companies' losses, in the event no oil is discovered, are not deductible—i.e. that this is the only project the companies are running in the country, or that all other projects are losing money and the companies have no profits to deduct from, thus there is no loss for the government in case no oil is discovered. *See infra* Part VII.B.

revenue with less deadweight loss. The second would be to decide that the public goods it intends to provide with the extra $366 million are not worth the cost, and thus reduce the amount of public goods accordingly. Table 1 summarizes this example. All figures are in millions of dollars.

Table 1

	Net Profits from Field A	Net Profits from Field B	Government Take	Deadweight Loss
50% tax rate	355	140	610	0
80% tax rate	571	(10)	976	390

In this Article I will argue that the actual deadweight loss is, counterintuitively, lower than in the calculations above. As a result, it is possible that Resourcia should still opt for the 80% tax rate, even if there is an alternative tax mechanism that can raise the additional revenue with a deadweight loss lower than $366 million.

Current analysis of the effect of taxation on gas and oil production overestimates the deadweight loss of taxation. As a result, it prescribes suboptimal tax rates on gas and oil production. Specifically, conventional analysis does not fully take into account the strong possibility of a reduction in the costs of exploration, development, and production of oil and gas that stems from technological progress. Such technological advances, however, have a significant impact on the deadweight loss of taxation for oil and gas. Even if in the short run a given tax rate might prevent additional explorations, discoveries, and production, in the medium run there is a high likelihood that the exploration and production will still take place. The expected reduction in exploration and production costs due to technological innovation will turn such explorations into profitable activities even under the higher tax rate. The value that such an expectation generates—the opportunity to explore, develop, and produce gas and oil in the future, when the activity will probably be more valuable even if it is not profitable in the present—is what I label "real option value."

In the example above, taking into account a 20% probability that the costs will decrease by 60% in the future changes the picture. Even if in the short run—t_1—Field B will not be developed, there is a 20% chance that it would be developed in the medium run—t_2. Under such a scenario there will still be deadweight loss from postposing the production due to the time value of resources: possessing the resources later in t_2 is worth less than having them now in t_1. There will, however, also be a surplus from waiting to develop due to the reduction in costs.[4] The actual social value of such a scenario depends on the relationship between the discount rate of the future value of the resources and the rate of the reduction in cost. Let us assume that, due to the time value of resources, the present value of the resources extracted in t_2 would be 10% lower than in t_1, but that the costs would decrease by 60%. Under such a scenario, the value of exploration of Field A in t_2 would be $69.2 million, and it would be explored:

$$0.2*0.5*(1000+0.6*220) – 0.5*0.4*220$$

The term on the left side is the expected benefit from the exploration: a 50% probability that the $1.132 billion net value of resources would be discovered in t_2, multiplied by the after-tax profits (0.2). The net value has increased from $1 billion because of the 60% decrease in costs. The term on the right is the expected cost, which would constitute only 40% of the costs of exploration in t_1. The overall deadweight loss of the 80% tax would decrease to $297 million when taking into account the real option value of production in t_2:

$$0.8*390 – 0.2*(132-50)*10/11$$

The term on the left is the expected deadweight loss if the technological innovation does not take place. The term on the right is the expected surplus if the technological innovation does take place. The reason for the minus sign is that if the technological innovation does take place, postponing production to t_2 generates a surplus and thus reduces the deadweight. While postponing production decreases costs by $132 million (0.6*220), it decreases by $50 million the expected value due to the time value of resources (500*0.1). In order to convert this net surplus from postponing production and reducing future costs to present value terms, the expression is multiplied by 10/11.

The decrease in the deadweight loss by $97 million might turn the 80% tax rate to an attractive tax regime. Let us assume that the deadweight loss of the alternative tax mechanism for raising the same revenue is $320 million. Under the traditional analysis of deadweight loss, an 80% tax would seem inefficient: it would have generated a higher deadweight loss for the same revenue. In contrast, under the analysis that took into account the real option value of not developing the tract in t_1, the 80% tax seems efficient: the assessed deadweight loss

[4] This possibility is not essential for the argument of the Article; it is sufficient that real option value will reduce the deadweight loss. It does not require that production in the future will be of higher value than production in the present. For a discussion regarding the likelihood of such a possibility, see *infra* Part IV.

is lower than that of an alternative tax mechanism. This would be true for any alternative tax mechanism with a deadweight loss between $297 and $390 million. While under the traditional analysis an 80% tax rate on gas and oil would be inefficient compared to such alternatives, under the analysis that takes into account the real option value generated by the tax, such rates would seem efficient.

The real option value that a tax generates stems from adding a dynamic element into the economic analysis of the effect of a tax, in contrast to the static economic analysis that underlies the conventional account of deadweight loss. The dynamic analysis is more sensitive to how the exogenous economic circumstances evolve over time, and reveals that the deadweight loss of the tax is coupled with a possible benefit—the possibility that the economic activity that the tax prevents in the present will take place in future. In a world without the tax, the economic activity would have taken place in the present and thus the option of producing the oil at lower cost would not exist.

Part I of this Article lays out the legal framework for taxation of oil and gas, and the processes and considerations of government agencies that determine the appropriate tax rate. Part II presents the general concept of real option value and its relevance to oil and gas taxation. Part III of this Article demonstrates how real option value fits into the basic economic model by which the optimal tax rate on oil and gas should be determined. Part IV substantiates the claim that there is a strong probability of a future decrease in the cost of exploration and production in the oil and gas sectors. Part V attempts to provide an account for why real option value has been overlooked. Part VI discusses several potential problems with my argument: the possibility of realizing the real option value of exploration in the present, the possibility of setting up an oil and gas tax regime with no deadweight loss, and the possibility of the forecasts for future decreases in costs being erroneous. I conclude the Article by arguing that even though there are significant caveats in the analysis presented in this paper, taking the dynamic element of real option value into account is preferable to the current static approach.

II. THE LEGAL FRAMEWORK AND PRACTICE OF GAS AND OIL TAXATION

In the United States, taxes on oil and gas extraction activity consist of the standard corporate tax[5] in addition to royalties, rents, and "bonus bids"—the lump sum payment companies make in an auction for leasing a particular tract.[6] The royalty rate differs between offshore tracts and onshore tracts. Offshore extractions are taxed at a rate of 18.75%, while onshore extractions are taxed at a rate of 12.5%. The reason for this difference is not economic, but legal. The statute providing the Secretary of Interior with authority to set the royalty rate on offshore leases is the Outer Continental Shelf Act,[7] which provides the Secretary flexibility in setting the rate. In contrast, the rate for onshore extractions is controlled by the Mineral Leasing Act, which requires that the rate be set by Department of the Interior regulations.[8] Revising regulations is a much more complex task, and thus the Secretary of Interior has less flexibility in determining the rate for onshore extractions.[9]

The revenue the government collected from these direct payments for development of resources reached $9.7 billion in 2012. The lion's share of this revenue—87%—stemmed from royalties ($8.5 billion). Bonus bids are the source of 10% of this sum ($946 million) and rental fees are the source of 3% of this sum ($273 million).[10] While this overall sum seems like a significant source of revenue, it is only a small portion of the revenue companies have received from the sale of

[5] Unlike most other OECD countries, there is no special tax rate in the United States for profits from natural resources. Such profits are taxed at the same rate as other sources of income: up to 35% of corporate profits and 39.6% of profits of individuals and pass-through entities. *See* 26 U.S.C. §§ 11(b)(d), 1(a)(2) (2014). The effective tax rate is even lower than the standard tax rate on revenues. The tax code provides generous rules for expensing and deducting expenses incurred in the production of natural resources, such as the percentage depletion allowance that enables gas and oil producers to deduct 15% of their gross income. As a result the cumulative depletion could exceed the amount of capital the taxpayer spent on acquiring the property. *See* 26 U.S.C. § 613 (2014).

[6] 43 C.F.R. § 3120.1-1 (1988).

[7] 43 U.S.C. § 1337 (2014).

[8] 30 U.S.C. § 181 (2014).

[9] The Secretary of the Interior is in the process of increasing the royalty rate for onshore extractions. In response to a report of the Government Accountability Office, which recommended increasing the royalty rate for onshore extractions, the Department of the Interior claimed that such a change in regulation would take a long period of time due to the requirement of going through notice-and-comment rulemaking, which takes one to two years. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-14-50, OIL AND GAS RESOURCES: ACTION NEEDED FOR INTERIOR TO BETTER ENSURE A FAIR RETURN 17–18 (2013), *available at* http://www.gao.gov/assets/ 660/659515.pdf.

[10] *Reported Revenues by Category for FY2012*, OFFICE OF NATURAL RESOURCES REVENUE, *available at* http://statistics.onrr.gov/ReportTool.aspx (last visited Apr. 14, 2015).

oil and gas produced from federal land and waters, which was $66 billion.[11] The amount of revenue raised, and the proportions provided by the different sources of income, have remained more or less constant since 2005 with the exception of FY 2008. Due to a staggering increase in energy prices the revenue doubled in 2008, and the amount raised from bonus bids jumped from the multi-year average of 10% of the total revenue to over 50% of the total revenue ($9 billion).[12]

The Government Accountability Office has already criticized the suboptimal taxation of gas and oil extractions. In its 2007 report it pointed out that the overall government take—the aggregation of all forms of taxes and royalties that apply to gas and oil producers—from federal waters such as the Gulf of Mexico is approximately 41–45%.[13] This rate of government take is one of the lowest in the world,[14] much lower than Norway with a government take of 76%,[15] and even lower than the United Kingdom with a government take of 52%.[16] Since the report the government take has increased, due to an increase in royalties on offshore extractions by 6.25% (from 12.5% to 18.75%). But according to recent OECD data the U.S. government take from deep-water oil extractions is only 51%, still far below Norway which has remained around the same level—75% and even the United Kingdom with a 51.5% government take. The government take on extractions

---

[11] *Supra* note 9, at 1.

[12] Irena Agalliu, *Comparative Assessment of the Federal Oil and Gas Fiscal System*, BUREAU OF OCEAN ENERGY MGMT. 8 (2011), *available at* http://www.energy.senate.gov/public/index.cfm/files/serve?File_id=d174971c-4682-4d96-b194-a85fa2b86774.

[13] U.S. GOV'T ACCOUNTABILITY OFFICE, OIL AND GAS ROYALTIES: A COMPARISON OF THE SHARE OF REVENUE RECEIVED FROM OIL AND GAS PRODUCTION BY THE FEDERAL GOVERNMENT AND OTHER RESOURCE OWNERS 4–5 (2007), *available at* http://www.gao.gov/assets/100/94953.pdf [hereinafter GAO REPORT]. In most states there is an additional severance tax that applies to the net value of production and ranges from 3% (Utah) to 15% (Alaska). For survey of tax rates in different states, see Ujjayant Chakravorty, Shelby Gerking & Andrew Leach, *State Tax Policy and Oil Production: The Role of the Severance Tax and Credits for Drilling*, *in* U.S. ENERGY TAX POLICY 305–37 (Gilbert E. Metcalf ed., 2009), *available at* http://www.americantaxpolicyinstitute.org/pdf/energy_conference/chakravorty-gerking-leach.pdf.

[14] GAO REPORT, *supra* note 13, at 4–5.

[15] *Id.*

[16] *Id.* It should be noted that although the GAO report is based on the summary of four studies, which all have approximately the same numbers, Daniel Johnston claims that in the case of the U.S. the government take is actually much higher, around 70%. According to Johnston, these studies do not take into account the price the U.S. charges for leasing land, which is one of the highest in the world per-acre, and the "bonus bid" mechanism through which the U.S. captures a substantial portion of the rent of the production of natural resources and raises $65 billion in revenue. *See* Daniel Johnston, *Changing Fiscal Landscape*, 1 J. WORLD ENERGY & BUS. 31, 49–50 (2008).

from the shelf is higher, at around 57%.[17] Given the economic attractiveness of the American fields, due to their proximity to the American market and the relatively low expenses for the mobilization of the extracted resources, the U.S. government take still seems far too low.[18]

The discussion between the different agencies on the optimal royalty rate is especially interesting, because it reveals the on-the-ground reasoning behind the rate. It stands in contrast to political decisions regarding the income or corporate tax rate. Because these decisions are made by Congress and not by executive agencies, the outcome is primarily a factor of political economy considerations, and is not expected to mirror optimal tax policy. In the case of royalties in which an executive agency is in charge of deciding the rate, optimal tax policy considerations dominate the process, along with other "pure" policy considerations such as environmental and distributive effects. While legal scholarship demonstrates how even governmental agencies could be captured by private interests,[19] governmental agencies are relatively more insulated than the legislature from such

---

[17] OECD ECONOMIC SURVEYS: NEW ZEALAND 2013, AVERAGE GOVERNMENT TAKE IN OIL AND GAS FISCAL REGIMES 31 (2013), *available at* http://www.keepeek.com/Digital-Asset-Management/oecd/economics/oecd-economic-surveys-new-zealand-2013/average-government-take-in-oil-and-gas-fiscal-regimes_eco_surveys-nzl-2013-graph21-en#page1 (last visited Jan. 21, 2014). This increase seems to be part of a general trend in those years in which many other countries also increased the government take after energy prices peaked in 2008. The trend has reversed in many of the countries after the deep decline in energy prices after 2008. *See* Agalliu, *supra* note 12.

[18] GAO REPORT, *supra* note 13, at 7.

[19] For a description of the ascendance of "capture theory," and the transition from the belief that executive agencies are the "transmission belt for implementing legislative directive" to the belief that agencies are dominated by the regulated industries, see Richard B. Stewart, *The Reformation of American Administrative Law*, 88 HARV. L. REV. 1669, 1675 (1975). For an overview of more modern versions of "capture theories," see Nicholas Bagley & Richard L. Revesz, *Centralized Oversight of the Regulatory State,* 106 COLUM. L. REV. 1260, 1285 (2006) (describing a shift in the conceptualization of capture, from a focus on the pressure of regulated industries on committee members overlooking the agency to cooperation with the agency in providing it with information and guidance). The growing awareness of agencies' inclination to be "captured" by interests of regulated industries brought legal scholars to focus on the means by which agencies could be protected from capture, especially their independence from the political sphere. *See* Paul Verkuil, *The Purposes and Limits of Independent Agencies*, 1988 DUKE L.J. 257, 259–60 (1988); Marshal Berger & Gary J. Edles, *Establishing the Practice; The Theory and Operation of Independent agencies*, 52 ADMIN. L. REV. 1111, 1113 (2000); Daryl Levinson & Richard Pildes, *Separation of Parties, Not Powers*, 119 HARV. L. REV. 2311, 2376–77 (2006); Neal Devins & David E. Lewis, *Not-So Independent Agencies: Party Polarization and the Limits of Institutional Design*, 88 B.U. L. REV. 459 (2008); Rachel Barkow, *Insulating Agencies: Avoiding Capture Through Institutional Design*, 89 TEX. L. REV. 15 (2010).

interests.[20]

When observing the considerations both the Department of the Interior and the Government Accountability Office are taking into account, one finds that they primarily focus on the revenue forgone due to the decrease in the amount of leases as a result of an increase in the royalty rate. They balance this loss against the increase in revenue from the remaining leases. The decrease in the amount of leases is what is labeled in economic jargon as the tax's "deadweight loss."

These considerations are reflected both in the reports of these governmental agencies and their internal discussions. The Governmental Accountability Office report mainly focuses on the comparison of the U.S. government take from oil and gas extractions to those of other countries. The report makes reference to the considerations that the DOI's representatives have raised in determining the royalty rate, which centered on balancing between increasing revenue on the one hand and decreasing output on the other. The decrease in output is referred to as a "net-cost" of raising the royalty rate:

> Interior's analysis included estimates for increasing royalty rates beyond 18.75 percent. Specifically, it estimated that royalty rate increases from 18.75 to 21.875 percent would cause production losses of 2 to 6 percent with royalty revenue increases of 11 to 17 percent. According to the analysis, the effect of increased royalty rates, depending on the size of the change, would be less production, but with the potential for higher revenues from royalties in the future. Interior found that a large increase in the royalty rate could curtail expected returns to lessees to such a large extent that it might unduly reduce leasing and future production by proportions greater than suggested in its analysis. Much higher royalty rates could also curtail production from new leases in the future as production declines in the later phases of a lease's productive life.[21]

The decrease in output as a result of the increase in the royalty rate is referred to as a "loss." There is no discussion regarding the possible

[20] *See* Peter H. Aranson et al., *A Theory of Legislative Delegation*, 68 CORNELL L. REV. 1, 55–63 (1982) (claiming that delegation from legislators to professional bureaucratic officials stems from strategic efforts to "duck" decisions that would displease interests groups); Jerry L. Mashaw, *Prodelegation: Why Administrators Should Make Political Decisions*, 1 J.L. ECON. & ORG. 81, 91–95 (1985) (arguing that delegating political decisions to the expertise of bureaucrats enables the legislature to get "more policy bang for its legislative buck").

[21] *Supra* note 9, at n.26.

economic upsides of a decrease in output.

A similar cost-benefit analysis by the Department of the Interior is also reflected in its analysis of an increase in the rental rates of tracts. The DOI juxtaposes the increase in revenue with an approximation of the number of tracts that would not be leased as a result of such an increase (5 tracts), which is treated as a net loss.[22] There is no mention of the possible upside of postponing production that might curtail the costs.

This approach is not limited to the brief description of the cost-benefit analysis of the DOI in the GAO report. It is also reflected in third party studies that the DOI has invited and on which its policy is based. The DOI's Bureau of Ocean Energy Management has invited a study from Economic Analysis, Inc. and the Marine Policy Center, entitled "Policies to Affect the Pace of Leasing and Revenues in the Gulf of Mexico." This report has also not addressed the possible upsides of decreasing the pace of leasing, aside from the environmental advantages. It too has assumed that a decrease in leasing will reduce revenues, without factoring in the possible impact of technological progress on the cost of future extractions.[23]

My argument in this Article is that there is an additional factor which is not taken at all into account in determining the optimal tax rate or royalty rate on oil and gas extractions. This is the real option value of extracting the resources in a later period. The main reason that such an option has positive value is due to the strong likelihood that the costs of extracting the resources will decrease significantly due to technological progress. As I have demonstrated above, none of the governmental agencies determining the royalty rate have taken this factor into account in any way. In the next section, I will delineate what the real option value is and how it relates to the economic analysis of oil and gas taxation.

III. REAL OPTION VALUE AND OIL AND GAS TAXATION

The real option value in the natural resources sector is of significant economic magnitude. In recent years many countries, especially the United States, have discovered significant amounts of

[22] *Id.* at 15.

[23] ECONOMIC ANALYSIS, INC. & MARINE POLICY CENTER, FINAL REPORT: POLICIES TO AFFECT THE PACE OF LEASING AND REVENUES IN THE GULF OF MEXICO, OCS STUDY BOEMRE 2011-013, at 26 (Aug. 2009), *available at* http://www.boem.gov/BOEM-Newsroom/Library/Publications/2011/2011-013-Part1.aspx.

natural resource reserves, especially shale gas[24] and shale oil.[25] On the one hand, the deficits in the national budgets of many of these countries, in addition to the high energy prices in 2006–2008, intensified their motivation to tax the extraction of these resources to their highest ability.[26] On the other hand, due to the increasing likelihood that additional reserves might be discovered, these countries wanted to avoid the deadweight effect of a tax on natural resources: tax rates that might deter companies from further exploration and production.[27]

Recent legal scholarship has raised awareness of option and real option value. In many fields it has been claimed that the existence of option value is overlooked and not taken into account by policymakers, legislators, and legal scholars. Ian Ayres has discussed option value in the context of legal entitlements in general.[28] Joseph Grundfest and Peter Huang use option value in the field of litigation behavior to provide an account of why certain lawsuits aren't settled as early as the conventional model prescribes.[29] In the field of bankruptcy, Douglas Baird and Edward Morrison claim that the option value that

---

[24] For projections of the future increase in production of shale gas, see *infra* notes 81–83 and accompanying text.

[25] *See* Leonardo Maugeri, *The Shale Oil Boom: A U.S. Phenomenon* 1–10, 18–24, (The Geopolitics of Energy Project—Harvard Kennedy Sch. Belfer Ctr., Discussion Paper #2013-05, 2013), *available at* http://belfercenter.ksg.harvard.edu/files/USShaleOilReport.pdf. Maugeri notes that in 2012 out of 6.44 mbd of crude oil, 1.14 (17.7%) is tight and shale crude oil. It is projected that by 2017 the tight and shale crude oil will reach almost 50% of all crude oil produced—5 mbd, out of an increased total of 10.4. *See id.* at 19. The reason why the technology of shale extraction had a much greater impact in the United States than in other countries is primarily due to the fact that shale extraction is highly drilling intensive, and 60% of rigs are located in the U.S. In addition, in the U.S. most shale fields are not located in densely populated areas. *See id.* at 1–2.

[26] The United States has increased the royalties rate in the Gulf of Mexico in both deepwater and the shelf (*see supra* Part II) and increased rental rates in 2009 from $7.50 per acre to $11–$44 in deepwater, and from $5 to $7–$28 in the shelf, *see* Agalliu, *supra* note 12 at 280. China introduced both a 74% windfall profit tax for when crude oil prices exceed $40 per barrel, and a 5% export duty. *Id.* at 274. In 2007, India increased the rate of the Minimum Alternate Tax from 7.5% of book profits to 10%. *Id.* In 2006, the United Kingdom increased the rate of the special petroleum tax from 10% to 20%, and in 2011 it raised the rate to 32%. *Id.* at. 279–80.

[27] Canada (Alberta) is a classic example of such a dynamic. In 2007 the government increased royalties from 30% to 50%. *Id.* at 272. After a decline in drilling activity it suspended the 2007 royalty framework and instated a lower royalty rate—up to 40% on oil and 36% on gas. *Id.*

[28] *See generally* IAN AYRES, OPTIONAL LAW: THE STRUCTURE OF LEGAL ENTITLEMENTS (2005).

[29] Joseph A. Grundfest & Peter H. Huang, *The Unexpected Value of Litigation: A Real Options Perspective*, 58 STAN. L. REV. 1267, 1275 (2006).

accompanies chapter 11 bankruptcies incentivizes parties to withhold information and thus makes chapter 11 less efficient than a mandatory auction.[30] Jacob Gersen and Eric Posner use option value to shed light on the undervaluation of the timing of legislation and regulation in the fields of administrative law and legislation.[31] Lee-Anne Fennel suggests using self-made options to mitigate the problem of unknown subjective valuation in the context of liability and property rights.[32] Lynne Hold, Paul Sotkiewicz, and Sanford Berg utilize an option value model to assess the uncertainty that a nuclear plant developer faces in the field of risk regulation.[33]

The most relevant application of real option value to legal policy to the one discussed in this Article is Michael Livermore's study of real option value in the context of the regulation of natural resources.[34] Similarly to the point raised above, Livermore refers to the real option value that accompanies non-exploration. Livermore concentrates on the application of this point to the regulation of the allocation of lease rights for exploration of natural resources through auctions.[35] His main argument is that the government does not internalize the option value that accompanies non-exploration, and as a consequence sets the lease price for exploring fields too low.[36] While Livermore does touch on the real option value that stems from uncertainty regarding extraction costs, he primarily focuses on the environmental social cost as a source of real option value.[37] Furthermore, Livermore emphasizes the real option value of reducing uncertainty by waiting. In this Article, I do not claim that waiting generates real option value *per se*; real option value exists when there is a *positive* expectation of an increase in value, otherwise waiting might generate *negative* real option

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

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

[32] *See* Lee-Anne Fennell, *Revealing Options*, 118 HARV. L. REV. 1399, 1402–07 (2005).

[33] *See* 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 (2008).

[34] *See* Michael A. Livermore, *Patience is an Economic Virtue: Real Options, Natural Resources and Offshore Oil*, 84 U. COLO. L. REV. 581 (2013).

[35] *Id.* at 585.

[36] *Id.* at 585–86.

[37] *Id.* at 605–13. Livermore touches technological development only briefly, as one dimension among three that account for the uncertainty of deep-water ocean drilling. The other dimension besides environmental and social costs is the price dimension of the natural resource.

value.[38] In this Article, I explore the relevance of overlooking the real option value of non-exploration to the analysis of taxation in general, and to the royalty rate of oil and gas exploration in particular. In addition, I will elaborate in Part III[39] on the main source of the positive option value that accompanies the non-exploitation of a field: the high probability of future technological progress that will reduce the costs of exploration, development, and production of oil and gas.

An additional study examining the application of real option value to the legal context is Jeff Strnad's study, which examines the relevance of real option value to the context of natural resource exploration and production and its impact on tax policy.[40] Strnad's primary concern is finding the optimal tax mix within the natural resources sector and reducing the distortionary effect of taxation on the decision which projects are pursued in the natural resources sector.[41] However, Strnad overlooks the most significant effect of real option value on the taxation of natural resources—its impact on the overall deadweight loss of taxation, and as a consequence on the optimal tax rate on natural resources. My goal in this Article is to explore this significant feature of option value. In contrast to Strnad, this Article does not go into internal questions of taxation on natural resources such as the appropriate mechanism through which natural resources should be taxed: royalties or taxation of the economic rent through a tax on profits. Rather, it is concerned only with the overall government take (GT) from revenues stemming from natural resources, and not with the elements that comprise the GT.[42] Strnad is concerned with the "internal deadweight" effect resulting from the structure of taxes on natural resources—their distortionary effect

---

[38] I will demonstrate my critique that waiting does not *per se* generate real option value by focusing on Livermore's third dimension of uncertainty: price uncertainty. Passing time doesn't resolve the uncertainty concerning the price. We may have information regarding the price in the period to which we postponed exploration, but we have added uncertainty concerning the price in the additional unit of time that has become relevant due to the postponement of the exploration (e.g., if we have postponed production from 1990 to 1991, and the price that is economically relevant is the price in the subsequent 20 years after the time of exploration, we may have information regarding the price in 1991 that we wouldn't have if we didn't postpone production, but we have added uncertainty regarding the price in 2021 that would have been irrelevant if we had not postponed production).

[39] *See infra* Part V.

[40] Jeff Strnad, *Taxes and Nonrenewable Resources: The Impact on Exploration and Development*, 55 SMU L. REV. 1683 (2002).

[41] *See id.* at 1686–91.

[42] *See* Johnston, *supra* note 16, at 38–39 (discussing a comparative study of government take from oil profits in different countries).

within the natural resources sector.[43] In contrast, the concern in this Article is with the "external deadweight" effect of taxes—the distortionary effect of taxes on the levels of economic activity in the market as a whole; the mix between the taxation on natural resources and other sources of revenue. This, of course, depends on the analysis of the deadweight loss of taxes on natural resources in comparison to the deadweight loss of other forms of taxation.

This Article will also shed light on how the neglect of real option value is connected to a more general problem in legal scholarship: it is too focused on static economic analysis and overlooks significant implications that stem from dynamic elements.[44]

Deadweight loss is one of the central considerations in designing an efficient tax mechanism, and analysis of deadweight loss has generated many implications for tax law. In their argument for a consumption tax, Bankman and Weisbach have emphasized the importance of levying taxes on goods with low elasticity rather than goods with high elasticity. The effect of taxes on behavior is weaker for low elasticity goods, and as a result the deadweight loss is more limited.[45] Terrence R. Chovart has justified imposing a second tax on corporate income by arguing that it triggers a weak response and, thus, has a minimal deadweight effect.[46] Daniel Shaviro has argued that rules identifying the realization of income should bend toward realization in cases of inelastic transactions to minimize deadweight loss.[47] In the same vein, Deborah Schenck has illuminated the effect of realization rules on marginal income elasticity, and how realization rules that decrease income elasticity reduce the deadweight loss of taxes.[48] David Schizer has claimed that to minimize deadweight loss, the tax system should discriminate between actors with inelastic preferences and actors with elastic preferences.[49] In this Article, I address the computation of the deadweight loss of a tax, and expose how the conventional analysis of deadweight loss misses a significant

---

[43] *See* Strnad, *supra* note 40. Strnad's main concern is with whether a given tax meddles with the pre-tax ranking of projects to be pursued.

[44] *See infra* Part 0

[45] *See* Joseph Bankman & David A. Weisbach, *The Superiority of an Ideal Consumption Tax over an Ideal Income Tax*, 58 STAN. L. REV. 1413, 1420 n.10 (2006).

[46] Terrence R. Chorvat, *Apologia for the Double Taxation of Corporate Income*, 38 WAKE FOREST L. REV. 239, 255 (2003).

[47] Daniel N. Shaviro, *An Efficiency Analysis of Realization and Recognition Rules Under the Federal Income Tax*, 48 TAX L. REV. 1, 4 (1992).

[48] Deborah H. Schenk, *An Efficiency Approach to Reforming A Realization-Based Tax*, 57 TAX L. REV. 503, 504–07 (2004).

[49] David M. Schizer, *Sticks and Snakes: Derivatives and Curtailing Aggressive Tax Planning*, 73 S. CAL. L. REV. 1339, 1353 n.47 (2000).

element that may decrease the estimated overall deadweight loss. One of the main implications of this analysis is that the tax rate on natural resources should be higher than it normally is under the conventional analysis and, thus, that taxes on natural resources should be a more significant element in the general tax mix.

Needless to say, tax policy is guided not just by efficiency considerations, but also by political and fairness considerations.[50] While in many cases concerns over efficiency considerations run counter to these other considerations, perhaps fairness in particular,[51] the efficiency consideration of taking real option value into account actually furthers fairness considerations. One of the most common fairness claims is that states should increase tax rates on natural resources because resources belong to the public at large and, thus, the public should be the primary beneficiary of any revenue generated. The state's claim to its resources is based on its "birthright to the natural heritage of the state."[52] Taking real option value into account thus furthers the goal of fairness by increasing the tax rate on revenues generated from the production of natural resources.

IV. FITTING REAL OPTION VALUE INTO THE ECONOMIC ANALYSIS OF OIL AND GAS EXPLORATION AND PRODUCTION

In general, optimal taxation is defined by the tax allocation that minimizes the deadweight loss of taxation, given the amount of revenue that the government is interested in collecting and its distributive choices.[53] The deadweight loss of a tax is a computation of a tax's social cost due to its distortionary effect on taxpayers, who alter their behavior in response to the tax and so eliminate mutually beneficial transactions that would occur in a tax-free world.[54] The deadweight loss thus equals the total surplus the two sides would have incurred from the transactions that did not take place due to the tax imposed.

---

[50] LIAM MURPHY & THOMAS NAGEL, THE MYTH OF OWNERSHIP 3–4 (2002).

[51] *See, e.g.*, Barbara Fried, *The Puzzling Case for Proportionate Taxation*, 2 CHAP. L. REV. 157, 168 (arguing that scholars supporting proportionate taxation on fairness grounds pay a price in terms of efficiency because proportionate taxes are not an optimal pricing solution for public goods).

[52] *See* Walter Hellerstein, *Political Perspectives on the State and Local Taxation of Natural Resources*, 19 GA. L. REV. 31, 34 (1984).

[53] *See* Agnar Sandmo, *Optimal Taxation: An Introduction to the Literature*, 6 J. PUB. ECON. 37 (1976).

[54] *See* Alan J. Auerbach, *The Theory of Excess Burden and Optimal Taxation*, *in* 1 HANDBOOK OF PUBLIC ECONOMICS 61, 67 (Alan J. Auerbach & Martin Feldstein eds., 1985).

The existence of deadweight loss in and of itself does not mean that the tax is inefficient. Almost all taxes cause some deadweight loss. The tax is inefficient only if the same amount of revenue could have been raised through an alternative tax mechanism with a lower deadweight loss effect.[55] Thus, in order to fully determine whether a certain tax is optimal, one has to know the deadweight loss of an alternative tax that would raise the same revenue. The first step for determining the optimal tax rate is assessing the deadweight loss it creates in absolute terms.

In order to estimate deadweight loss of a tax in the case of natural resources, one must estimate the effect of the tax on the value of the expected profile of extractions. This is one of the uses of the Hotelling Rule. According to the Hotelling Rule, framed by Professor Harold Hotelling, the optimal extraction of a resource will be determined such that the market return on the resource will equal the market return on an alternative investment.[56] If the expected return on the extraction of a marginal resource unit is below the market rate of return on alternative investments, the owner of the resource will prefer to invest the cost of extracting that unit in alternative investments where the return will be higher.

For example, assume the cost of extracting a given unit of a natural resource is $5, and the unit could be sold for $5.20 one year after making the initial investment. Assume the individual could buy a bond that would pay him a 5% interest with the same level of risk as in the extraction activity. Under such circumstances, the individual will not extract the extra unit—she will prefer to invest her money in the bond rather than investing it in extracting the marginal resource unit. While her returns for investing the $5 on the extraction of resources will be $0.20, her returns on investing in the bond will be greater: $0.25. For the previous resource units it may have been profitable for the individual to invest in extraction, since the cost function is increasing to scale and their extraction costs were lower and, thus, provided a higher return for the investment than for the bond. She will, however, extract that additional marginal resource unit only in the future, when the costs of extracting the marginal unit will be lower.

---

[55] *See* Sandmo, *supra* note 53.

[56] *See generally* H. Hotelling, *The Economics of Exhaustible Resources*, 39 J. POL. ECON. 137 (1931).

Given that natural resource stocks are much greater than the amount of natural resources extracted in equilibrium,[57] the Hotelling Rule predicts that the price of natural resources will increase at the same rate as the standard market rate of returns on alternative investments. Given a certain stock of resources, the deadweight loss of taxes on natural investments could be calculated by solving the following equation:[58]

$$DW_s = max_{qt}\left\{B(q_t) - C(q_t, S_t) + \frac{1}{1+r}E_t[V(S_{t+1})]\right\} - max_{qt}\left\{B(q_t) - C^{tax}(q_t, S_t) + \frac{1}{1+r}E_t[V(S_{t+1})]\right\} - T_{pv}$$

DW_s stands for the deadweight loss in the value of a given stock from the imposition of a tax. B(qt) denotes the benefit from the extraction of quantity q of the resource in period t. C(qt, St) is the cost of extracting quantity q in period t, out of the given stock S. C^{tax}(qt,st) is the cost of extracting quantity q in period t including the tax, r is the discount rate based on the market's rate of return on riskless investments, and E_t is the expectation of the value (denoted by V) of the stocks remaining in period t+1.[59] T_{pv} is the present value of the tax payments that would be paid on the production of resources from the stockpile.

According to this equation, the deadweight loss of a tax on a natural resource equals the difference between the pre-tax present value of the profile of extractions and the post-tax present value of the profile of extractions minus the taxes collected.

The problem is that the estimation of the overall deadweight loss caused by a tax on natural resources does not end here. There is an additional element that complicates the calculation of the deadweight loss in the case of natural resources. The deadweight loss is not

[57] This is due to the discovery of new deposits. *See* Jeffrey A. Krautkraemer, *Nonrenewable Resource Scarcity*, 36 J. ECON. LIT. 2065, 2102 (1998).

[58] This equation is based on one of the applications of the Hotelling Rule, noted by Boadway & Keen. They derived from the Hotelling Rule the present value attributed to a given resource stock, which is the expression in the parenthesis both on the right and on the left of the minus symbol in the middle of the equation. From this equation it is very simple to derive the tax's deadweight loss regarding a given resource. It is the present value of the extraction path in a tax-free world, minus the present value of the extraction path given a tax, minus the present value of the taxes collected by the government from the revenues of the resource. *See* R. Boadway & M. Keen, *Theoretical Perspectives on Resource Tax Design*, *in* THE TAXATION OF PETROLEUM AND MINERALS PRINCIPLES, PROBLEMS AND PRACTICE 26 (Philip Daniel & Michael Keen eds., 2010).

[59] This equation is recursive—value of the stock in time t could be determined only after determining the value of the stock in time t+1.

comprised only of the effect of altering the optimal extraction profile of a given stock referred to above. In addition, the tax on natural resources will diminish the amount of new stocks discovered by exploration, further increasing the deadweight of the tax. As explained above, the tax lowers the net profits a firm will receive from discovering a new stockpile of natural resources, and as a result there will be a lower incentive to execute explorations. This is because the lower expected returns may not compensate the firm for the risk involved in the explorations. The Hotelling rule was devised to estimate the optimal extraction path of a given resource. But the deadweight loss of taxes on natural resources is not comprised only of the distortion of the extraction path of a given stockpile. A central element of the deadweight loss is the effect of the tax on whether new stockpiles of natural resources are discovered. As stated above, such an effect will occur even if there is no tax on the exploration phase. Even if the firm is taxed on its rents from production, *ex ante* it will see a lower level of post-tax net profits. The lower level of net profits will lower its incentive to explore new areas for resources. Surprisingly, there is no formal economic model for estimating the deadweight loss caused by taxation on the discovery of additional stockpiles of natural resources.

The absence of a formal model that takes into account the complexities of the relationship between taxation and discovery of additional stockpiles may seriously distort any attempt to assess the deadweight effect of taxes on natural resources. One of the central problems with assessing the deadweight loss of taxes due to eliminating the discovery of additional stockpiles is that one can never be certain regarding the quantity of stockpiles that haven't been discovered. After all, we simply cannot know whether they exist. Although we have no perfect knowledge of the existence of such stockpiles, we do have partial information regarding the expectation that certain stockpiles may be found in certain areas.

If taxation at a certain rate would prevent us from discovering additional stockpiles, the deadweight loss should not equal the full value of the stockpile—the discovery has only increased the subjective likelihood that the stockpile exists. The high likelihood of finding a stockpile does not disappear if a certain tax regime makes it unprofitable to explore whether the stockpile actually exists. Similarly, the value of the expectation of finding a stockpile in a certain location does not disappear even if an exploration to find the stockpile is not pursued. The value of such a stockpile is essentially an option to invest X dollars for a probability P to find the value of Y in natural resources.

In other words, the value of the option to explore in the future whether there is a stockpile of natural resources in a certain site (denoted by O_n) could be described by the following equation:

$$O_n=P*Y-X$$

It is true that this option is worthless if at the expiration date X>P*Y. But it is not correct to deduce that if in the present X>P*Y, it will always be true that X>P*Y. Even if a tax rate may lower the post-tax value of Y, so that the value of P*Y is lower than the costs of exploration, in a dynamic setting where the parameters fluctuate these option may have positive value if P or Y increase or if X decreases.[60]

If there is no real reason to believe that any of these parameters will change, the value of O_n will not be substantial and will be close to 0—the future value will not deviate substantially from the present value of 0. This Article will argue that there are firm grounds to believe that in the future the cost of X will substantially decrease. As a result, even if in the present X>P*Y and, thus, no exploration will take place in such a field, the option O_n is still valuable due to the strong likelihood that in the future X will decrease. While there are strong grounds to assume that P and Y will not change—both the probability of finding a stockpile and the price and value of a resource incorporate information of future changes—X might change substantially. The expectancy of the change in X is based on the expectancy of technological innovations in the future that would reduce the costs of exploration and production. Thus when estimating the deadweight loss of taxes on natural resources, the loss from the non-exploration of the field should be reduced by the benefit of the option to explore the field in the future.[61]

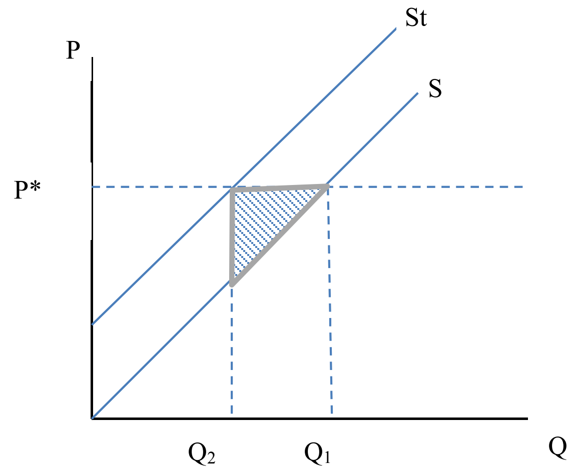
---

[60] Volatility is a significant factor in determining the value of the option according to the Black & Scholes formula for option valuation. *See* SHELDON NATENBERG, OPTION VOLATILITY AND PRICING 51–69 (1994) (discussing the measurement of volatility and its effect on the valuation of options).

[61] The emphasis regarding the expectancy for reduction of cost may seem to stray away from the theory of pure real option value presented by Dixit & Pindyck (*supra.* n. 2). Dixit and Pindyck emphasize the value of waiting *per-se*, without assuming an expectancy for an increase in the value of the underlying asset. Yet also according to Dixit & Pindyck the waiting has to generate a positive expectancy over a certain threshold in order that it would justify postponing the investment (*supra*, at 136-37). The fact that there is some expectancy for obtaining more information by waiting is not sufficient for justifying the waiting. While the waiting generates the benefit of the greater expectancy for valuable information, it also is accompanied by the cost of the time value of resources that is lost by waiting with the investment. Obtaining the product of the investment sooner has greater value than obtaining it later. Thus in order for the waiting to have a net positive value, the value of the positive expectancy the waiting generates has to surpass the time value of resources that is lost.

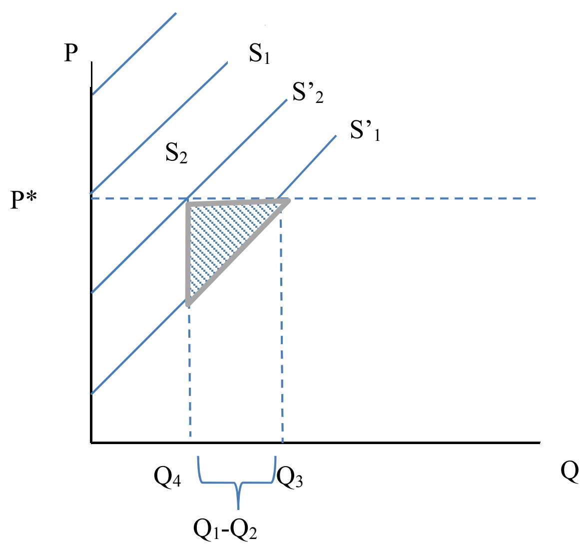
I will clarify this point through a two period model—t_1 and t_2. Graph 1 below describes the deadweight effect of a tax in t_1. The pre-tax supply curve—S—rises as the price increases. The graph S_t signifies the post-tax demand curve. The assumption behind the graph is that the country in which production takes place is a small open economy and, thus, the price that producers face is P*, the world price for each unit of natural resources. Given the tax, the equilibrium shifts from E_1, in which the quantity of resources explored and produced will be Q_1, to E_2, in which the quantity of resources explored and produced will be Q_2. The deadweight loss of the tax is represented by the striped trapeze.

Graph 1 - Deadweight Loss of Tax on Natural Resource in T_1



The equilibrium in t_2, given that technological improvements have reduced costs of exploration and production, is path dependent on whether a tax has been imposed at time t_1, and is described in Graph 2 below. S_{t1} signifies the basic supply curve given that a tax has been levied in both t_1 and t_2. It is similar to the post-tax supply curve in t_1; besides its starting point, production is positive only when the price is above P*. All the natural resource units for which the costs of exploration and extraction were lower than P* have been extracted in $t_{1,}$ assuming an increasing marginal cost function. The supply curve S_2—which applies to a scenario where there were no taxes in t_1 and the taxes have been introduced only in t_2—looks a bit different. It is located a bit higher than S_1—quantity supplied under any price would be lower than the quantity supplied under t_1. The reason for this is that the marginal units that would have been produced if the price was a bit higher than P* under the S_1 curve will not be produced under the supply curve S_2. This is because those units have already been discovered and produced in t_1, when there were no taxes and the cost the producer faced was lower. Thus, the quantity that will be supplied under the supply function S_1 in t_2 will be lower than under the supply function S_2. The maximum gap between the two supply functions S'_1 and S'_2 for the quantity supplied given a certain price is the difference between the production in t_1 with no taxes and the production with taxes.[62] Below, Graph 2 illustrates the maximum possible gap between S'_1 and S'_2. The difference in the quantities supplied under S'_1 and S'_2 (Q_3-Q_4) equals the difference between the quantities produced in t_1 with taxes and the quantities produced in t_1 without taxes. While the difference between Q_3 and Q_4 could be smaller than the difference between Q_1 and Q_2, it cannot be greater.

Graph 2 – Deadweight Loss of Tax on Natural Resource in T_2



It should be noted that if there were no technological improvements, no resource units would have been discovered and produced—the reservation price both under S_1 and S_2 are higher than the given world price of P*. The interesting result is that given

[62] The gap cannot be higher than the gap between production with tax and production without tax in t_1, but could definitely be smaller. This depends on the extent to which the costs of exploration are reduced by innovations in technology. If the reduction of costs is less significant than shown in graph 2, then the supply curve S'_1 will move to the left, and thus the gap between S'_1 and S'_2 in the quantity of production would be less than the gap between pre-tax and post-tax supply in t_1.

technological improvement, the taxes imposed in period t_1 will generate a surplus in t_2 that is signified by the striped triangle. Counterintuitively, in theory, the surplus in t_2 *might* even exceed in the deadweight loss in t_1 and, thus, in total, the taxes imposed in t_1 might surprisingly generate an overall surplus. The reason for this counterintuitive result is that the tax in t_1 postpones exploration and production of some of the units to t_2, in which a significant amount of units are produced for a lower cost.

It is important to emphasize that the argument of this Article is not based on the assumption that the tax in t_1 may generate a surplus by postponing production to a period with lower costs. It is based on a much weaker assertion: the deadweight is *overestimated*. The time value of resources which is lost by postponing production might be greater than the reduction in costs from technological improvement. As discussed above, even if the tax still generates a deadweight loss overall, the fact that it is smaller than estimated without taking the option value into account can have the effect of turning a supposedly inefficient tax into an efficient tax.

Even though the core argument in this Article does not require that the tax generate an overall surplus, such a scenario deserves to be discussed as an interesting *possibility* that stems from the analysis of real option value. Even as a mere possibility, it raises the question: how can it be theoretically possible that the tax generates a surplus? If postponing exploration and production due to the lower expected costs in the future generates a surplus, why wouldn't the private firms postpone exploration and production in order to maximize their private profits in a tax-free world? The theoretical possibility that the tax may generate a surplus relies on the assumption that private firms would not necessarily capture the surplus by delaying exploration and production anyway. Of course, this is a problematic assumption that is not congruent with the assumption underlying classical economic analysis that players will maximize their utility under the conditions of a free market.

Even if there seems to be expected gains from postponing production, there are three possible reasons why private firms would not necessarily postpone exploration or production. The first is due to the economic structure of the lease agreements for the exploration of tracts. After making the highest "bonus bid" for a tract and receiving the right to explore for oil and gas in the tract, firms still have to pay rent on the tract. A bonus bid payment in the U.S. isn't symbolic as in other countries: it has one of the highest rates per acre in the world.[63] Thus, even if for a firm the expected value of producing the resources in the future is higher, when factoring in the additional rent payments, the overall expected value of producing in the present may be higher. The firm can circumvent this cost by bidding for the tract only in the future, but by then some other firm may have made a bid. Thus, the firm will prefer making the bid in the present over making it in the future when the expected gains will be higher—better to have one bird in the hand than two in the bush.

This raises a separate question regarding the economic desirability of the government policy of charging a rent on tracts. It seems to cause an inefficient outcome, distorting the optimal production pattern by incentivizing firms to produce in the present when the expected gains from producing in the future are higher. Yet, imposing rent payments may still be economically justifiable. Firstly, having a right to explore a tract may generate negative externalities by limiting the public usage of the tract. The rent payment may be a way of internalizing this externality. This consideration is actually reflected in the DOI's reports, and is the central rationale behind the increase in the rent payments.[64]

Secondly, the government may have an additional interest in restricting the firm's decision of when to produce after it has leased a tract. The government has an interest in maintaining a national stockpile of energy resources.[65] Enabling firms that have leased tracts to freely decide when to extract adds significant uncertainty in assessing and controlling the amount of national energy resources. Although even after leasing a certain quantity of tracts the government does not know the potential production of the leases, enabling firms to freely decide when to produce adds an additional dimension of uncertainty and significantly increases the overall uncertainty over the amount of resources that would be extracted in a given period. Essentially, this source of uncertainty is also a negative externality that the rent payments may internalize.

---

[63] Johnston, *supra* note 16, at 50.

[64] FINAL REPORT: POLICIES TO AFFECT THE PACE OF LEASING AND REVENUES IN THE GULF OF MEXICO, *supra* note 23, at 9, 28.

[65] *See* Paul N. Leiby, *Estimating the Energy Security Benefits of Reduced U.S. Oil Imports*, OAK RIDGE NAT'L LABORATORY 3–4 (Feb. 2007), *available at* http://www.epa.gov/otaq/renewablefuels/ornl-tm-2007-028.pdf (analyzing the benefits of energy security).

The second reason why a firm would not postpone production is the time value of resources. Even if the cost would be lower if firms postponed production to t_2, the gains may not be sufficient to offset the loss of the time value of resources they have lost by postponing exploration and production to t_2. Accordingly, it is not correct to determine that, overall, non-exploration in t_1 would generate a surplus. When taking into account the firm's time value of resources, imposing the tax may result in a loss in present value terms. This difference between the firm's discount rate and the discount rate of social institutions may result from the different time horizons with which these entities are concerned. Social institutions have a more distant time horizon, which studies have demonstrated is accompanied by a lower discount rate. Private firms have a closer time horizon, which is accompanied by a higher discount rate.[66]

The third answer is that even though there is an expected surplus from postponing exploration and production to t_2, private firms would not postpone production due to risk aversion.[67] A central source of uncertainty for firms is government regulation. Private firms cannot rely on the projections for taxation in t_2, and thus even if the expected cost reducing technology will materialize, they might still find themselves with lower post-tax revenue in t_2. The government is not exposed to any risk in this respect, due to the fact that it controls the decision. Besides regulatory uncertainty, firms may be risk averse in response to the uncertainty of future innovations, and thus may prefer the secure payoffs in t_1 to the probabilistic higher payoffs in t_2. Governments may be less risk averse than private firms, and thus may prefer the higher expected payoffs to the lower and secure payoffs resulting from imposing a tax in t_1.[68]

---

[66] For experiments demonstrating the correlation between the distance of the horizon and the discount rate, see S. Fredrick, G. Loewenstein & T. O'Donoghue, *Time Discounting and Time Preference: A Critical Review*, 40 J. ECON. LITERATURE 351 (2002). Regarding the view that the government's discount rate should be lower than the market's discount rate, so that no generation is favored over the other, see Robert Solow, *The Economics of Resources or the Resources of Economics*, 64 AM. ECON. REV. 1, 10 (1974) *See also* Tyler Cowen, *Caring About the Distant Future: Why It Matters and What It Means*, 74 U. CHI. L. REV. 5, 5–6 (2007).

[67] Even in publicly traded firms, in which the shareholders are risk neutral as a result of the diversification of their portfolios, the managers who make the investment decisions tend to be risk averse. *See* John Coffee Jr., *Shareholders Versus Managers: The Strain in the Corporate Web*, 85 MICH. L. REV. 1, 19–21 (1986); John Coffee Jr., *Systematic Risk After Dodd-Frank: Contingent Capital and the Need for Regulatory Strategies Beyond Oversight*, 111 COLUM. L. REV. 795, 807 (2011).

[68] Regarding government's abilities to manage risk, see DAVID MOSS, WHEN EVERYTHING ELSE FAILS: GOVERNMENT AS THE ULTIMATE RISK MANAGER 1–2 (2002); *compare* BARBARA VIS, POLITICS OF RISK TAKING: WELFARE STATE REFORM IN ADVANCED

Taking into account the real option value that a tax may generate has a significant impact on the analysis of deadweight loss in particular and tax policy in general, especially in cases for which there is a strong expectancy for technological development. This Part has discussed taxation of gas and oil as a classic case of the significant impact of real option value. The next Part will substantiate the claim that there is a strong expectancy for technological developments in the gas and oil exploration and production sector that make it the classic example for real option value.

V. SUBSTANTIATING THE STRONG EXPECTANCY FOR A REDUCTION IN COSTS

While every tax may yield new possible scenarios for the future by preventing some economic activity from taking place in the present, the value of these new scenarios may be positive or negative. Without additional information one cannot conclude whether the value of the new set of possible scenarios is higher than the value of the possible scenarios before the tax was imposed. For this reason, they are disregarded in the economic analysis of taxation. In the case of taxation of gas and oil, there are firm grounds to believe that the value of the new set of possible scenarios is significantly higher than the value of the scenarios in which the tax hasn't been imposed. The reason for this is the strong expectancy that significant technological developments will occur in the near future which will reduce substantially the cost of extracting gas and oil from a given tract. In this Part I will provide the reasons for the strong expectancy of significant reduction in costs.

One of the primary indications of future reductions in the cost of extraction of gas and oil resulting from technological developments is the projection of the U.S. Energy Information Agency through its National Energy Modeling System (Graph 3). According to the projection made by the EIA, in 2020 technological progress will increase United States domestic natural gas output by 2.5 trillion cubic feet.[69] The model calculates the expected effect of technological

DEMOCRACIES 166–69 (2010) (claiming that prospect theory and risk preferences apply the same way to government as they apply to individuals).

[69] Ted McCallister, *Impact of Unconventional Gas Technology in the Annual Energy Outlook 2000*, ENERGY INFOR. ADMIN. 12–13 (2000), *available at* http://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/4265704/FID3754/pdf/multi/uncongas.pdf. The methodology used in the estimation is based on profiling the resources into undeveloped resources, proved resources (resources that "geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating

developments under 11 categories[70] in accordance to the developments that are projected in the field, and that may mature and be implemented over the next several years. The model evaluates the possible effect of each of these categories on the existing reserves and on the industry's ability to turn undeveloped resources into proved resources, and proved resources into resources "in-play." Development and drilling technologies have the greatest expected impact on the future production of natural gas—increasing output by 11.4 trillion cubic feet.[71] Meanwhile, technological developments in the exploration phase are expected to increase output by 5.7 trillion cubic feet,[72] and technological developments in the production phase are estimated to increase output by 9.2 trillion cubic feet.[73]

It is illuminating to compare the projections of increased production from technological advancement made in 2000 to the actual output in recent years. In 2007 the actual unconventional gas production was lower than projected: approximately 4 trillion cubic feet[74] in comparison to the estimated 5.1.[75] By 2008 the gap had disappeared—the forecast and the actual output were fairly close: the former 5.1 trillion cubic feet[76] and the latter 4.9.[77] From 2009 onwards,

conditions,") and resources which are "in play." *Id.* at 3. The technological developments are comprised of eleven categories that encompass the full spectrum of key disciplines: geology, engineering, operations and the environment and affect exploration, development of wells, and production. The following categories affect exploration efficiency: basin assessments; play-specific extended reservoir characterization, advanced exploration and natural fracture detection R & D. The following categories affect well-development efficiency: geology/technology modeling and matching, more effective lower damage well completion and simulation technology, targeted drilling and hydraulic fracturing R & D and advanced well completion technologies such as cavitation, horizontal drilling, and multilateral wells. The following categories affect production efficiency: advanced well performance diagnostics and remediation, new practices and technology for gas and water treatment, other unconventional gas technologies such as enhanced gas shale recovery using nitrogen or carbon dioxide injection, mitigation of environmental and other constraints on development. *Id.* at 3–4.

[70] *Id.*

[71] *Id.* at 9.

[72] *Id.* at 6.

[73] *Id.* at 12.

[74] U.S. ENERGY INFO. ADMIN., NATURAL GAS ANNUAL 2011, at 9 (2011), *available at* http://www.eia.gov/naturalgas/annual/pdf/nga11.pdf [hereinafter NATURAL GAS ANNUAL 2011]. The total above for the actual unconventional natural production was derived by adding the amount produced from coalbed wells (1.99 trillion cubic feet) to the amount produced from shale gas wells (1.99 trillion cubic feet). *Id.*

[75] McCallister, *supra* note 69, at 13.

[76] *Id.*

[77] NATURAL GAS ANNUAL 2011, *supra* note 74. Production from coalbed wells stood at 2.022 trillion cubic feet and shale gas wells produced 2.87 cubic feet of natural gas.

a reverse gap has developed in which actual output substantially exceeds the projection. In 2009 the actual unconventional gas production reached 6 trillion cubic feet in comparison to the projected 5.15 trillion cubic feet.[78] In 2011 the actual unconventional gas production grew to an astonishing 10.3 trillion cubic feet,[79] not only exceeding the projection for 2011 by approximately 5.3 trillion cubic feet, but exceeding even the projection for 2020 which was 7.5 trillion cubic feet.[80] In short, not only did past projections of technological development not exaggerate the impact of technological development on output, but they have even greatly underestimated the increased capacity over time, especially after several years.

Needless to say, current projections for unconventional gas production, on which technological developments have the greatest impact, increased significantly from the estimations made in 2000. The current estimate for natural gas production from unconventional sources in 2020 has more than doubled, from the 7.2 trillion cubic feet estimated in 2000 to 17.7 trillion cubic feet estimated in 2012.[81] In 2035, natural gas production from unconventional sources is projected to reach an astonishing level of 21.5 trillion cubic feet.[82] This increase is mostly due to the growth rate in the production of shale gas, projected to increase an average of 4.1% per year between 2010 and 2035.[83]

It should be noted that the increase in the expected output due to technological developments is not proportionate to the expected increase in producers' revenue streams. Revenue is expected to rise at a much slower pace because the technological developments are expected to decrease energy prices. According to the national modeling energy system, the technological developments in the exploration phase are expected to decrease the wellhead price of a thousand cubic feet of natural gas by 17 cents in 2020 compared to a scenario with no technological developments.[84] In the case of the

Id.

[78] McCallister, *supra* note 69, at 13.

[79] NATURAL GAS ANNUAL 2011, *supra* note 74. Production from coalbed wells amounted to 1.78 trillion cubic feet and production from shale gas wells amounted to 8.5 trillion cubic feet of natural gas. *Id.*

[80] McCallister, *supra* note 69, at 13.

[81] U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2012, at 159 (2012), *available at* http://www.eia.gov/forecasts/aeo/pdf/0383 (2012).pdf.

[82] *Id.*

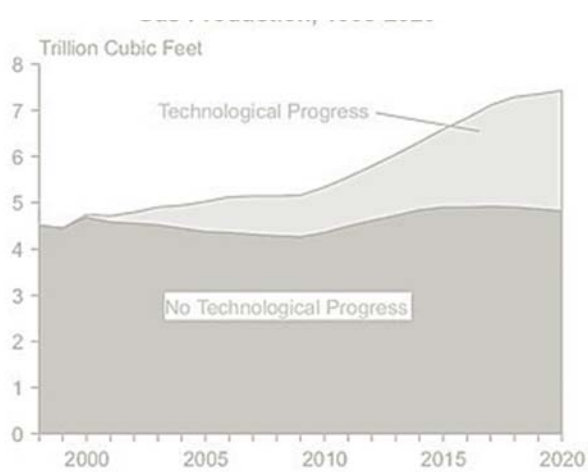
[83] *Id.*

[84] McCallister, *supra* note 69, at 6, 20 (projected price with technological advancement is $2.81, and without is $2.98).

development and drilling phase, they are expected to decrease the price by 33 cents and in the production phase by 23 cents.[85] Assuming the technological development takes place in all phases, the wellhead price of a thousand of cubic feet of gas is estimated to be 78 cents lower than under a scenario in which no technological development takes place.[86]

Graph 3[87]

Projected Effect of All Unconventional Gas Technologies on Unconventional Gas Production 1998–2020



The significant and ongoing effects of technological progress on the cost involved in the production of natural resources are not restricted to the natural gas industry, but also pertain to oil production, especially from off-shore sources.[88] Fagan found an 18% annual

[85] *Id.* at 12, 20 (projected price with technological advancement is $2.81, and without development and enhanced drilling technology is $3.14, and without production enhanced technology is $3.04).

[86] *Id.* at 13, 20 (projected price with technological advancement is $2.81, and without is $2.03).

[87] AEO 2000 NATIONAL ENERGY MODELING SYSTEM, runs BASINS D060600A and UGRT04.D051600A, graph *available at* http://www.sitterdrilling.com/docs/DOE_gas_production_increases_by_use_of_technology_on_unconventional_shales.pdf, at 13 (last visited Feb. 7, 2014).

[88] Measurement of technological advancement is a prerequisite for exploring the impact of technological advancement on the costs of exploration, development, and production of natural resources. Often, this involves using the expenditures on R&D as a proxy for technological advancement. *See, e.g.*, Zvi Griliches, *Productivity, R&D and Basic Research at the Firm Level in the 1970's*, 76 AM. ECON. REV. 92 (1986). The

decrease in costs in the off-shore oil industry between the years 1977 and 1994, more than offsetting the increase in costs due to depletion, which was assessed to have climbed to an annual rate of 12% in the same period.[89] Forbes and Zampelli examined the success rate of gas and oil explorations that had a direct impact on the costs per unit between 1981 and 1995 in the Gulf of Mexico. They found an extraordinary 8.3% annual growth in success rate between 1985 and 1995.[90] Furthermore, Managi, Opaluch, Jin, and Grigalunas found a constant increase in the gross total factor productivity (TFP) in the production of gas and oil in the Gulf of Mexico in the 49 years between 1948 and 1997, averaging an annual increase of 1.2%.[91] As they note,[92] this rate is significantly higher than the general increase of the gross TFP in the economy estimated by Färe, Grosskopf, Norris, and Zhang.[93] In a subsequent study, Managi, Opaluch, and Grigalunas analyzed the effect of technology on costs in the exploration phase. They used the

assumption that there is a direct link between one's investment in technology and the technological output has been much contested. *See* Zvi Grilliches, *Productivity R&D and the Data Constraint*, 84 AM. ECON. REV. 1 (1994). The second method is to use patent counts as a proxy for technological advancements. *See* J. Schmookler, *The Level of Inventive Activity*, 36 REV. ECON. STAT. 183 (1954). This method was refined in order to account for the variance in the commercial applicability of different patents by counting citations to a patent. *See* B.H. Hall, A.B. Jaffe & M. Trajtenberg, *The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools*, (National Bureau of Economic Research, Working Paper No. 8498, 2001), *available at* http://www.nber.org/papers/w8498.pdf. A third method, concentrating on the petroleum industry, was developed by Cuddington & Moss, accounting for the diffusion of technology in the market by constructing an index counting reports on technological innovation in the industry's trade journals. J.T. Cuddington & D.L. Moss, *Technological Change, Depletion and the U.S. Petroleum Industry: A New Approach to Measurement and Estimation*, 91 AM. ECON. REV. 1135 (2001).

[89] M.N. Fagan, *Resource Depletion and Technical Change: Effects on U.S. Crude Oil Findings Costs from 1977 to 1994*, 18 ENERGY J. 91, 98 (1997).

[90] K.F. Forbes & E. M. Zampelli, *Technology and the Exploratory Success Rate in the U.S. Offshore*, 21 ENERGY J. 109, 118–19 (2000).

[91] S. Managi, J.J. Opaluch, D. Jin & T.A. Grigalunas, *Technological Change and Depletion in Offshore Oil and Gas*, 47 J. ENVTL. ECON. & MGMT. 388, 403 (2004). Their central finding that the net TFP is a U-shaped curve is not of interest to this Article. The net TFP takes into account the depletion of resources, and the depletion of resources is of no concern to this Article. The point of this paper is that the costs for *a given resource* decrease overtime due to technological developments. The deadweight loss of a tax that eliminates the exploitation of a resource in the present is lower than perceived because there is a strong likelihood that in the future the *same* resource *will be* utilized due to the technological improvements that will lead to lower costs. The gross TFP and not the net TFP is of relevance for the measurement of future estimated costs of certain resources.

[92] *Id.*

[93] R. Färe, S. Grosskopf, M. Norris & Z. Zhang, *Productivity Growth, Technical Progress and Efficiency Change in Industrialized Countries*, 84 AMER. ECON. REV. 66, 80–81 (1994).

data from of the Joint Association Survey on Drilling Costs published by the American Petroleum Institute regarding offshore drilling costs between 1955 and 1996. They found that technology also had a significant impact on reducing the costs of the exploration phase.[94]

The conclusion that emerges from the studies above is that there is a very strong expectancy that technological advancements in the future will decrease the costs of exploration, development, and production of natural resources, especially oil and natural gas in offshore drilling. This probability should have a significant impact on the design of taxes on natural resources, as the next Part will demonstrate.

VI. IGNORING OPTION VALUE AND REAL OPTION VALUE

Considering the findings outlined above, why is option value so often overlooked and ignored? Although a few studies have shown that option value is often not taken into account in various fields of legal policy, the cause of this omission still needs to be explained. This Article aims to fill that gap by arguing that our tendency to overlook option value stems from a wider phenomenon that has also received attention in legal scholarship: a general tendency to focus on static analysis, based on historical data, and a failure to detect dynamic elements that change over time. A static analysis aims at adopting the policy that will enhance social welfare given certain conditions. A dynamic analysis takes into account how such a policy might itself change those conditions over time, and thus how its effects might substantially differ from those predicted by a static analysis. The dynamic model exposes how the equilibrium that the static model predicts is only a temporary equilibrium and thus not as significant as the static model portrays.[95]

As it typically happens in the economic analysis of the law, the relatively recent trend of focusing on dynamic analysis has mainly originated from the field of antitrust law.[96] David Evans and Keith

---

94 Shunsuke Managi, James J.Opaluch & Thomas A. Grigalunas, *Technological Change and Petroleum Exploration in the Gulf of Mexico*, 33 ENERGY POL'Y 619, 629 (2005).

95 DAVID M. DRIESEN, THE ECONOMIC DYNAMICS OF LAW 508 (2012).

96 Antitrust scholarship has pioneered the way for general law and economics analysis since its inception. In the conventional account of the historical development of law and economics analysis, Aaron Director's course in law and economics in the 1930's at the University of Chicago Law School is seen as the origin of the law and economics movement. As Harold Demsetz notes, only in the early 1960's did "[t]he interaction of law and economics burst beyond the narrower confines of the antitrust area." *See* Edmund W. Kitch, *The Fire of Truth: A Remembrance of Law and economics at Chicago 1932–1970*, 26 J. L. & ECON. 163, 191 (1983); *see also* Ejan Mackaay, *History of*

Hylton were the first scholars to note the deficiency in most static antitrust models, which overlooked important possible effects since they did not admit a dynamic element.[97] More specifically, Gregory Sidak and David Teece argue that the static models of competition in antitrust do not account for effects associated with competition such as the introduction of new products, new features, and new pricing methods.[98] Joseph Harrington argues that under a dynamic model that does not focus only on one time period, the penalty multiple required to deter corporations from colluding is two to three times smaller in size than in a static model.[99] Judge Douglas Ginsburg and Professor Joshua Wright pointed out that the need for incorporating dynamic models into antitrust legal scholarship is broadly accepted among scholars, and the main question now is how such incorporation should take place.[100]

The need to incorporate dynamic analysis into the study of legal institutions has permeated other fields—mainly environmental law, but other legal fields as well. For example, David Dreisen emphasized the need for environmental law to be based on dynamic models that take into account changes in consumption patterns over time and the effects of current policies on future innovation.[101] Dreisen also demonstrated how dynamic economic analysis could contribute to the optimal management of infrastructural commons, including environmental resources, by taking into account their evolution over time.[102]

The cognitive error of conflating present value and option value might also explain the neglect of option value: an erroneous inference that an option for developing a project in the future is worthless because it does not have positive economic value in the present. This inference may be true under a static analysis, in which we assume there

Law and Economics, 1 ENCYCLOPEDIA OF LAW AND ECONOMICS 65, 72 (2000).

[97] David Evans & Keith Hylton, *The Lawful Acquisition and Exercise of Monopoly Power and Its Implications for the Objectives of Antitrust*, COMPETITION POL'Y INT'L, 203, 240 (2008).

[98] J. Gregory Sidak & David F. Teece, *Dynamic Competition in Antitrust Law*, 5 J. COMPETITION L. & ECON. 581, 602 (2009).

[99] Joseph Harrington, *Who Should be the Target of Cartel Sanctions?: Comment on Antitrust Sanctions*, 6 COMPETITION POL'Y INT'L 41, 44 (2010).

[100] Douglas H. Ginsburg & Joshua Wright, *Dynamic Analysis & the Limits of Antitrust Institutions*, 78 ANTITRUST L.J. 1, 2 (2012).

[101] David Driesen, *Symposium: Economic Dynamics of Environmental Law and the Static Efficiency: The Economic Dynamics of Environmental Law: Cost-Benefit Analysis, Emission Trading and Priority-Setting*, 31 B.C. ENVTL. AFF. L. REV. 501, 507–09 (2004).

[102] David Driesen, *An Economic Dynamic Approach to the Infrastructure Commons*, 35 ECOLOGY L. Q. 215, 217–19 (2008).

are no grounds to believe that any of the exogenous circumstances significant for the economic outcome will change in the future. Under such an assumption the future value will not depart substantially from the present value, hence an option to obtain the future outcome cannot be of significant value: the difference in outcome will be worthless in the future similarly to its present value. An option to obtain a worthless outcome is worthless. In contrast, in cases in which there are firm grounds to believe that in the future the circumstances will change so that the project will have positive economic value, the option value may substantially depart from the present value. Generally, it might be true that there are no grounds to believe that circumstances will change significantly in one way or the other. While the value of the underlying asset may increase in the future, it may also decrease. But as I have noted above, in the case of oil and gas, there are good grounds to believe that a positive option value will emerge in the future.

In addition to a standard cognitive error account, overlooking the option value could be explained through the focusing illusion bias. According to Schkade and Kahneman, the focusing illusion happens "when a judgment about an entire object or category is made with attention focused on a subset of that category . . . the attended subset is overweighed relative to the unattended subset."[103] Wilson et al. have extended the application of the focusing illusion to cases in which an individual focuses on the occurrence in question, and fails to consider the consequences of other events that are likely to occur.[104] Wilson's description seems to fit perfectly with the case we are concerned with—the consequences of a tax. The occurrence in question is the economic effect of the tax. The evident and direct effect of the tax is its distortionary effect—eliminating certain beneficial transactions that would have taken place in a tax-free world. Scholars have focused on this direct effect of taxation, but neglected to account for an additional

[103] David A. Schkade & Daniel Kahneman, *Does Living in California Make People Happy? A Focusing Illusion in Judgments of Life Satisfaction*, 9 PSYCHOL. SCI. 340 (1998). Schade & Kahneman demonstrate the focusing illusion through a famous experiment in which they ask students from the Midwest and California questions regarding the life satisfaction of a similar individual from the other region. Participants rated the life satisfaction of Californians higher, although there was no difference in the self-reporting of life satisfaction of the students from the two regions. Schade and Kahneman reasoned that climate-related aspects are an easily observed difference between the regions and participants tended to focus on it (hence the focusing illusion), although in reality climate does not actually have much impact on life satisfaction.

[104] Timothy D. Wilson et al., *Focalism: A Source of Durability Bias in Affective Forecasting*, 78 J. PERSONALITY & SOC. PSYCHOL. 821, 822 (2000).

consequence: the option value the tax may generate by enabling an economic activity to take place in the future. The phenomenon of the focusing illusion is related to an additional phenomenon that could explain the neglect of dynamic analysis in general: people's tendency to give disproportionate weight to accessible information and to focus on what comes easily to mind.[105] This can explain our tendency to ignore the possibility of a dynamic model: a result of its complexity and its concern with remote contingencies in time—information that people tend to ignore.

The focus on costs when analyzing the effect of taxation is reminiscent of a similar tendency in tort law. Professor William Bishop has underscored how, counter-intuitively, the occurrence of a tort can generate an economic benefit. The occurrence of a tort that causes an economic harm, like loss of income to a business, may generate an opportunity to benefit to its rivals.[106] Bishop argues that that may be the justification for excluding compensation in cases of economic harms: as a rule of thumb, these torts do not necessarily cause social cost—the revenue lost by one business may just end up in the hand of its rivals.[107] Due to the fact that such losses to third parties are not a social cost, from the perspective of the tortfeasor's optimal level of care and level of activity it is not desirable that the tortfeasor will internalize such consequences. The example Bishop discusses is of a train accident that causes the citizens of town A to move to town B due to a leakage of poisonous substances, and as a result, the businesses of town A lose all their revenue.[108] In such a case, the harm to the businesses of town A is not necessarily a social cost, due to a possible shift of business to town B, and thus should not be internalized through the tort system.[109]

105 *See* Norbert Schwartz, *Feelings as Information: Informational and Motivational Functions of Affective States, in* 2 HANDBOOK OF MOTIVATION AND COGNITION 527 (R. Sorrrentino & E.T. Higgins eds., 1990); E.T. Higgins, *Knowledge Activation: Accessibility, Applicability and Salience, in* SOCIAL PSYCHOLOGY: HANDBOOK OF BASIC PRINCIPLES 133 (E.T. Higgins & A. Kruglanski eds., 1996).

106 W. Bishop, *Economic Loss in Tort*, 2 OXFORD J. LEGAL S. 1, 3 (1982).

107 *Id.* at 4–7 (assuming the costs for the rival business are similar to those of the harmed business—that marginal costs do not increase with scale).

108 *Id.* at 5–6.

109 The most striking counterintuitive implication of Bishop's analysis is his assertion that, in the circumstances he analyzes, the moral hazard of insurance does not generate a social cost. Even if a business loses revenue due to its own reckless behavior, as long as there are other businesses that could profit from that loss without higher costs than that of the initial business, this reckless behavior does not generate any social cost. *See id.* at 9–10.

Similar to Bishop's observations regarding the possible positive consequences of a tort that should be taken into account, this Article points out the possible side-benefits of a tax. Both torts and taxation are perceived as representing negative events; their consequences are comprised primarily of costs. Although this is generally true, in both cases this perception may cause us to overlook possible side-benefits, such as the emerging business opportunities for third parties as a consequence of economic harm in the case of torts, and the option value for future exploration with lower costs in the case of taxation of natural resources. In both cases there is still a net social cost, but taking into account the side-benefits may have a substantial effect on policy—excluding compensation for economic harm in the case of torts and increasing the tax rate in the case of taxation on natural resources. Although Bishop did not address any cognitive biases in his article, Kahneman's[110] and Wilson's[111] cognitive analyses can provide a unified explanation of why both the point Bishop illuminates, as well as the option value of taxes discussed in this article, have been overlooked.

VII. POSSIBLE OBJECTIONS

A. Option Value of Present Exploration

In this Article I have presented the option value that may be generated by not exploiting the field in the present. Even if one accepts this conclusion, taking into account real option value might not necessarily decrease the deadweight of taxation as claimed in this Article, and might actually increase it. Real option value might also be generated by the exploitation of a field, and not only from non-exploitation. For example, the exploitation of a field might also open valuable options that wouldn't have existed if the field had not been exploited. These additional options that emerged by exploitation might add substantial value to the exploitation of the field, in addition to the market value of the resource itself. The additional resources might turn a country into a resource independent country, and thus have a significant impact on its foreign policy and role in world trade.[112]

---

[110] *See supra* note 103.

[111] *See supra* note 104.

[112] Regarding economic benefits of energy independence as a significant consideration for energy policy, see Randolph Comstock, *FUA: The Transition to Alternative Fuels in the Industrial and Electric Utility Sectors*, 29 KAN. L. REV. 337, 364 (1981). Regarding the effect of energy dependence on the U.S. foreign affairs policy, see James Woolsey & Anne Korin, *Turning Oil into Salt*, NAT'L REV. (Sept. 25, 2007), http://www.nationalreview.com/article/222256/turning-oil-salt-r-james-woolsey-anne-korin. For reference to the benefits of energy independence in both the

In addition, the resources produced may tilt a country over a tipping point that has a significant impact on the state such as scale advantages that enable the country to decrease costs of production in its region.[113] Last but not least, the exploitation itself might generate new drilling technology, by conveying significant information on the connection between the geologic structures in the area exploited and the likelihood of finding natural resources in such structures. This option value of exploitation may be generated even in case of failure to produce natural resources from the field.[114]

An empirically supported source of the option value of exploitation is the option to sell oil and gas at current prices—an option that only extraction enables firms to execute.[115] There are reasonable grounds supported by data for the claim that the option to sell under current prices is of significantly higher value than the option to sell under future prices. It has already been noted that a side effect of technological advancements is a decrease in the price of the natural resource: the greater productivity increases the supply and reduces the price. That effect alone is not necessarily sufficient to offset the positive option value of technological development;[116] an additional source for an expected decrease in future prices is a projected decline in the demand for natural resources, especially fossil fuels, due to substitute goods such as solar energy and greater productivity in the use of natural resources.[117]

---

economic sphere and the foreign policy sphere, see Ariel Cohen,, *Ukraine's Economic Benefits from Integration into the Euro-Atlantic Community*, HERITAGE.ORG (June 12, 2007), *available at* http://www.heritage.org/research/lecture/ukraines-economic-benefits-from-integration-into-the-euro-atlantic-community.

[113] For an example of a similar "tipping point" effect, see Jeffrey D. Sachs & Andrew Warner, *The Big Push, Natural Resource Booms and Growth*, 59 J. DEVELOPMENT ECON. 43, 43–44 (1999).

[114] *See* Alwyn Young, *Invention and Bounded Learning by Doing*, 101 J. POL. ECON. 443 (1993) (discussing experience as a significant factor for advancing technology).

[115] It is possible to some extent to receive a price close to current prices for future production by obtaining a put option. Yet if it is common knowledge that there is a strong probability that prices will decrease, the put option will more likely reflect the lower prices than the current high prices.

[116] *See* McCallister, *supra* note 69, at 6, 12, 20.

[117] It is instructive to note that under certain circumstances the greater productivity of natural resources such as fossil fuels might increase consumption, a phenomenon labeled in the scholarship as the "rebound effect." The greater productivity reduces the quantity of natural resources needed for a given purpose, reducing the price of the activity for which the natural resource is used and thus increasing the overall consumption of the natural resource. The classic example of the rebound effect is the case of car usage of fuel. The enhanced fuel efficiency of cars, increasing the miles per gallon ratio, reduces the per-mile price of driving and thus may increase the amount of mileage driven and increase the overall consumption of oil. For a

Overall, there are many possible sources for option value in the reverse direction from the one suggested in this Article—option value that stems from the exploitation of resource fields. Taking into account such options will alter significantly the analysis provided in this Article.

There are two ways of presenting this objection to the Article's argument: a strong version and a weak one. The strong version raises questions regarding the general methodology of a dynamic model that incorporates option value into the economic analysis of deadweight loss: that option value might tilt the balance in both directions. The fact that there are endless scenarios for how option value might be generated just reflects how messy a dynamic analysis that takes option value into account can be, and raises the question of whether this analysis can actually lead to fruitful results.

The weak version of this objection does not question the general dynamic analysis methodology, but only the specific conclusion that taking option value into account decreases the deadweight loss of the tax on natural resources and justifies increasing the tax rate. The possibilities mentioned above demonstrate that it is possible that the option value may actually increase the deadweight loss of taxation due to non-exploitation. According to the weak-version objection, there is no fundamental methodological problem with a dynamic analysis of deadweight loss that takes real option value into account; the problem is only that this Article's proposed model is too limited and does not fully incorporate real-world option value into its analysis. It cherry-picks the option value of non-exploitation while pushing aside the option value that may accompany exploitation.

While the strong version of this objection is ultimately unpersuasive, the weaker version raises important questions that should prompt further research. Simply put, the strong version objection, which calls for a wholesale rejection of the dynamic analysis methodology employed in this Article, is itself too simplistic. The fact that the dynamic analysis called for in this Article is fairly complex, and has to consider a vast amount of possible sources of option value working in different directions, is not a reason to abandon it. If one admits that taking option value into account may have a significant impact on the analysis of taxation's deadweight loss, one simply has to attempt to take it into account, no matter how complex the analysis. To paraphrase the saying mostly attributed to Maynard Keynes[118] and

discussion of the rebound effect, see Kenneth A. Small & Kurt Van Dender, *Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect,* 28 ENERGY J. 25 (2007).

[118] ROBERT SKIDELSKY, KEYNES: A VERY SHORT INTRODUCTION 20 (2010).

Amartya Sen,[119] but originally phrased by the philosopher Carveth Read, it is better to be roughly right than precisely wrong.[120]

The softer version of the objection above raises more serious concerns. One could not object to the possibility that option value may be generated through exploitation as well as through abstention. The indications for option value stemming from exploitation, however, are not as strong as the indications for option value stemming from non-exploitation. There are many studies regarding technological advancements in the natural resources sector, and the projection that such advancements will continue in the future is widely accepted.[121] In contrast, there are not many studies regarding most of the sources for option value stemming from field exploration. There are some studies showing the technological experience gained by exploration—"learning by doing."[122] While there are studies that assert that future natural resources prices, especially natural gas and oil, will decline, these assertions are highly contestable among scholars.[123]

The analysis in this Article, however, does not pretend to be exhaustive. It only presents the basic model for such an analysis. It is also very likely that even if the general framework presented in this Article is correct and the data on which it relies is not, there may be certain cases with unique attributes[124] in which the option value of exploitation is greater than the option value of non-exploitation. In short, the analysis presented here should provide a platform for further scholarship and research that takes into account the complexity of dynamic economic analysis of taxation in general and the taxation of natural resources in particular.

B. Is there Actually a Deadweight Loss in the Taxation of Oil and Gas?

This Article is premised on the assumption that taxation of oil and gas is necessarily accompanied by deadweight loss. I have argued that

---

119 LIAM MURPHY & THOMAS NAGEL, THE MYTH OF OWNERSHIP: TAXES AND JUSTICE 24 (2002).

120 CARVETH READ, LOGIC, DEDUCTIVE AND INDUCTIVE 272 (1898).

121 *See supra* notes 89–91, 94.

122 *See* Young, *supra* note 114.

123 According to the basic economic model and the Hotelling Rule, prices of natural resources are projected to increase, see Hotelling, *supra* note 56. For reinforcement of the classic view in the case of fossil fuels, see McCallister, *supra* note 69, at 10, 12. In contrast, Vincent, Panayotou & Hartwick project that in the long-run prices will decrease. *See* Jeffrey Vincent, Teodore Panayotou & John M. Hartwick, *Resource Depletion and Sustainability in Small Open Economies*, 33 J. ENVTL. ECON. & MGMT. 274, 282 (1997); *see also* Peter Berck & Michael Roberts, *Natural Resources Prices: Will They Ever Turn Up?*, 31 J. ENTVL. ECON. & MGMT. 65, 77 (1996).

124 *See supra* notes 112–114 and accompanying text.

given that deadweight loss is a key factor in determining a tax rate, incorporating option value has a significant effect on deadweight loss and as a result also has a significant effect on the optimal tax rate on oil and gas. The existence of the deadweight effect in the exploration and production of natural resources in general and oil and gas in particular is questionable, both on the empirical level and the theoretical level. On the empirical level, most of the exploration, development, and production of oil and gas is conducted by large multi-national firms that pursue many similar projects simultaneously.[125] As a result, even if a firm loses money in a specific location because, for example, exploration there does not lead to any results, it could deduct those losses from the profits on its other projects. Thus, in essence, the firm does not incur the full costs of the failed exploration. The deductibility of the loss from its other profits is equivalent to a partial reimbursement for its investment from the government, equaling the tax rate on its profits.

If the government incurs a share in the losses equivalent to the share it collects through taxation, the firm's decision whether to invest is not distorted by taxation. The ratio between the firm's expected gains and its expected losses is identical in both a world with no taxes and in a world with taxes. Assume that its expected pre-tax revenues if the exploration is fruitful are P*X, and its expected losses if the exploration fails are (1-P)*Y. Given that the firm will be reimbursed for its losses at a rate that equals the tax rate on its gains, the post-tax

[125] The biggest American gas and oil company, Exxon Mobil Corp (total asset value of $345 billion), drilled 1,163 wells in the U.S. during 2012 alone. Chevron (the second biggest U.S. oil and gas company with a total asset value of $233 billion) drilled 951 wells, and Conoco Philips (the third biggest with a total asset value of $117 billion) drilled 492 wells. The company that had drilled the most is Occidental Petroleum Corporation (the fourth biggest U.S. oil and gas company with a total asset value of $64 billion dollars), which drilled 1,411 wells during 2012. The phenomenon of drilling numerous wells is not limited to these conglomerates. Even companies bellow the top 50 biggest companies drill tens of wells in a given year, such as Clayton Williams Energy Inc., the 63rd biggest with 97 wells, Fidelity Exploration & Production Co. the 64th biggest with 67 wells, and Roseta Resources Inc. the 65th biggest with 82 wells. The biggest 150 oil and gas companies drilled 18,598 wells in the U.S. during 2012, averaging 124 wells per company. For full information regarding the activity of the 150 biggest oil and gas companies, see Conglin Xu & Laura Bell, *OGJ 150 Earnings Down as US Production Climbs*, 111 J. GAS & OIL 34, 46–51 (2013). Exxon Mobil Corp. is only the fourteenth both in the share of worldwide oil reserves it holds (0.7%) and in its share of worldwide natural gas (0.65%). *See* American Petroleum Institute, *Putting Earnings Into Perspective*, at 4 (Dec. 2013), *available at* http://web.archive.org/web/20140327140452/ http://api.org/oil-and-natural-gas-overview/industry-economics/~/media/Files/Statistics/Earnings-Perspective/ earnings-perspective-low-res.ashx (accessed by using the Way Back Machine to view the older version of this website).

ratio of its expected gains and losses will equal the pre-tax ratio of its expected gains and losses:

$$(1\text{-}P)*Y*(1\text{-}T) : P*X*(1\text{-}T) = (1\text{-}P)*Y : P*X$$

In the equation above, it is evident that the ratios of the pre-tax expected gains and losses (on the right side of the equation) equal those of the post-tax expected gains and losses (on the left hand of the equation)—both the numerator and the denominator are multiplied by the same factor—(1-t)—the firm's post-tax share of both losses and gains.

The fact that the ratio of the expected profits and losses is constant in both a pre-tax world and in a post-tax world essentially means that taxes do not distort the firm's decision to invest in exploring a certain field. The firm's decision is based on whether the expected gains are lower or higher than the expected losses:

$$P*X \gtreqless (1\text{-}P)*Y$$

The sign will not change after both sides of the equation are multiplied by the same factor—(1-T):

$$P*X*(1\text{-}T) \gtreqless (1\text{-}P)*Y*(1\text{-}T)$$

This means that imposing a tax will not alter the firm's decision whether or not to invest in a certain field. The relationship between the two sides of the equation and the decision over whether to invest in production are not affected by the tax rate, or by whether there is any tax imposed.

This in and of itself does not necessarily make the argument presented in this Article superfluous. There may be cases in which there will be no deadweight loss, because a firm with substantial profits will not incur the full loss of an exploration but will only lose the fraction of post-tax profits they receive from the gross profits. Yet there are still many other cases in which a firm does not have any profits it could use for deducting its future losses. Such a scenario is likely to happen when there is a sudden drop in energy prices. This objection may limit the scope of the argument in the paper, but does not undermine it.

Even if in reality there might be many firms without profits from other sources, meaning that their decisions will be distorted by taxes, there is a theoretical challenge facing the application of real option value to such cases. If a refundable negative tax were provided to such firms, their decision whether or not to invest also would not have been distorted by taxes. Under such a regime, there would not be any case in which a decision of the firm over whether to invest would be distorted by taxes, and thus there would not be any case in which there is a deadweight loss as a result of taxation of natural resources. Such a regime, with strong support on the theoretical level, would make the argument presented in this Article futile: there would not be any deadweight loss from taxation of natural resources or any need to reassess it by taking into account option value.

I admit that such a regime has a strong justification in theory, but in practice it does not exist in almost any country, including the U.S.[126] Scholars have provided different explanations for why such a regime does not exist, from political economy explanations to administrative explanations.[127] What matters is that at the end of the day the deadweight effect of taxes on natural resources is still with us and is here to stay, so at least it should be assessed properly.

C. Missing the Technological Development Target

The conclusion of this Article is premised on assessments regarding technological developments in exploration, development, and production in the gas and oil sectors. Although these assessments are the best available in the industry, they are still assessments, and their projections may turn out to be erroneous. If the policy suggested by this Article is adopted, certain fields may still not be exploited because the actual cost reduction is not, in fact, large enough to offset the increased tax rate. Furthermore, the price of the natural resources in question might decrease and reduce the profitability of producing those natural resources even if the expected technological development materializes. Assuming that under such circumstances the option value has diminished significantly, the increased tax rate would generate a significant deadweight loss. Although the question of error costs is relevant to any policy, the question is especially relevant to a policy such as the one suggested in this Article. Policies that mainly rely on speculation regarding future trends have an especially

[126] In the U.S., § 172 of the I.R.C. permits taxpayers to carry losses back three years and carry losses forward fifteen years, but in order for the losses to be of any use to the taxpayer they have to be accompanied by gains. The tax court suggested in *Alprosa Watch Corp. v. Commissioner* that the U.S. should permit a refundable credit for losses even without incurring gains in any time frame. 11 T.C. 240 (1948). For an argument for accepting such a mechanism, see Mark Campisano & Roberta Romano, *Recouping Losses: The Case for Full Loss Offsets*, 76 NW. L. REV. 709, 709–10 (1982).

[127] Regarding the administrative cost of burdening the treasury to pay out refunds to businesses, see Campisano & Romano, *supra* note 126, at 741. Campisano and Romano claim that that is one of the central justifications for preferring free transferability of losses (enabling firms with losses to sell their losses to firms with gains) over a refundable credit. Regarding political economy explanations for the current system that does not permit a refundable credit for losses, see Mark Campisano & Roberta Romano, *On the Benefits of Loss Recoupment: A Response*, 21 TAX NOTES 209, 211 (1983) (arguing that practitioners have a strong interest in maintaining the current complex system of loss carry back and carry forward).

high chance of erring.

On the face of it there seems to be a simple solution: it is always possible to decrease the tax rate and mitigate the costs if predictions turn out to be incorrect. It is important to understand, however, the significant costs that accompany such reductions of the tax rate. In his book on the subject, Professor Daniel Shaviro emphasizes the substantial costs that are involved with legal transitions in general, and transitions in the tax system in particular. The instability generated by changes in the tax system is a substantial cost of such changes.[128] Adam Smith has expressed this view through the maxim that the only good tax is an old tax.[129] A transition to reduce a tax might be even worse than a transition to impose or increase a tax. From an efficiency perspective, a transition in which a tax is imposed retroactively may enhance efficiency—it enables the government to collect taxes without the price of deadweight loss, and it does not distort the individual's decision making because it applies to a decision he has made in the past.[130] The reverse is true for a transition in which the tax rate is decreased: society incurred the cost of the deadweight loss without reaping the benefit of collecting taxes. Firms have made decisions under the assumption that a high tax rate would apply and as a consequence reduced exploration and production, but eventually paid only a low-rate tax.

This is the caveat to the policy suggested in this Article—dynamic analysis is complex and should involve the best possible application of empirical data. There is always a significant chance that even the best-informed predictions will turn out to be false. Although it is always possible to mitigate such a mistake by decreasing the tax rate, the costs of such transitions are significant. Thus, the treatment of changes in the tax rate based on projections should be analyzed cautiously before implemented, even though it seems that one could always roll back to the previous tax rate.

---

[128] DANIEL SHAVIRO, WHEN RULES CHANGE: AN ECONOMIC AND POLITICAL ANALYSIS OF TRANSITION RELIEF AND RETROACTIVITY 2–3 (2000). It should be noted that in his book Shaviro also highlights that in some cases the transition costs are inflated: he distinguishes the transition risk effect which should not raise any efficiency concerns and the retroactive tax effect which should. *See id.* at 5–7.

[129] *Id.* at 3 (quoting ADAM SMITH, AN INQUIRY INTO THE NATURE AND CAUSES OF THE WEALTH OF NATIONS 457 (1976 ed.)).

[130] *See* Alan J. Auerbach & Laurence Kotlikoff, *Investment Versus Savings Incentives: The Size of the Bang for the Buck and the Potential for Self-Financing Business Tax Cuts*, *in* THE ECONOMIC CONSEQUENCES OF GOVERNMENT DEFICITS 121 (Laurence Meyer ed., 1983); Shaviro, *supra* note 128.

VIII. CONCLUSION

This Article opens with a quotation from Robert Frost's poem, *The Road not Taken*: "*And both that morning equally lay / In leaves no step had trodden black / Oh, I kept the first for another day*!"[131] These verses serve as a preamble to the central theme in the Article—that by imposing a high tax rate we might essentially be keeping an option for another day, and this option that is not taken into account may have considerable value. But the next verses of the poem reveal a concern about leaving a path for another day: "*Yet knowing how way leads on to way / I doubted if I should ever come back*."[132] We may never, in fact, exploit the fields put off for the future—our predictions, no matter how carefully formulated, may turn out wrong.

This Article aims at substantiating the claim that even if a high tax rate does not enable exploring and developing a field in the present, there is still a strong likelihood it will be developed in the future under the same tax rate. The reason for this is the constant technological advancements in the gas and oil sectors that should reduce costs over time. The central argument of this Article applies to taxation in general: the estimated deadweight loss of taxation may be lower than the conventional assessment due to the neglect of the option value that accompanies a tax. Taking into account the neglected option value may imply that the optimal tax rate should be higher than the current rate. The Article has focused on taxation of gas and oil since substantiating the option value in that sector is fairly easy; yet in principle, this argument could be relevant to other taxes in which there is a substantial option value that is generated by postponing present economic activity. This argument has significant fiscal implications for tax policy: the volume of oil and gas taxes in the U.S. should be much larger.

Even if this forecast is erroneous, and the technological advancements would not be sufficient for exploring new gas and oil resources under the higher tax rate, it is always possible to "roll back" to the prior development path by decreasing the tax rate. This is one of the major sources of the real option value—it leaves different courses of action open, so even if the prospects one has based his actions on have not materialized, one can hedge such a loss by going back and taking the other path that has been left open. Even though changing the tax rate may be accompanied by substantial costs, it still enables us to hedge the decision appropriately.

---

[131] ROBERT FROST, *The Road Not Taken*, *in* MOUNTAIN INTERVAL 9 (1916).

[132] *Id.*

The argument made in this Article is based on a wider claim, gaining traction in legal scholarship, that economic models of law may overlook significant dynamic elements that may have a substantial impact on the analysis. Integrating these dynamic elements may enable us to capture the effects of policy choices over time. Dynamic models are inevitably more complex, but without taking into account this complexity the conclusions of the economic analysis are likely to be erroneous. To paraphrase Carveth Read, it is better to be roughly right than precisely wrong.[133]

[133] *See supra* note 120.