

***SPECULATIVE IMPERATIVES IN THE ECONOMIC CONSERVATION OF PETROLEUM  
AND THE ABORTIVE INSTITUTIONS OF PETROLEUM EXPLOITATION***

**John Brätland  
U.S. Department of the Interior**

**April 3, 2003 (4:08 P.M.)**

**Working Paper**

**Running Head**

***SPECULATIVE IMPERATIVES IN ECONOMIC CONSERVATION***

**Address correspondence to**

**John Brätland, Ph.D.  
U.S. Department of the Interior  
1849 C Street N.W., Mail Stop 4230  
Washington, D.C. 20240**

**john.bratland@MMS.gov**

**(202) 208 3979**

## **ABSTRACT**

Economic conservation of petroleum is premised on property rights necessary to speculate. However, this process is aborted by court-imposed implied covenants that govern petroleum exploitation. These legal institutions fragment property rights. Petroleum conservation is aimed at maximizing the value of continuously evolving portfolios of investments in both old and new oil fields. Developer's portfolios evolve because depletion drives up the cost of incremental development in older oil fields. Eventually, exploration and development of new fields becomes relatively more profitable. Uncertainty highlights the importance of speculation since the choice and the timing of exploration and development projects must accommodate market change. However, the implied covenants prevent delay in receipt of royalties by expediting exploration and development. Hence, royalty owners and the petroleum developers usually have mutually incompatible objectives. Unfortunately, the laws governing leasing on public lands have codified the covenants; but expedited exploration and development are defended as a means to 'displace oil imports' and bolster the 'domestic petroleum industry.' But these constraints raise the costs and create chaos in building and holding portfolios of petroleum leases. An integration of property rights is suggested; explorers would acquire ownership and control of reservoirs by their discoveries. Covenants would no longer prohibit speculation.

# *SPECULATIVE IMPERATIVES IN THE ECONOMIC CONSERVATION OF PETROLEUM AND THE ABORTIVE INSTITUTIONS OF PETROLEUM EXPLOITATION*

John Brätland<sup>1</sup>

## I. THE PROBLEM

Perhaps more than any other economist, Ludwig von Mises fully understood the speculative imperatives of the market process. In his treatise *Human Action*, Ludwig von Mises observed that “[t]he distinctive reasoning of the speculator is an understanding of the relevance of various factors determining future events....action necessarily always aims at the future and therefore uncertain conditions and thus is always speculation” (p. 58). In his book *Socialism*, he trenchantly noted:

In the majority of cases in which it is assumed that there is a contrast between profitability and productivity no such contrast exists. This is true, for example, of the profits from speculation. Speculation provides for the adjustment of supply and demand over time and space. The source of the profit from speculation is, from a business and the economic point of view, an increase in value. The alleged contrast between profitability and productivity does not exist. ... Speculation performs a service which cannot possibly be eliminated without curtailing not only profitability but productivity as well (Mises 1981, p. 125).<sup>2</sup>

Petroleum conservation is, in the truest sense, fundamentally speculative in nature involving a perpetual sequence of choices between alternative investments and decisions bearing on the timing of these investments. This process is necessarily speculative because individual petroleum properties are subject to depletion and because reserve replacement must occur within markets that are uncertain and subject to persistent change. But the basic economic processes by which petroleum resources are conserved are in fundamental conflict with the legal institutions

---

1

John Brätland is a Ph.D. economist with the U.S. Department of the Interior. The views expressed in this study are strictly those of the author.

2

Mises goes on to note:

Economic activity is necessarily speculative because it is based upon an uncertain future. Speculation is the link that binds isolated economic action to the economic activity of the society as whole. .... In an economic system based on the private ownership of the means of production, the speculator is interested in the results of his speculation to the highest possible degree. ... If it succeeds, then in the first instance it is *his* loss. If it fails, *he* is the first to feel the loss. The speculator works for the community, but he himself feels the failure of his action proportionately more than the community. As profit or loss, they appear much greater in proportion to his means than to the total resources of society (p. 182).

defining and constraining the way in which these resources are exploited. The central issue prompting conflict is the fragmenting of property rights. Economic conservation of petroleum, as it can be manifested in practice, requires secure rights of private property in discovered, *in situ* reservoirs without which developers cannot profitably manage the resources as capital assets. Hence, conservation is an economic struggle against uncertainty and change to maximize the net present value of resources; speculative choice and speculative delay are critical to these endeavors.

However, the legal institutions that define the way in which petroleum resources must be exploited have the effect of fragmenting property rights and taking the managerial decisions out of the hands of the petroleum developer and into the hands of royalty owners. These legal institutions take the form of covenants inferred and imposed by the courts to protect the financial interests of royalty owners. The principal feature of these covenants is the foreclosure of the lessee's ability to choose the timing of exploration and development in a way that maximizes the net present value of the lease. Legal institutions have evolved in a manner that has exacerbated this clash of interests by essentially ignoring issues of efficiency and economic conservation. Claims are made to the effect that the *implied covenants of petroleum leasing* were initially intended to clarify the rights and responsibilities of both petroleum developers and lessors (surface owners) and to "determine what the developer (as lessee) is required to do for the mutual benefit of itself and its lessor" (Matlock 1997, p. 10). The phrase 'mutual benefit' is paradoxical in the descriptions of the covenants in light of the fact that the lessee and the lessor are made economic adversaries with mutually incompatible interests. More accurately put, the covenants are best described as '...unwritten promises that generally impose burdens on petroleum developers for the purpose of protecting the financial interests of royalty-owning lessors.' One begins to understand why these covenants are described as being 'abortive' in nature. In addition to the foreclosure of speculative latitude, the covenants may be enforced in a way that mandates 'excessive investment' in additional development drilling intended to protect a lease from drainage by the production of neighboring petroleum developers competitively draining petroleum from the same reservoir.

As the preceding discussion suggests, the 'excessive investment' mandated by the implied covenants is only a part of the problem (Lowe 1995, p. 336).<sup>3</sup> Of perhaps greater importance is the fact that the covenants sharply curtail the property rights of the lessee in dealing with the uncertainty of changing markets and in deciding on the appropriate time to explore, develop, produce and market the resource. Depending upon market expectations, these decisions would frequently necessitate deliberate delays. Yet the implied covenants condemn this essential and important activity as 'malfeasance' or evidence of 'presumptive incompetence.' Nonetheless, timing decisions that may involve delays are critical in the lessee's ability to efficiently manage the lease and to achieve economic conservation of the resource (as distinct from physical conservation). But delay is always inimical to the lessor's interests as a holder of an investment asset embodied in royalties receivable.<sup>4</sup> The royalty owner has the opportunity to earn a higher

---

4

As with any investor, the lessor as the royalty owner seeks to maximize the net present value of his assets. Expedited revenue recovery is always optimal for the lessor (as royalty owner) since royalty receivables, as an investment asset, generally cannot appreciate in value at a rate equal to the rate of return on alternative investments.

rate of return by quickly recovering funds from royalty receivables and immediately investing in assets that earn a higher, more competitive rates of return. Protected by the implied covenants, the lessor as royalty owner has little vested economic interest in the management of the lease as a capital asset. While the lessee and the royalty owner have mutually opposing interests, the latter's interests are most often given much greater weight by the courts in dealing with the massive stream of litigation that has persistently arisen in these adversarial relationships. While the covenants have certainly served their intended purpose over the last century, their economic legacy can only be described as one of inefficiency and economic waste. Unfortunately, this problem has been compounded by the fact that these covenants have been largely codified into public statutes governing the leasing of public lands in the United States. While the covenants have found their way into public law of petroleum leasing, the very large volume of litigation attendant to their enforcement is a symptom of grave defects in the structure of property rights applied to petroleum resources. This paper examines these issues and explores a resolution in which first discoverers would "homestead" petroleum reservoirs and acquire full and complete ownership and control of the relevant production unit (Bradley 1996, pp. 71-73).<sup>5</sup> Surface owners would no longer have a contingent claim to a share of the petroleum produced from beneath their property and would not be able to use the institutions of state-imposed law to supercede production decisions.

## II. ECONOMIC CONSERVATION AS SPECULATIVE CHOICE AND TIMING OF INVESTMENTS

The economics of petroleum conservation has rarely addressed the negative realities of petroleum exploitation.<sup>6</sup> The economic theory of petroleum conservation tends to be characterized by at least five notable features. *First*, it tends to be cast in an equilibrium framework in which the economic variables faced by petroleum developers tend to be measurable and universally recognized as objective by all market participants. In fact, no market ever satisfies these conditions. Even in economic models that purport to address market uncertainty, the equilibrium assumptions seem to be implicitly retained. *Second*, with very few exceptions, insufficient attention is given to the multiplicity of investment options presented by exploration, development activities.<sup>7</sup> The petroleum developer must apply prudent and essentially speculative judgement in choosing between the investment options that are available.

---

The lessor's interests are based on gross value of the lease since his flow of revenue is determined as a fixed percentage of the gross market values of petroleum products sold; in contrast, the lessee's interests are based on maximizing the lease's net present value. The gross value of the lease may be static or declining while the net value may be appreciating. Hence, the lessor always has a vested interest in immediate recovery and sale. But if the rate of appreciation of the net value of the lease exceeds the highest alternative rate of return obtainable by the lessee on alternative investments, delay is most efficient from an economic perspective. In essence, the lessor and the lessee have diametrically opposite incentives in terms of lease management since the legal institutions of petroleum exploitation are designed, in part, to protect the lessor, as royalty owner, from speculative delay.

6

There have been a few very general references to the "institutional milieu" (Watkins 1992, pp. 1-23; McDonald 1994, pp. 1-17).

7

The notable exception is found in the work of Morris Adelman (1995; 1993).

*Third*, conservation economics tends to ignore or under emphasize the central importance of adaptive flexibility in the timing of exploration, development and production of petroleum. Hence, little account is taken of the partial ignorance of the future that necessarily accompanies most economic decisions. Even theoretical treatments purporting to address uncertainty really ignore the realities of market change and the need to adapt plans to evolving circumstances. *Fourth*, this literature is almost totally devoid of any acknowledgment of the legal institutions that govern the exploitation of petroleum and the extent to which these institutions actually abort the speculative process and the conservation of petroleum resources.

As traditionally presented, the economic theory of petroleum conservation implicitly rests on the assumption of secure property rights. In other words conservation of petroleum requires *rights of private property sufficient to speculate in the management of investment assets*. While the term ‘speculate’ has acquired the baggage of negative connotation over the centuries, it is important to understand that it is at the heart of all market activity; no economic efficiency would ever be possible without the property rights necessary to speculate. This latitude in decision-making is critical and central to the producer’s ability to preserve and maximize the net present value of the petroleum as a capital asset. This degree of latitude remains essential even with newly emerging techniques being applied in the valuation of petroleum properties.<sup>8</sup> However, the actual legal institutions within which petroleum developers must function impose crippling economic realities with respect to rights of property.

#### **A. The general implication of uncertain and changing markets**

Real markets, unlike the markets presented in text books, are always in a process of change. Hence, the future of any market is always uncertain which means that the actions of any market participant such a petroleum developer require subjective or speculative judgment. These features apply with particular force to petroleum markets. For this reason, the process of petroleum conservation is essentially a form of robust speculation. The fact that the markets are never in an objectively definable equilibrium is the principal reasons that the economic variables (i.e., prices, costs, interest rates) confronting decision makers are subjective. Hence, timing decisions cannot be successfully prescribed through regulatory or court-imposed sanctions.

##### **(1) *the speculative nature of prices in real markets***

One can make a compelling case that most market activity is equilibrating in a rough sense of the word, but no actual equilibrium ever emerges in the real world; market changes preclude the emergence of any such state (Lewin 1999, pp. 20-39). One equilibrating activity can be seen in the fact that investors pursue investment activities by shifting the marginal investment dollar toward the highest rate of return. This process is perpetual and ongoing regardless of the

---

8

The phrase ‘new techniques’ refers to the valuation of petroleum leases as ‘real options.’ The advantages of real option techniques have been described in the following way: “ there is no need to forecast oil prices, or to employ risk-adjusted discount rates. ... This simplification removes a potentially large source of error and further reduces the judgmental component in property valuation” (Pickles and Smith 1993, p. 2).

institutional framework within which decisions are made. While at any moment in time there may be a rough alignment between alternative rates of return as they are apprehended by the individual investor, any differential in returns between actual or prospective investments will usually prompt a shift toward a higher return consistent with the investor's attitudes toward uncertainty. Moreover, petroleum markets are constantly changing which means that expected prices are always in a state of flux. These changes may be prompted by geopolitical developments, vagaries of climate or longer-term technological changes that reduce costs or shift demand to or from more intensive use of petroleum. No decision maker can point to a particular price as an equilibrium price for petroleum nor could any individual recognize an equilibrium price or equilibrium "time path" for prices were one ever to emerge.<sup>9</sup> "[T]he activities ...of actors on the economic scene are not guided by consideration of any such things as equilibrium prices...entrepreneurs take into account anticipated future prices not final prices or equilibrium prices" (Mises 1998, p. 326) "No [actor] has anything to do with equilibrium and equilibrium prices....What impels [the actor] is not the vision of equilibrium prices, but the anticipation of the height of the prices ... on the date at which it plans to sell" (Mises 1998, p.707). Hence, petroleum conservation, as it is manifested in the actions of individual petroleum developers, is a process of continuous adaptation to disequilibrium situations.

## (2) *opportunity cost as necessarily subjective valuation*

Ludwig von Mises has addressed the practical aspects of the valuation issue in the following observation: "[T]he market...deals with [firms that] are to different degrees aware of changes in the data and who, even if they have the same information, appraise it differently...different [firms] draw different conclusions in appraising their effects" (Mises 1998, p. 328). In his book *Cost and Choice: An Inquiry in Economic Theory*, James Buchanan examines the equilibrium conditions that must be simultaneously satisfied before opportunity costs can be objectively discerned from financial outlays. These conditions stipulate the following: (a) *no market uncertainty can exist*; (uncertainty means that appraisements and valuations will differ between economic agents and will tend to be subjective in nature.) (b) *no unexploited profit opportunities can be perceived anywhere in the economy* (profit opportunities emerge in uncertain, changing environments and are subjectively perceived by the actor)<sup>10</sup>; (c) *decisions must be prompted by strictly pecuniary motivations* (non-pecuniary considerations imply that actions are motivated by elements not reflected in objective market data); and (d) *decisions must be made strictly at the margin* (at the margin, no additional gains can be attained by some incremental action; non-

---

9

Mario Rizzo observes "But could we recognize an equilibrium if we saw one? ... Most importantly, a position of equilibrium is defined in relation to a set of expectations. To the extent that these expectations are not directly or indirectly observable, we could not know whether a real world state of affairs is an equilibrium or not. The empirical identification of a position as near or at equilibrium requires a knowledge of subjective states" (Rizzo 1978, p.85). See also, Brätland (2000, pp. 9-18).

10

There is some redundancy in the stipulations or conditions. If uncertainty is somehow eliminated, the stipulation that 'no perceived profits can exist' becomes essentially moot. With certainty man would never act to capture a profit and with certainty no unexploited profit opportunities could exist.

marginal decisions imply that the actor is not in an equilibrium and is still striving to avail himself of some incremental gain). This latter condition emphasizes the idea that resource employments for resource owners must be at the “margin of indifference” (i.e., no *quasi-rents* can accrue in particular employments). Buchanan is emphatic in his observation that these conditions must all hold simultaneously in order for opportunity costs to be objectively measurable magnitudes. He notes: “It is essential, however, for each of the qualifying conditions to be satisfied if marginal opportunity costs [marginal financial outlays] is to be employed as an objective representation of the subjective element that actually enters the individual’s choice calculus ..... If the whole economy is not operating at full competitive equilibrium...the evaluation of alternatives by the actual decision-taker may differ from the evaluations of any external observer...choices in disequilibrium must be informed by opportunity costs that cannot even indirectly be represented by measured [monetary] outlays” (Buchanan 1969, p. 49-50).

Ronald Coase has emphasized similar points in noting that “costs are not necessarily the same as payments. It is this fact that makes the 'costs' disclosed by cost accountants something quite different from ‘opportunity cost.’” Coase goes on to note: “.... the businessman’s attitude to risk taking, which as I have said, is purely subjective, will be an important factor determining the decision actually taken. Since no method of accounting can reproduce on paper the mental processes of a businessman, the decision to be taken is one in which no mechanical process of accounting can disclose” (Coase 1981, pp. 107-108). As examples, depreciation in the value of capital through current use and user costs (foregone future net revenue arising from current employment) associated with current petroleum recovery are two classic examples.<sup>11</sup> For projects that are underway and in production, both of these costs are inevitably imputations based on subjective judgements of future market conditions (Coase 1981, p. 115).<sup>12</sup> This judgment regarding the reduction in value from use may differ significantly from the amortization schedules contrived through an accounting rule (Buchanan 1969, pp. 49-50; Buchanan 1981, pp. 1-16). In similar manner, the “user cost” associated with the recovery of petroleum reflects the

---

11

In assessing the prospective net present value (NPV) of a “new” petroleum project, a lessee may initially employ discounted cash flow analysis (DCF). Under many circumstances depreciation and user costs would play no role in a DCF analysis. The term “new” in the preceding sentences means that the project is *not* part of a larger capital restructuring involving existing capital goods. To the extent that the project were part of a larger capital reallocation, depreciation and user cost would certainly part of the NPV analysis. But even in the case of a new project, the investor contemplating an investment would do numerous DCF analyses employing a broad range of plausible assumptions regarding the size and timing of outlays and revenues. Each of the analyses would test a different planned production scenario for the anticipated life of the project each employing alternative assumptions regarding delay and investment timing. The point of such an exercise would be to determine what production profile produces the largest prospective NPV for the project. In arriving at such a prospective maximum NPV, depreciation and user costs must be implicitly addressed in the DCF analysis. An important point to note is that these decisions are a high degree of speculative judgement.

12

One may offer the observation that production platforms have no prospective alternative employments and hence their use in the production of petroleum should involve no depreciation cost. However, the chosen structure of the production profile over the entire life of the petroleum project affects the timing and extent of maintenance costs and expenditures for capital replacement.

developer's subjective judgement of the net future economic value that is relinquished in producing "now." No such recovery decision would be made unless the estimated net benefit of current recovery was judged to exceed the subjective judgement of user cost. Not only are the decisions speculative in nature but the valuations upon which the decisions are made are necessarily subjective and can never be otherwise. These valuations will be made on the basis of the petroleum developer's judgements about the future of the market and hence, will differ between firms and will evolve as market changes unfold.

## **B. Petroleum investment as speculative choice between competing projects**

The petroleum developer always faces choice in terms of alternative investments. Presumably most of these choices will be within the petroleum industry involving an array of exploration and/or development efforts. As the opportunity cost of recovering petroleum from existing projects rises, the petroleum developer is forced to explore lands that are already under lease and to acquire new leases. In a literal sense, each of these undertakings is in competition for the petroleum developer's investment dollar. In turn, these prospective projects are in competition with other investment outlets some of which may even be outside the petroleum industry. Speculative choice between these alternative investments is a critical aspect of economic conservation of petroleum. Hence, conservation is *not solely* a process of economically depleting a given fixed stock resource but also includes investment required in the replacement and augmentation of that stock in a way that maximizes a rate of return to the investor. The process by which reserves are augmented involves a continuous response to any differentials between the rates of return obtainable from alternative investments on leases in various stages of the discovery-development-production cycle.

### **(1) *investment options available to the petroleum developer***

Exhaustion of a particular petroleum deposit will be reflected in higher marginal costs of production.<sup>13</sup> All petroleum developers must face this reality with respect to all producing properties that they control. Hence, reserves must be replaced or augmented as petroleum developers encounter rising opportunity costs of producing from older fields. At any moment in time, the petroleum developer faces an array of investment options from which to choose. This array creates a competition for the marginal investment dollar and means that at any one moment in time, the petroleum developer will be managing a constantly evolving portfolio of petroleum assets. *First*, the developer always has the option of investing outside of the petroleum industry if the prospective rates of return appear to be greater than those that seem to be possible through investment in petroleum projects. *Second*, the developer always has the opportunity to undertake more intensive development in older fields. But eventually, the increasing opportunity costs depress the rate of return on such investments below that obtainable elsewhere. As a *third* option, the developer may consider more intensive development of newer fields from which it

---

13

The term "marginal" as used in the paper retains its traditional meaning in economics. In this sense, the term is roughly synonymous with "incremental" or "additional." It does not mean 'minimal,' 'inferior,' or 'substandard.'

may currently be producing petroleum.<sup>14</sup> But newer fields eventually become older fields and recovery of additional petroleum will at some point become so costly that termination of production is the only viable course of action. In these latter two alternatives, increases in incremental opportunity cost drive down the marginal return obtainable by the developer from any increase in development and current extraction.

When the rate of marginal return on development and recovery is driven below the rate of return on competing investments (an opportunity cost), the developer has a *fourth* option of undertaking exploration efforts on existing but unexplored leases in hitherto unexplored areas.<sup>15</sup> But as marginal costs are driven upward on existing leases, eventually the rate of return on the marginal investment dollar committed to exploration, development and recovery declines, the developer will be forced to seek still other alternative avenues for investment. In choosing from among alternative investment opportunities, the petroleum developer may choose a *fifth* alternative that involves the acquisition of new leases. Such leases may be in areas in which the developer has already made investments or the developer may seek to obtain leases in areas that are considered 'frontier regions.' Again, the developer's principal objective in acquiring new leases will be to maintain or even increase the rate of return on the marginal investment dollar. But at any given moment in time, most petroleum developers will be managing a portfolio of projects falling into several of the above categories.

## (2) *opportunity cost and speculative tradeoffs within investment portfolios*

In his book, *The World Oil Market*, Morris Adelman observed: "At the margin, development cost in known fields equals finding cost plus development cost in new fields" (Adelman 1972, p. 6). What is Adelman driving at here? The higher cost of finding petroleum in new fields will drive up development cost in known fields as the latter are more intensively developed. Without new discoveries, the petroleum developer must incur higher development cost as old reserves are depleted. "Discovery is necessary to stave this off." But, in turn, increasing development cost in mature fields will induce petroleum developers undertake exploration in new fields and to invest in the acquisition of new leases. The marginal development cost in mature fields establishes an upper limit on the incremental cost of finding and developing new reserves. If the latter

---

14

In evaluating such investments, the developer will estimate a probable future time stream of revenues from such a venture and a time stream of investment outlays and addition operating expenses that would follow such development as newly developed reserves are produced. The developer would then attempt to determine what rate of discount will make these two time streams of estimated revenues and outlays equal to each other. This discount rate would represent the estimated internal rate of return for this prospective investment option. The developer will conduct a series of such valuations for each of the prospective development options it sees as being available.

15

A rate of return on exploration expenditures can only be estimated in the context of portfolios of ventures. With the use of probabilities of exploration success over a range of exploration efforts, the firm is able to estimate an expected cash flow that may be forthcoming from the expected percentage of successes within a portfolio of incremental expenditures on exploration. In judging the prospective rate of return on exploration investments, the firm will project tentative schedules of subsequent development and recovery taking into account the probabilities that economic discoveries may be made.

incremental costs exceed, the marginal cost of development in mature fields, resources have been wasted. But since, opportunity costs are inherently subjective for the petroleum developer, no empirical basis exist by which an external observer can determine if ‘wasteful decisions’ have been made or if prospective decisions are wasteful.<sup>16</sup> The array of investment options and the subjectivity of opportunity costs convey the reality of the conservation process; developers are constantly driven into considering newer prospects and possibly more ‘risky’ undertakings. This being the case, these investments are not mutually exclusive. At any one moment in time, most petroleum developers will be undertaking alternative investments that fall into various categories of risk and prospective return. Hence, every petroleum developer will be faced with the task of speculatively managing a constantly evolving portfolio of such ventures.

The process of petroleum conservation is essentially a process by which all petroleum developers manage such portfolios seeking the highest rate of return consistent with the developer’s *subjective attitude* toward geological risk and market uncertainty.<sup>17</sup> Clearly ‘management’ of the portfolio is a fundamentally speculative process in major part because the reckoning of opportunity costs requires subjective judgement. Adelman observes: “In thousands of projects, there are comparisons between the market value and the cost of reserve additions in reservoirs exploited; known but unexploited; incompletely known; suspected; hoped-for... and so on...” (Adelman 1993, p. 243) “Marginal opportunity cost, in each is constantly driven toward equality with opportunity cost everywhere else. Therefore, change in any type of cost is a proxy for change in every other...” (Adelman 1993, p. 222). In other words, through a process of conscientious speculation, each of these rates of return is opportunity costs in committing to a particular investment. In making individual decisions on these competing investments, the next most-attractive, relinquished rates of return are always part of opportunity costs associated with committing resources. If the rate of return on development investments in older fields appears to decline relative to the rate of return on investments in exploration, development and recovery in newer fields, then the lessee will shift resources to the latter.<sup>18</sup> In this example, part of the opportunity cost of development will be reflected in the higher rate of return on exploration. When the opportunity costs become too high, it is a signal to shift the direction of investment.

The preceding discussion emphasizes that petroleum conservation is a process occurring over a broader range of investment activities involving numerous leases and concessions some which have yet to be explored and others requiring an additional round of more intensive development investment; existing reserves are perpetually augmented as new discoveries on new leases are made and previous discoveries are developed. Here again, what is considered the next ‘most attractive’ investment will be strongly colored by the investor’s attitude toward the perceived uncertainty associated with the alternative investments. Specifically, the rate of return chosen as

---

17

In the context of petroleum economics, the concepts of risk and uncertainty are legitimately distinct; ‘risk’ is appropriately applied to the quantifiable probabilities associated with discovery, for example. ‘Uncertainty’ is properly applied to the subjective inferences regarding the future of the market; while the economics profession has struggled to deny the fact, these subjective inferences are not amenable to the use of probabilities in the quantitative sense. Ludwig von Mises employs the terms *class probability* and *case probability* to draw distinctions between these concepts ( Mises 1998, pp. 105-118).

“next best” will be a matter of subjective conjecture since the choice is always conditioned by the decision maker’s attitudes toward the risk and uncertainty associated with the different investments. These ‘attitudes’ are necessarily unique to the investor. The important point to note in this process is that it can only unfold as a process of continuous speculation. Speculative choices are integral to this conservation process and cannot properly function without latitude in making speculative choices from among these respective investment outlets.

### C. Timing issues in the speculative choice of conservation investments

Speculative timing in exploration and development is necessary in efforts of petroleum developers to respond to market conditions in efforts conserve the net present value resource. These responses may include one or more of the following: (1) to delay operations when confronted with the likelihood that the net value of the *in situ* resource may be increasing at a rate equal to or exceeding the rate of return on the next most profitable investment; (2) adapt the timing of investments in light of fact that the petroleum market is always evolving and subject to unexpected change; and (3) apply the best subjective judgment possible in trying to interpret the future of the market and the ways in which investment plans may be affected.

#### (1) *the rate of appreciation of net economic value as a rate of return*

If the net economic value of a lease is appreciating, timing decisions themselves become a critical determinant of the prospective rates of return on competing investments. The prospective net present value of particular petroleum deposits may well be increasing with the passage of time and this rate of increase could well exceed the rate of return obtainable on competing investments. Such scenarios are usually premised on the increasing global scarcity of petroleum.<sup>19</sup> But scarcity of petroleum need not be the reason for an increase in the net present value of a petroleum deposit. The net present value of a petroleum deposit may be increasing as a result of declining costs induced by technological improvements. Improved technologies in exploration, development, production and the most ‘efficient’ means by which petroleum can be brought to the highest-paying market are a more likely reason for increases in net present value. Each improvement in technology could have the effect of driving down opportunity costs. The implication of this observation is that delay may still in some cases be an important speculative strategy in efforts to maximize rate of return on petroleum investments. Such a delaying strategy would be particularly important in the case of marginal petroleum deposits that may be too costly to explore or develop at the present time. Marginal and uneconomic petroleum properties will be discussed at greater length below.

One note of clarification is in order regarding (1) rates at which unrecovered reserves appreciate in market value and (2) decisions to develop and produce petroleum reserves. The famous Hotelling Principle states that if the rate of appreciation in the value of undeveloped reserves fails to equal the rate of return obtainable on competing investments, it is a signal to the petroleum developer to recover the resource and the invest the proceeds in the most profitable competing investment.<sup>20</sup> However, the entire deposit cannot be recovered instantaneously and

---

20

This simple decision rule for economic conservation of a resource has come to be known as the Hotelling Principle.

sold in a manner that will allow all the proceeds from the petroleum deposit to be invested in the more profitable undertaking. Much of the recoverable petroleum must remain unrecovered and in the ground over the decades that define the productive life of the oil field. But how is the petroleum developer to be compensated for the discrepancy between the competitive rate of return obtainable on the most profitable alternative investment and the lower rate at which *in situ* undeveloped reserves are appreciating in value? One notes that the petroleum developer will seek a means to be compensated for this discrepancy by designing the project and developing the reserves on a scale that will yield a 'rate of payout' of cash flow sufficient to cover this discrepancy (Siegel, Smith and Paddock 1987, pp. 22-30). The rate of payout is measured as a percentage of the market value of remaining developed but unrecovered reserves. The sum of the payout rate from recovery plus the rate of appreciation of the unrecovered reserves represents the lessee-investor's rate of return on the petroleum investment project. This total rate of return should be at least equal to the rate of return on competing investments over the time period in which reserves are recovered from the project.

(2) *adaptability to market change as critical to timing of investments*

Economic conservation of petroleum is a continuous speculative process of adapting to changing circumstances. These changing circumstances may be geologic, political, technological and economic in origin. For example, some exploratory efforts may be much less successful than had initially been anticipated by individual petroleum developers searching for new oil deposits. In other instances, discoveries may involve higher development costs than had previously been expected. Political circumstances may include the imposition of unexpected regulatory sanctions, difficulties in negotiating unit agreement for operations on a particular discovered reservoir or, changes in the production policies of the world's major oil producing countries who may be members of the Organization of Petroleum Exporting Countries (OPEC). Technological advances can reduce costs of exploration and development or create an expectation that these costs will be significantly lower in the more distant future. Advances in technology may also be the source of expected decline in long term demand for petroleum products such as gasoline. Also, on a world wide basis, proven reserves could be growing at a previously unexpected rate creating an expectation of lower long-term petroleum prices.

All of the above circumstances require flexibility in adapting plans to changing circumstance. This changed circumstance will inevitably involve some shift in the planned allocation of resources and, in some cases, delays in commencing certain activities such as exploration or development. In other cases, an acceleration of previously planned activities may appear to be warranted. But again, one notes that the essence of this adaptive process is speculation in the purest sense of the word. Stephen McDonald observes the following with respect to the importance of speculation in economic conservation: "The optimum time-distribution of production is defined for one point in time only. It changes as its determinants change from point to point in time. In particular, it changes with every change in current and expected costs and prices. .... Thus, continuously maximizing net present value (continuously conserving) *requires flexible adjustments* in the time-distribution of production as the economic values

---

(Hotelling 1931, pp. 137-175).

reflecting sacrifice and gains of satisfaction (costs and prices) change over time” (McDonald 1971, pp. 83-84).<sup>21</sup> One notes that Stephen McDonald does not use the term *speculation* in his observation. However, the quote makes clear that what he is describing is a fundamentally speculative process. While McDonald’s comments focus on the need for flexibility in the timing of production, by extension, his remarks also have a direct relevance to the timing of all exploration and development activities. McDonald’s observation highlights the fact that efficient timing of activities on petroleum properties is in a state of constant adjustment as the market changes. Hence, timing agenda and or investment schedules are subject to revision by the petroleum developer because prior to the point at which costs are sunk, these decisions are inherently, necessarily and appropriately speculative. For example, *in the judgment of a lessee*, the net present value of the unexplored or undeveloped lease may be appreciating in market value more rapidly than the lessee’s next best alternative rate of return. Anticipated improvements in certain technologies may prompt such expectations. Delay is always warranted in such circumstances.

Market changes can be reflected in changing levels of oil-price volatility. Volatility in oil price is necessarily reflected in the market prices of both undeveloped and developed reserves. Ordinarily price volatility would be associated with greater uncertainty which, in turn, would usually be detrimental to investment value. However, the uncertainty manifested in oil-price volatility is a source of enhanced-investment value for both undeveloped and developed reserves. This enhanced value is particularly important in the case of both marginal and currently uneconomic petroleum properties; the enhancement in investment value arises from the latitude afforded the developer in delaying both exploration and development. This source of increase in value is referred to as *option value*; the petroleum lease itself is viewed as kind of option to obtain an underlying asset such as undeveloped reserves or developed reserves. In much the same manner as a stock option presents its owner with the option of buying a particular stock (the underlying asset) at a pre-specified price during the period in which the option is ‘open,’ the petroleum lease provides the developer with an option to obtain an underlying asset.<sup>22</sup> In the case of both stock options and real options such as petroleum leases, the volatility in the price of the underlying asset makes delay a critical element to the process of economic conservation. The logic of this relationship is that the holder of the real option is afforded “windows of opportunity” in which to exercise the option when the market price of the underlying asset exceeds the pre-specified exercise price. In fact, in the valuation of real assets such as petroleum leases, option valuation finds its most useful role in those situation in which the market value of the underlying asset fluctuates, instances in which outlays are not recoverable (i.e., are sunk) and those circumstances in which there is value to being able to delay commitment of resources (Dixit and Pindyck 1994, p. 4).

Two important features of option valuation should be highlighted in noting its applicability to the valuation of petroleum leases. *First*, the critical element in enhancing the value of the underlying asset is the upward volatility since in, the holding of the option, downside volatility

---

21

As the following discussion will make clear, McDonald’s insights are not made obsolete by the possibility of using ‘real option’ techniques to value oil and gas tracts.

does not result in any downside losses. While such petroleum properties may increase in value as the result of technology-driven, downward trends in costs of exploration, development and production, increases in the value of such investment prospects are as likely to arise from the upside volatility of the market price of petroleum. In much the same manner, an option to buy a particular stock is made more valuable by the upside volatility in the price of the stock itself. In the former case, the more volatile the market prices of developed reserves, the greater the option value of the petroleum lease. *Second*, this approach to valuing leases is made possible by the fact that the underlying assets, in this case, developed reserves, are traded in the market and have an existing market value (Adelman 1995, pp. 20-22). Since the underlying asset is traded in the market, real option valuation of investments makes efficient use of existing, readily available market information.<sup>23</sup> But the analytical superiority of the real option technique does not diminish the importance of speculation in the process of conserving the economic value of the petroleum resource. In fact, use of real option techniques is an important form of speculation and cannot be fully and effectively employed without the ability to alter plans in response to market change.

### (3) *applying the best subjective judgements in timing decisions*

Socially optimal timing decisions by petroleum developers can only be given objective definition under implausible equilibrium conditions that can never be simultaneously satisfied in the real world. But, in a disequilibrium world in which the valuations are inevitably subjective, decisions are always tentative conjectures made on the basis of an interpretation the “best information” available. Hence, in perpetually changing markets, the process of speculation is indispensable in allocation of petroleum over time. In making timing decisions, petroleum developers try to apply their best understanding of the future in attempting to maximize a net return on investment. But expected values for net revenue that may accrue at different moments in future time are subject to change as the conditions of the market change. Since all timing decisions for petroleum investors are inevitably made within a market environment that is constantly evolving, judgement inevitably become the critical element defining the nature of the decision-making process. But from an *ex post* perspective, no judgement is necessary in assessing past decisions; past market change may subsequently reveal that other timing decisions may have been more successful than those initially implemented. After the fact, one can, with some analytical effort, discern what timing decisions made by petroleum developers have been most effective in

---

23

Real option techniques used in the evaluation of leases employ current market prices thus allowing the petroleum developer to avoid forecasting future petroleum prices. But in addition, the real option technique of valuing petroleum leases relies on the use of a riskless rate of interest thus avoiding the need for subjective adjustments to account for ‘market risk.’ The valid use of a riskless interest rate is contingent upon the real option being properly valued at all points in time. Since the market value of the developed reserves is subject to market fluctuations, the development option held by the lessee must be valued in a way consistent with a hedged portfolio that contains the development option itself and a *short market position* in the developed reserves which are traded on the market. The object of the hedge in this case is to hold both the option and the *short position* in the developed reserves in relative combinations or ratios that permit any capital gains (or losses) in the developed reserves to be exactly matched by equivalent capital losses (or gains) on the development option. The development option is ideally priced when the market establishes an equality between these prospective capital gains and losses (Dixit and Pindyck 1994, pp. 31-33).

maximizing the value of petroleum resources. With this hindsight, 'bad decisions' can stand out in bold relief and one can readily point to those timing choices which in retrospect appear to have been mistakes. But *ex post* judgements of earlier decisions made on an *ex ante* basis are essentially moot. What is relevant is the interpretation that the decision maker is able to put on the information that is actually available at the time that decisions are made.

The fact that petroleum markets are subject to persistent change and economic uncertainty gives rise to a multiplicity of expectations and plans on the part of those considering exploration or development decisions. A multiplicity expectations and plans necessarily account for the reality that, in real markets, optimal timing never has any objective existence that can be observed or prescribed by anyone. A timing decision, to the extent that it is ever thought of as "optimal," can exist as subjective conjectures in the mind of the petroleum developer. But such judgements can only be tentative prior to the implementation and the commitment of capital. As markets are subject to perpetual change, petroleum developers will not necessarily view the future of the market in the same way nor necessarily develop the same "best plan" for exploration, development and production on a particular leased tract. The need for speculative flexibility is made evident by the fact that "optimal-timing decisions," to the extent that they can ever appear to be such, change through time as the expectations and perceptions of petroleum developers respond to constantly evolving market conditions.

As noted above, the option valuation technique makes excellent use of existing market information in relieving the lessee-operator of the task of estimating future cash flows. However this valuation technique is not free of subjective judgement. For example, different petroleum developers tend to view the future differently, taking into account different subjective considerations in trying to judge the future volatility of petroleum prices. The volatility assumption can profoundly affect the valuation of the lease and the planned timing of exploration and development.<sup>24</sup> It is of note that the period of time to expiration for the petroleum lease covers a term during which several types of market changes can affect oil-price volatility. Periodic lapses in OPEC strength would be one such example. Realistically, any cartel such as OPEC is persistently subject to cheating on the part of its members. To the extent that cheating

---

24

Radford Schantz of the Minerals Management Service in the Department of the Interior has conducted an econometric examination of historical real petroleum price volatility for the period 1974 to 2001. His analysis yields an estimate of 22 percent as the real oil price volatility for that 27 year period. But his analysis for the more recent period 1986 to 2001 indicates volatility for real oil price of 27 percent. The real natural gas-price volatility for the period 1974 to 2001 is shown to be 27 percent but for the period 1986 to 2001 the historical volatility was found to be 34 percent. Radford Schantz surmises that the differences in the volatility estimates derived for these two time periods is explained by structural change in the market during the mid 1980's. But again, the central issue is the extent to which these estimates bear on the volatility likely to be experienced in the future. While there is every reason to believe there were structural changes that occurred during the mid 1980's, it is also a practical fact that structural change is a persistent phenomenon at work in all markets during all time periods. Just as the volatility in petroleum prices for the years 1974 to 1986 was an inaccurate indicator of actual price volatility for the period 1986 through 2001, this later period may be a very poor predictor of future volatility in the decades ahead. While such historical measures are intended to serve as estimates of future price volatility, their most compelling contribution is in providing empirical evidence that the volatility of petroleum prices is prone to change. This information was received through personal communication on November 20, 2001.

is occasionally detected and becomes known, the cohesion of the cartel is jeopardized and the members become competitors with the consequence that prices will fall. Nonetheless, the specter of periodic OPEC strength has created uncertainty over petroleum prices. This uncertainty has prompted more intensive exploratory activity around the world and the development of less costly, more efficient exploration, development and production technologies. While none of these changes would necessarily cripple the OPEC cartel, they would certainly affect judgements regarding oil-price volatility. Hence, even the practice of employing simple extrapolations of historical oil-price volatility involves subjective judgements. Such speculative judgement is essential in dealing with this uncertainty over future prices.<sup>25</sup>

In addition, different firms will be affected differently by changing market conditions and will frequently place their own interpretation on what these events may mean to the firm. Thus, at any particular moment in time, those timing decisions seen as somehow “optimal” are necessarily unique to the individual petroleum developer. In principle, no scientific or objective means exist to determine, before the fact, that one petroleum developer’s plan is “better” than that of another petroleum developer. In other words, the degree to which a petroleum developer’s plan is “optimal” only has meaning within the context of the petroleum developer’s own decision-making; there is no “socially-optimal plan” which can be defined and imposed on the petroleum developer through regulatory decree. But, by granting sufficient speculative latitude in decision-making, society benefits from the diversity of perspectives held by petroleum developers because, after the fact, some plans will be shown to be both more profitable and more beneficial to society. In exercising this latitude, petroleum developers render a “conservation” service by making the timing decisions which result in the production of oil and gas when they are valued most highly by society. If speculation is somehow precluded because of conditions specified or implied in the petroleum leases the process is necessarily chaotic and inefficient

### **III. THE ABORTIVE INSTITUTIONS OF PETROLEUM EXPLOITATION**

If petroleum conservation must be viewed as speculative investment, do the institutions of petroleum exploitation accommodate this reality? In fact, petroleum conservation is entirely at odds with these institutions. Uncertainty and change mean that choices between alternative investments are inherently speculative, requiring subjective judgement and property rights necessary to exercise these judgements. Petroleum markets are subject to long cycles of change some which are triggered by receding or advancing OPEC power, technological change, global business cycles or a combination of these events. Investment plans can be quickly obsolesced by events; institutions must foster adaptability and flexibility if efficient economic conservation is ever to be attained.

#### **A. The emergence of fragmented and conflicting property interests**

---

25

Avinash Dixit and Robert Pindyck suggest that an estimate of future oil-price volatility could be arrived at through a survey industry experts (Dixit and Pindyck 1994, p. 400).. But obviously, this suggestion only highlights the degree of subjectivity implicit in such estimation procedures.

An early interpretation of the surface land owner's rights to subsurface minerals was first enunciated by the British jurist, William Blackstone: "land hath also, in its legal specification, an indefinite extent, upwards as well as downwards....downwards, whatever is in direct line between the surface of any land and the center of the earth....if a man grants all his lands, he thereby grants all mines of metal and other fossils. This is incorporated in the fundamental law of the land" (Blackstone 1908, pp. 404-405). However, this interpretation of mineral ownership encountered difficulties in its application to *in situ* petroleum and the unusual properties of petroleum reservoirs. These properties include the following: (a) The areal extent and configuration of oil and gas reservoirs are such that the reservoir may lie under the land of several different surface owners each of which could establish a private property claim to the resource to the extent it were captured in production. (b) The apportioning of petroleum ownership on the basis of surface property titles is not possible because the volume, size or extent of the deposit remains largely uncertain until the deposit is exhausted economically. (c) The migratory nature of petroleum means that resources can be extracted from the reservoir in a manner that draws the resource from beneath the land of several different surface owners (Bradley 1996, p. 59). The fact that petroleum migrates laterally has fostered several different theories of ownership as evinced by the fact that across the United States individual states embrace different theories of petroleum ownership in their application of petroleum law (Williams and Meyers 1993, Sec. 203.1-203.3; Lowe 1995, 29).<sup>26</sup> While a full review of these theories and their respective complicated histories is well beyond the intended scope of this paper, what has emerged in practice is an explicit acknowledgment of the *rule of capture*. Because of the fluid, migratory nature of subsurface petroleum, a *rule-of-capture* has evolved such that the surface owner has no property claim to a discovered reservoir and neither does the discoverer. The petroleum is not actually owned by anyone until it is actually captured at the surface. The petroleum is in a literal sense an unowned resource until it actually appears at the wellhead. The rule of capture applies irrespective of the fact that the petroleum resources may have migrated from beneath another surface owner's property.

In a sense, the *rule of capture* appears to partly nullify Blackstone's conception of property ownership in land, but his interpretation is the apparent basis of the surface owner's right to a royalty share of the petroleum finally captured at the wellhead located on the surface owner's land. Given that the surface owner has a contingent stake in what is produced, the petroleum deposit must yield an economic rent or income over and above all of the opportunity costs incurred in the exploration, development and production of the resource.<sup>27</sup> If there were no such

---

26

John Lowe notes that "the theory of ownership embraced by a particular state is likely to be of more importance to law professors than to mineral owners....Which theory applies may be crucial to specific fact situations. On a day to day basis however, the similarities in the rights of mineral owners in non-ownership and ownership in place theory states are far greater and far more important than the difference" (Lowe 1995, p. 39).

27

In accounting terms, economic rent can be simply defined as gross receipts from sales of production minus the sum of (1) operating expenses, (2) depreciation charges on invested capital, and (3) a competitive return on invested capital (Gaffney 1977, pp. ).

prospective surplus generated, there would be no incentive for the land owner to grant drilling rights to a prospective lessee. Moreover, the explorer-developer would have no basis for compensating the land owner for the rights to explore. While, this compensation could take the form of a lump-sum payment (e.g., a bonus) to the surface owner, uncertainty pervades all aspects of investment in petroleum operations. Prior to the discovery of a sufficiently economic deposit of petroleum there is no assurance that any economic rent even exists. There is no assurance for prospective lessees that anything will be found and that the lessee will not sustain a loss on the exploration effort. But a lease contract specifying a fixed percentage royalty on the *gross market value* of the petroleum produced and sold makes it possible for lessors to capture economic rent on a contingent basis. Lessees are able to obtain leases with lower bonuses and lessors are provided with a means of sharing investment uncertainty and geologic risk with the lessee. Hence, the royalty obligation appears to be mutually beneficial to both parties.

Why would a lease contract with a fixed-percentage royalty provision harbor any problems for the economic conservation of petroleum? Traditional criticisms of the royalty feature of petroleum leases have usually focused on the fact the fixed royalty created an incentive to leave more petroleum unrecovered than would otherwise be the case. The lessee more quickly reaches a point in the productive life of the reservoir in which the marginal cost production, inclusive of the fixed-percentage royalty, exceeds the market price obtainable on the last barrel produced. Another criticism is that the royalty obligation creates an incentive for the lessee to delay operations on the lease. Hence in these two ways, economic conservation of the petroleum is affected. But the problem goes much deeper. *The central issue is that the fixed percentage royalty confronts the royalty-owning-lessor and the investing lessee with mutually and fundamentally incompatible objectives.* The lessor receives a fixed percentage of the gross value of the petroleum that is produced and sold. In almost all circumstances, the capitalized value of royalty-receivables depreciates with delay (Brätland 2001, 694-695). This fact means that any delay in exploration, development or production is always detrimental to the financial interests of the royalty-owning-lessor. Any action on the part of the lessee in which he fails to expeditiously recover all of the petroleum possible is detrimental to the interests of the royalty-owning-lessor. Hence, if the royalty-owning-lessor views the capitalized value of the royalty stream as an investment asset, *he will want to see the operation managed so that the present value of the operation's gross revenue stream is as large as possible.* Expedited activity on the lease is always critical to the royalty owner's interests while speculative timing of activity on the part of the royalty-paying lessee is anathema to those interests since responsible speculation may involve delay.

## **B. Protection of the royalty estate and its implications**

The royalty interest premised on the Blackstone interpretation of land ownership establishes a clash of interests between the royalty-owning lessor and the royalty paying lessee. While the royalty owner's principal concern is the gross value of the operation, the lessee's chief objective is the maximization of net present value and having the flexibility required to seek this objective. In a general sense, economic efficiency is about actions that promise to yield the greatest net gain and is always the principal objective of any investor. This objective can only be attained through speculative activity (Mises 1998, p. 251). Market uncertainty and economic change

mean that speculation is critical in managing capital assets. For the investing petroleum developer, delay in exploration, development or production will sometimes be critical to the efficient management of the investment project. The developer as a lessee may refrain from some incremental investment because the prospective net return is less than the net return that the lessee may be able to obtain on other investment outlets. Such speculative decisions would be integral to an efficiently managed operation and to the economic conservation of the petroleum. But the covenants impose requirements that obligate petroleum developers to expedite all activities on the lease including exploration, development and production.

**(1) *Covenants implied to protect the interests of the royalty owner***

The more troublesome management conflicts emanate from the effects of the implied covenants that have been imposed by the courts to ‘protect of the royalty estate’ owned usually by the surfacing-owning lessor. In general the implied covenants impose a series of demands upon the lessee to manage the leases in a manner that protects the financial interests of the royalty owner. Unfortunately, these demands generally have the effect of superceding the most basic decisions regarding the efficient management of petroleum leases. All of the implied covenants bear on the timing of lessee activities in the management of the lease. To this extent, the covenants have been designed to protect the property interests of the lessor largely at the expense of the highly-attenuated property interests of the lessee. Historically these covenants were assumed to be necessary because traditional lease agreements do not usually set explicit requirements for the operation of the lease property or the marketing of the product once production commences.<sup>28</sup> The implied covenants implicitly obligate lessee manage the lease in specific ways.

*First*, the lessee is obligated to *expeditiously explore* the lease. The timing of exploration is only one phase in the management of the capital asset embodied in the lease. When viewed in this context, one can clearly see that exploration decisions must be closely tied to market-price expectations. In trying to responsibly manage the lease, the lessee may be best served by decisions to postpone or delay exploratory activity. However, the implied covenant to expeditiously explore largely strips the lessee of the market prerogatives and in some cases may force the lessee into an exploration program that may be premature from the perspective of the

---

28

An examination of the literature on these covenants reveals two different perspectives on how they have been viewed. One group of writers tends to describe the covenants as clarifications of the unexpressed intentions of both the lessor and lessee (Lowe 1995, p. 297) The covenants are described as unwritten promises that “... have been fashioned by the courts to fill the [lease] drafting void in the context of particular facts” (Matlock 1997, p. 10) In light of the facts arising in particular situations, the courts establish what action is expected by the lessee for the mutual benefit of both the lessee and the lessor. With reference to ‘mutual benefit,’ however, one must note the absurdity of this claim. There is nothing in the covenants that serves the interests of the lessee in his efforts to efficiently manage the lease. Another group of writers takes a contrasting perspective on the implied covenants. They note that “implied covenants impose duties upon lessees because those duties [directives] are necessary to achieve a fair, equitable and just result”(Lowe 1995, p. 297). It is this latter perspective that is more troublesome since it represents the reality of the fact that the courts view the covenants as *dictums* [not unexpressed intentions] with which the lessee must comply. To this extent, the implied covenants are legally sanctioned infringements on the property rights of the lessee in managing the capital asset embodied in the lease. They encroach on the lessee’s latitude in managing the lease property and in adapting to changing oil and gas markets.

efficient capital management, or, what is the same thing, conservation of the resource.

*Second*, with due diligence, the lessee must conduct development of discovered petroleum deposits. “Failure to do so deprives the lessor of the use of the royalty that he or she otherwise would have received, prevents the lessor from making other arrangements to develop and suggests that the lessee lack the economic motivations of the prudent business person” (Lowe 1995, p. 304). Any delays in the development of the lease or of an apparent failure to undertake additional development usually prompt the inference of incompetence or bad-faith speculation on the part of the lessee (Lowe 1995, pp. 305-306). But this covenant imposes pressure on the lessee to commence development ahead of a schedule that, from the lessee’s perspective, may best enhance the net value of the lease. The net present value of the undeveloped lease may be appreciating in market value more rapidly than the lessee’s next best alternative rate of return. Delay is always warranted in such circumstances since it can be an integral part of maximizing the present value of the lease. However, because of this covenant, the lessee is not able benefit from this delay and appreciation in the value of the lease. Without some latitude in speculation, the lessee cannot manage the lease as a capital asset. If the lessee has waited for what may appear to be an extended period without development, lessee is prone to a legal challenge from the lessor.

*Third*, the lessee has a duty to promptly protect the lease property from drainage by the activities of other petroleum developers operating on neighboring tracts but competitively producing from the same reservoir. The covenant is designed to deal with situations in which the areal extent of the producing lease is smaller than the areal extent of the producing reservoir and that other neighboring or adjoining leases are also producing from the same reservoir. Within a producing reservoir, oil and gas may migrate as production commences which means that production from a neighboring lease can drain petroleum from under another lease. The implied covenant *to protect the lease property from drainage* obligates the lessee to deal with such a situation by drilling ‘offset wells’ or protection wells and securing the production that would otherwise be lost to competing leases. Although most commentary on this covenant does not seem to acknowledge the fact, this implied covenant also has a negative impact on the timing of development and production from petroleum reservoirs. The mandated additional drilling on each lease is the way in which this competition is manifested on the part of each lessee. But in this competition everyone can lose. As petroleum developers compete or as production from each lease competes, production from the reservoir is accelerated with the likely result that the reservoir pressure is depleted and less production is ultimately obtained from the reservoir. In other words the reservoir as a whole may be wasted as a result of competitive production; moreover, the present value of the reservoir as a whole is reduced even though the total ultimate production from an individual lease may be increased as a result of the drainage-protection measures. An important second consideration in considering the waste associated with the drilling of protection wells is that drainage of petroleum from leases may, in many cases, be a normal consequence of orderly and timely production from the reservoir as a whole.

The actions undertaken to prevent inter-lease drainage by individual petroleum developers operating on competing leases can significantly distort the timing and extent of production from an individual reservoir. Not only is wasteful incremental drilling undertaken but the present

value of the producing reservoir is diminished. The reduction in present value of the reservoir is reduced for two reasons. First, the total ultimate recovery from the reservoir is probably reduced because of depletion of pressure and second, the rate of production during each period in the reservoir's production horizon is at odds with a rate that achieves economic conservation. The efficient solution to the drainage problem is unitization or pooling in which the reservoir is managed as a single operation with the goal of maximizing the present value of the reservoir.<sup>29</sup> This unitization should be done as early as possible in the development of the reservoir. Not only should all of the leases on the reservoir be brought into the unit but the unit must include an explicit agreement on the sharing of aggregate royalties. Of course, a great deal of time and effort may be involved in forging such an agreement (Weaver 1986, pp. 29-33).

## (2) *economic implications of the implied covenants*

In the context of the petroleum lease, the lessor's economic interests are defined by the attainment a rate of revenue recovery that maximizes the present value of the royalty-receivables revenue stream. Expedited revenue recovery is optimal for the lessor and the covenants provide the means by which this objective can be met. As with any investor, the lessor seeks the highest rate of return obtainable from alternative rival investments. The lessor seeks to earn at least a competitive rate of return on all its investments and prospective investments. These investments include all other alternative competing investments in addition to royalties receivable. If the rate of return from its competing investments is higher than the rate of appreciation on royalty receivables, the lessor will want to see the lease managed so that exploration, development and production on the lease property will be accelerated. An accelerated schedule means that royalty proceeds are acquired earlier and are available for investment in assets earning a competitive rate of return.<sup>30</sup> Of course, any rate of appreciation in the royalties receivable will never equal the rate of return on alternative investments. In fact, in most cases the rate of appreciation in the present value of royalties receivable will be non-existent; the lessor earns a higher rate of return by extracting funds from royalties receivables and as quickly as possible investing in assets that earn a competitive rate of return.

One point to note in the lessor's quest for the highest rate of return is that it cannot succeed unless the possibility of speculation is foreclosed for the lessee. While a sound and compelling

---

29

Mandatory unitization through regulation has been vigorously championed by Stephen McDonald (1971, pp. 229-252). Another thoughtful discussion of unitization is found in Lovejoy and Homan (1967, pp. 59-96). Unitization would place the entire reservoir under the management of one operator; this operator would be chosen by the lessees in a position to recover petroleum from the affected reservoir. Of course all of the other covenants would continue to be binding upon the petroleum operator managing the reservoir.

30

Another covenant inferred by the courts is the duty to diligently market the oil and gas produced on the lease. The lessee would ordinarily make decisions to market based on the prices prevailing in the market. In some cases, if oil or gas prices are particularly depressed, the appropriate course of action may be to shut in the lease and wait for the return of higher prices. However, any such action on the part of petroleum developers may in any given instance trigger a legal challenge from the lessor as royalty owner. While this covenant, as with all of the other covenants, holds the lessee to a "reasonable operator standard" it is a standard that is reasonable in name only.

case can be made that from the perspective of the management of the resource, speculation on the part of the lessee is vitally important, from the lessor perspective such activity on the part of the lessee is inimical to a maximum rate of return on the lessor's investments. Economics of petroleum conservation is subverted by the realities of the implied covenants since these constraints foster enhancement in the net present value of the stream of royalties receivable not the net present value of the reservoir. A second point of note is the fact that as protected by the implied covenants, the lessor has no vested interest in seeing the lease managed as a capital asset; for the lessor, asset value is based on gross value of the lease that does not change over time in the way that the net value does (Brätland 2001, p. 695). In terms of the time value of money, the royalties receivable are a depreciating asset. Hence, the receipt of revenues at the earliest possible date is the agenda for the management of the lease that meets the lessor's interests as an investor.

The management of the lease as a capital asset necessitates the timing of lease activities so that present value of economic rent is maximized. Achieving this goal is the essence of the economic conservation of the resource. But in fact, the implied covenants have the effect of dissipating economic rent. Economic rent is dissipated as the covenants impose exploration, development and production decisions that can be wasteful from the perspective of 'economic conservation.' The implied covenants impose very real costs on petroleum developers by compelling exploration, development and production on expedited schedules that may be inconsistent with the efficient management of leases. To complicate matters further, uncertainty is aggravated by the fact that a mandates to undertake these activities at an earlier moment in time means that the opportunity cost associated with these activities will be increased.<sup>31</sup> The perpetual shortage of drilling rigs is the classic example of this practical fact. But under normal market circumstances, a decision to expedite exploration or development would only be made if the estimated capital value of the project were increased by expediting. Clearly any attempt to impose artificial schedules on decision makers can only create confusion, chaos and economic inefficiency. In his very real sense, covenants have made the lessor and petroleum developers economic adversaries because what is beneficial to one party is detrimental to the interests of the other. By not allowing speculative latitude in timing these activities, the covenants are reduce both the net present value of petroleum resources and the option value.

---

31

Opportunity costs can be driven upward as a direct function of the extent to which commencement of exploration, development or production is expedited (Alchian, 1959, pp. 23-40). In his paper, Alchian treats "cost" as a charge that must be imputed to planned output to maintain the "equity value" of the firm. Though Alchian does not acknowledge the fact in this paper, one must note that, in all cases, regardless of context, this 'charge to be imputed' is inevitably a subjective judgement on the part of the decision maker. Paul Bradley has adopted Alchian's approach to 'costing' to the petroleum industry (Bradley 1967, p. 18).

#### **IV. THE ABORTIVE POLITICS AND LAW OF LEASING PUBLIC LANDS**

Substantial portions of the land surface of the United States is controlled by the Federal government or by the governments of the respective states. The leasing of government lands for oil and gas has already been substantial. The laws authoring petroleum leasing on these lands could have broken new ground in the implementation of property rights for petroleum developers but for various historical reasons, such was not to be the case. The laws authorizing the leasing of public lands have uncritically adopted most if not all of the features of private leasing law. With very few exceptions, these statutes have incorporated covenants that foreclose the requisite speculative on the part of petroleum developers. But at the Federal level, the rhetoric supporting these laws has aimed at convincing the public that there are actual benefits associated with expedited exploration, development and production of petroleum from public lands.

##### **A. Codification of the covenants in public leasing law**

Since the implied covenants were designed to protect the interest of the private royalty owner, speculation (latitude in the timing of investments) was and has been largely foreclosed to petroleum developers. Both the Mineral Leasing Act (MLA) of 1920 and the Outer Continental Shelf Lands Act (OCSLA) are essentially statutory reaffirmations of the implied covenants of private leasing described above. In analogous manner, the short lease terms and diligence requirements of the MLA and the OCSLA are intended to expedite all activities undertaken by petroleum developers of Federal lands and, hence, to minimize and possibility of speculation in the timing of investment on the lease. Moreover, petroleum-leasing laws passed by the respective states do not differ significantly from the Federal statutes with respect to prohibitions on the speculation that may be undertaken by petroleum developers.

Unfortunately, as suggested above in the discussion of the implied covenants, these provisions of the law cannot be reconciled in any convincing way with efficient management of petroleum resources when markets are uncertain.<sup>32</sup> Aside from an understanding that diligence requirements expedite royalty receipts, the MLA and OCSLA are both devoid of economic understanding or any insight into the realities of modern-day petroleum markets. Indeed, it would not be a gross distortion to observe that both of these statutes reflect contempt for practical economics and a willful ignorance of what markets can accomplish and what governmental mandates cannot. But given the fact that the speculative function is critically productive, one cannot avoid the reality of the fact that the diligence features of these laws are a presumptive source of economic waste in the allocation of petroleum assets since they preclude the speculative behavior on the part of petroleum developers needed to deal with market uncertainty. The additional consequence of these stringent timing conditions has almost certainly been to increase the requisite financial outlays for exploration, development and

---

32

On the subject of timing issues, a sound and balanced critique of the Outer Continental Shelf Lands Act can be found in Mead, et al. (1985).

production.<sup>33</sup> In the enforcement of both laws, there has never been proper acknowledgment or understanding of the fact that the speculative function as it applies to investment on the lease is absolutely essential in the economic conservation of Federal resources in uncertain markets. These presumptive sources of waste in Federal petroleum leasing provides a compelling rationale for revamping or even abandoning this obsolete laws in order to provide a means for harnessing the market in allocating of these resources in changing markets.<sup>34</sup>

## **B. Policy rationalizations with respect to the need expedite activities**

Concordant with the language of the laws, the rhetoric of leasing policy has been aimed at convincing the public that there is some social benefit associated with expediting activities on Federal lands. As noted, diligence provisions in Federal petroleum leasing have been defended, however unconvincingly, as somehow reducing U.S. dependence on imported oil. The latter policy goal is thought to somehow complement the explicitly stated energy policy objective of “maintaining a strong domestic oil and gas industry” since the shorter lease terms drive down the fair market value of leases and are hence thought to give smaller firms some additional prospects of acquiring leases on Federal lands. However, little thought was given or is currently given to

---

33

One of the principal reasons for the increase in outlays is related to shortages and bottlenecks that arise in acquiring capital goods such as drilling rigs for example. These types of bottlenecks are a major reason for the fact that most issued leases are ultimately relinquished prior to exploration. The practical implications for the costs of exploration can be seen in current deep-water leasing the Gulf of Mexico. Even though there are numerous deepwater prospects waiting to be drilled, there are a limited number of deepwater drilling rigs available. At the present time, there are 45 rigs in the Gulf of Mexico (GOM) capable drilling deepwater wells; this fact means that only a small fraction of the 3670 deepwater leases (as of April 2001) can be drilled before they expire at the end of 10 year lease terms. Potentially high quality leases often expire without the possibility of being explored. As of the year 2000, there are only 4 rigs in the GOM capable of drilling in water depths of 7500 ft or greater. About 470 such deepwater tracts under lease can probably not be explored because of the unavailability of drilling rigs. Apparently none of the estimated 4 new deepwater rigs coming on line in the next year can be used in the 7500 water depth. For those deepwater tracts that can be drilled, the economic costs of expedited exploration are driven upward because of the intense competition for the small number of rigs that can be employed at any one moment in time. One significant indicator of this possibility is the fact that of the 15 new deepwater rigs coming on line during the next year, only 4 will be available for use in the GOM. However, as noted above, none of the 4 remaining deep water rigs will be usable in water depths of 7500 feet or greater. (U.S. Department of the Interior. 2002. *Deepwater Gulf of Mexico 2002: America's Expanding Frontier [OCS Report MMS 2002-021]*. New Orleans: U.S. Government Printing Office).

34

The interventionist nature of leasing on the outer continental shelf (OCS) forces the Federal government to assess performance of its leasing program in the narrowest terms focusing on essentially ‘physical productivity.’ For example, they note data such as the following: (1) since the commencement leasing on the outer continental shelf in 1953, the offshore leasing program has issued leases totaling nearly 1.5 billion acres of offshore lands; (2) offshore production from the OCS is an important component of the domestic energy supply and now accounts for about 25 percent of the Nation’s natural gas and 22 percent of oil production; (3) offshore petroleum from the OCS has proven to be an important source of wealth for the United States; (4) the U.S. government collects approximately \$4 billion per year from offshore oil and gas production activities; (5) the market value of oil and gas produced since OCS leasing began in 1953, totals over \$385 billion; and (6) direct government receipts from this production have totaled over \$126 billion. Implicit in this self congratulations is the assumption that net benefits have accrued to society from the attainment of these goals. Clearly no such assumption is warranted.

the additional costs incurred by petroleum developers in trying to comply with diligence constraints. These policy objectives are the explicitly touted justification for the short lease terms and strict diligence requirements quite aside from the likelihood that these features of Federal leasing probably have effects exactly counter to those stated by the Federal government. Offshore tracts that are offered in lease sales are worth very little and are perpetually re-offered in future lease sales as petroleum developers are forced to relinquish active leases. Perpetual recycling (relinquishment and re-offering) means that the much of the capital structure in the petroleum industry is in a constant state of turmoil and *chaos*. The uncertainty associated with the holding of the lease is actually magnified by the diligence provisions of the leases and, of course, the value of offshore petroleum resources are minimized.

Governmental rationalization on the need to expedite exploitation of petroleum resources on public lands is most persuasive when cast as a need to correct a 'market failure.' The purported need to eliminate speculation in the timing of exploration has been presented in just such a light. The argument is based on the view that petroleum developers are affected by the presence of "externalities" or "external effects". Petroleum developers holding leases on tracts located on the same subsurface geologic structure, for example, are thought to delay or retard their exploration efforts in hopes of benefiting from the exploratory information generated from a neighboring petroleum developer's drilling activity (DasGupta and Heal 1979, pp. 435-436). Thus, it is alleged that petroleum developers need the inducement of exploration diligence to correct for these "perverse incentives" and induce a more "socially optimal" or "socially desirable" level of exploratory information. A problem with this type of interventionist thinking is that it ignores the possibility that there may be net social benefits rather than net social costs resulting from such delaying behavior. First, there is the possible benefit of delaying exploration so that all affected lessees can respond to perceived market expectations--that is, there is economic conservation effect resulting from the speculative delay. Second, allowing every petroleum developer to speculatively schedule exploration and development would avoid duplication of exploratory effort and the resulting waste of resources that can accompany such duplication (DasGupta and Heal 1979, p. 437). Petroleum developers voluntarily form "exploration units" in which the affected developers would formally agree to cooperate in the exploration and in the sharing of exploration information. With the formation of exploration units the spurious externality issue associated with exploration largely disappears.

## **V. RESOLUTION THROUGH AN INTEGRATION OF PROPERTY INSTITUTIONS**

The solution to the problem examined in this paper requires the abandonment of current leasing institutions in both private and public petroleum leasing. Clearly the generic problems outlined in this paper require a fundamental change in the property rights bearing on the exploitation of petroleum resources. The root of the problem arises from that feature of U.S. law that prohibits the establishment of a discoverer's property claim in an entire discovered reservoir. Such a property claim would require the abandonment of the stricture that no ownership is established until petroleum is captured at the surface. Also, the surface owner would have no contingent claim to resources ultimately recovered from beneath the surface property.

### A. Original subsurface appropriation as a means to resolution

But Robert Bradley observes: “In the case of first title [original appropriation of surface land], it is the surface land that has been transformed, not minerals below....it does not logically follow that the surface homesteader [legitimate owner] should claim an *a priori* monopoly to exclude ... [oil and gas] owners beneath him. A tenable theory of first-title rights should have consistent application....” (Bradley 1996, pp. 70-71). The ownership of land surface would be separated from any presumptive property interest in subsurface resource or in the produced resource at the surface. As applied to petroleum, such a principle of ownership would be provided by a legally sanctioned process in which the first discoverer of petroleum would have the opportunity to become the sole owner of the entire deposit by properly delineating the reservoir. These acts of discovery and delineation would be treated under the law as the requisite equivalent acts of mixing of one’s labor with the resource to establish ownership. As Robert Bradley observes: “the reservoir would then be turned into owned inventory from its prior ‘state of nature’”(Bradley 1996, p. 71).<sup>35</sup> A point of note is that first discoverer’s ownership claim would only apply to the reservoir discovered. Other reservoirs located in the same general area whether contiguously located or located above or below the discovered, appropriated reservoir would not be part of the first discoverer’s legitimate ownership claim. But, the appropriator’s property rights would be protected under the law; an attempt on the part of another driller or operator to drain the claimed reservoir through directional drilling would be guilty of invasion, and subject to legal action once the theft is detected.<sup>36</sup>

Since the explorer must still have access to surface land to conduct exploratory activities, would not the surface owner still be able to extract economic rent from the petroleum developer in bargaining over the lease rights to use a surface area for drilling? In general, the answer would be *no*. Instances would certainly arise in which the surface owner would have such bargaining power, however, in most instances, this power would probably not exist. Under current petroleum law, drilling in a directional manner to explore for reserves under adjoining properties is a form of trespass.<sup>37</sup> Under rules of property in which first discovery establishes ownership, the petroleum developer would not be constrained by this legal sanction. The surface owner

---

35

The event of discovery would require certain administrative procedures to give ‘original appropriation’ any operational meaning. Once a discovery were established, the fact would need to be registered in some way to make possible a declaration that surrounding acreage would be ‘off-limits’ to other operators conduction exploration activities in the area. The imposed suspension of exploratory activities by other operators would remain in effect “until the operator had the opportunity to drill frontier wells to delineate the field” (Bradley 1996, p. 73).

36

Robert Bradley mentions several sources of information that would be useful in exposing such theft, i.e., well depth, well distance, crude type, geological formation: see Bradley (1996, p. 72). However, one should note the potential of 4 dimensional seismic technology in detecting illegal drainage from an already owned reservoir. This technology permits the user to monitor what is happening to the oil deposit with the passage of time.

37

“The intent of the driller of the directional well is immaterial to the commission of the trespass, which occurs when there is unauthorized entry upon the land of another” (Williams and Meyers 1993, p. 227).

would have no presumptive property claim to subsurface petroleum resources. The developer would not be restricted to vertical drilling and hence would be able to use directional drilling to reach numerous subsurface petroleum prospects. This fact would considerably reduce the bargaining power of the surface owner in attempting to extract any future economic rent that may accrue from an economic discovery. Since the size of economic rent would be function of the developers management of the reservoir, the appropriable economic benefit would largely accrue to the owner of the reservoir.

## **B. Economic advantages of subsurface appropriation**

Several important economic advantages would accrue from reservoir ownership by original appropriators. First, the wasteful and inefficient diligence requirements would not negatively impinge on the management of the reservoir and conservation of petroleum reserves. Economic rent that may accrue from the development, production and sale of petroleum would be the sole property of the reservoir discoverer and owner. The owner of the reservoir would not pay royalties to a royalty owner and hence would not deal with the encumbering implied covenants designed to protect royalty interests of the Federal lessor. The reservoir would be under *one control* by the exclusive owner who would have complete freedom to perform the requisite speculative functions and manage the reservoir as a capital asset (Bradley 1996, pp. 72-73). The owners of reservoirs would have complete freedom to alter plans in the face of changes in the market. In other words, one of the most beneficial benefits of casting aside the implied covenants (and their counterparts in public leasing law) is that the timing of oil and gas operation would again be brought into the productive and critically beneficial, but grossly misunderstood, realm of speculation.

Second, the problems associated with the rule of capture would be totally mitigated. Since the reservoir would be under the sole ownership of the original appropriator, unitization would not be a regulatory responsibility since by definition the operation would already be unitized (Bradley 1996, p. 73). Unitization is a formal operating agreement among neighboring operators to put the management of the single reservoir under the control of one operator. The creation of a successful operating unit can be fraught with numerous obstacles because such agreements are frequently difficult or even impossible to achieve on a voluntary basis. But the migration of petroleum from one point of a reservoir to another location would not be an issue since the owner would have complete control over the structure. This fact obviates the need for unitization. Original appropriation of the reservoir by first discovery achieves a far more efficient means to a unitized operation. But more generally, original appropriation fosters the ability of the reservoir owner to speculate thus providing a genuine assurance that resources are managed in a way that maximizes their value to society.

The original appropriation of petroleum reservoirs has implications for the way in which public petroleum lands could be managed. Robert Bradley and Walter Mead have jointly proposed a leasing procedure that would accommodate homesteading of reservoirs under significantly amended laws of public leasing. Under their proposal, 'large blocks' of land would be auctioned on a bonus-bid basis with no royalty obligation and no constraints on the timing of exploration and development on leases. Restrictions on qualified bidders would largely be removed which

means that lease holding would not be restricted to oil companies. Hence, environmental organizations could become lessees. “While title to surface land (and water) would remain in the public domain, the lease rights would remain in perpetuity with the lessee. The grant would preferably be for exploration and production of all minerals, not just oil and gas ...”Bradley and Mead 1998, pp. 207-235). Under their proposal, once a discovery were made, the lessee would become the sole owner of the reservoir. Clearly their proposal would accommodate the speculative imperatives that must be integral to the economic conservation of petroleum.

## VI. CONCLUSIONS

! All markets are generically uncertain and subject to change. Hence, all investments undertaken in response to the data of the market are speculation requiring subjective judgment. No market exists in the functional sense without speculation and no market ‘efficiency’ is even possible without speculation.

! The economics of petroleum conservation is fundamentally speculative both in the choice of alternative investments and in the timing of these investments. Conservation is inherently a process of choosing between more intensive development of mature oil fields and the exploration and development of newer oil fields.

! But the speculative process is aborted by the legal institutions that govern petroleum exploitation. These institutions have been inferred and imposed by the courts as implied covenants to expedite production and royalty-revenue collection. To this end, the covenants preclude or curtail speculation on the part of the petroleum developer and, hence, abort the process of petroleum conservation. In effect, management of reservoirs is taken out of the hands of the investing developer.

! The speculative imperative is not diminished by ‘real-option’ techniques of evaluating leases. While this technique does eliminate some of the forecasting tasks, it is in fact premised on the ability of the lessee to speculate in the timing of exploration, development and production.

! The implied covenants of private leasing have, unfortunately, been codified into the statutes that govern the leasing of both Federal and state lands. However, in the case of Federal petroleum leasing, the language of the statutes is designed to convince the public that there are actually social benefits associated with the expediting of exploration and development on public lands. For example, expedited development and production of petroleum is supposed to reduce dependence of imported oil. This claim ignores the fact that expedited exploration, development and production almost certainly increases the opportunity cost of petroleum production.

! Resolution requires the abandonment of the fragmented property institutions upon which both private and public petroleum leasing are based. Original appropriation by first discoverers must be employed to establish full, unconditional property rights in discovered reservoirs. Such property rights would afford the owner total managerial control over the reservoir including those decisions bearing on the timing of investment activities. Rights to speculate would be within the total discretion of the owner – the petroleum developer.

## REFERENCES

1. Adelman, Morris. 1995. *Genie Out of the Bottle*. Cambridge, Massachusetts: MIT Press.
2. Adelman, Morris. 1972. *The World Petroleum Market*. Baltimore, MD: Johns Hopkins University Press.
3. Adelman, Morris. 1993. *The Economics of Petroleum Supply*. Cambridge, Massachusetts: MIT Press.
4. Alchian, Armen. 1959. "Costs and Output." In *The Allocation of Economic Resources*. Moses Abramovitz ed. Stanford, California: Stanford University Press.
5. Blackstone, William. 1908. *Commentaries on the Laws of England*. Philadelphia, PA: J. B. Lippincott Publishing Company.
6. Bradley, Paul. 1967. *The Economics of Crude Oil Production*. Amsterdam: North Holland Publishing Company.
7. Bradley, Robert and Walter Mead. 1998. Resolving the Federal Oil and Gas Royalty Valuation Dispute: A Free Market Approach. *The Journal of Energy and Development*. 23(2): 207-235.
8. Bradley, Robert L. Jr. 1996. *Oil, Gas and Government: The U.S. Experience*. Lanham, Maryland: Rowan & Littlefield Publishers, Inc.
9. Brätland, John. 2001. "Economic Exchange as the Requisite Basis for Royalty Ownership of Value Added in Natural Gas Sales." *Natural Resources Journal*. 41(3): 685-711.
10. Brätland, John. 2000. "Human Action and Socially Optimal Conservation: A Misesian Inquiry into the Hotelling Principle.", *The Quarterly Journal of Austrian Economics*. 3 (Spring): 3-26.
11. Buchanan, James M. 1969. *Cost and Choice: An Inquiry in Economic Theory*. Chicago: Markham Publishing Company.
12. Coase, Ronald. 1981. "Business Organization and the Accountant." In *L.S.E. [London School of Economics] Essays on Cost*. James Buchanan and G. F. Thirlby, eds. New York, NY: New York University Press, 95-132.
13. DasGupta, P.S. and G.M. Heal. 1979. *Economic Theory and Exhaustible Resources*. Cambridge, U.K.: Cambridge University Press.

14. Dixit, Avinash and Robert Pindyck. 1994, *Investment Under Uncertainty*. Princeton, New Jersey: Princeton University Press.
15. Gaffney, Mason. 1977. "The Objectives of Government Policy in Leasing Mineral Lands." In *Mineral Leasing as an Instrument of Public Policy*. (Michael Crommelin and Andrew Thompson eds. Vancouver, British Columbia: University of British Columbia Press.
16. Hoppe, Hans-Hermann. 1989. *Theory of Socialism and Capitalism*. Boston, MA: Kluwer Academic Publishers.
17. Hotelling, Harold. 1931. "The Economics of Exhaustible Resources." *Journal of Political Economy*. 39(April): 137-175.
18. James Buchanan, "Introduction: L.S.E. cost theory in retrospect." In *L.S.E. Essays on Cost*. James Buchanan and G. F. Thirlby, eds. New York, NY: New York University Press, 1-16.
19. Lewin, Peter. 1999. *Capital in Disequilibrium: The Role of Capital in a Changing World*. New York, NY: Routledge.
20. Laslett, Peter. 1970. *Locke's Two Treatises of Government: A Critical Edition with Introduction and Notes by Peter Laslett*. Peter Laslett, ed. Cambridge, U.K.: Cambridge University Press.
21. Lovejoy, Wallace F. and Paul T. Homan. 1967. *Economic Aspects of Oil Conservation Regulation*. Baltimore, MD: Johns Hopkins University Press.
22. Lowe, John Lowe. 1995. *Oil and Gas Law*. St. Paul, MN: West Publishing Company.
23. Matlock, Judith. 1997. "Payment of Gas Royalties in Affiliate Transactions." *48th Inst. On Oil & Gas Institute L. & Tax'n*. 9(1).
24. Matlock, Judith Esq. 1997. "Payment of Gas Royalties in Affiliate Transactions." *48<sup>th</sup> Annual Institute on Oil and Gas Law and Taxation*.
25. McDonald, Stephen. 1994. "The Hotelling Principle and In-Ground values of Oil Reserves: Why the Principle Over Predicts Actual Values." *The Energy Journal*. 15(3): 1-17.
26. McDonald, Stephen. 1967. "Percentage Depletion, Expensing Intangibles and Petroleum Conservation." In *Extractive Resources and Taxation*. Mason Gaffney, ed. Madison, WI: University of Wisconsin Press, 269- 288.

27. Mead, Walter, Asbjorn Moseidjord, Dennis Muroaka, and Phillip Sorensen. 1985. *Offshore Land: Oil and Gas Leasing and Conservation on the Outer Continental Shelf*. San Francisco, California: Pacific Institute for Public Policy Research.
28. Mises, Ludwig von. [1949] 1998. *Human Action: A Treatise on Economics, The Scholar's Edition*. Auburn Alabama: Ludwig von Mises Institute.
29. Mises, Ludwig von. [1922] 1981. *Socialism: An Economic and Sociological Analysis*. Indianapolis, Indiana: Liberty Fund Incorporated.
30. Pickles, Eric and James L. Smith. 1993. "Petroleum Property Valuation: A Binomial Lattice Implementation of Option Pricing Theory." *The Energy Journal*. 14(2): 1-12.
31. Rizzo, Mario. 1978. "Uncertainty, Subjectivity and Economic Analysis." In *Time, Uncertainty and Disequilibrium*. Mario Rizzo, ed. New York, NY: Lexington Books.
32. Rothbard, Murray. 1997. "Justice and Property Rights." In Rothbard, *The Logic of Action One: Method, Money and the Austrian School*. Cheltenham, U.K.: Edward Elgar Publishing Ltd.
33. Rothbard, Murray. [1982] 1998. *Ethics of Liberty*. New York, NY: New York University Press.
34. Siegel, Daniel, James Smith and James Paddock. 1987. "Valuing Offshore Oil Properties with Option Pricing Models." *Midland Corporate Finance Journal*. 5(Spring): 22-30.
35. (U.S. Department of the Interior. 2002. *Deepwater Gulf of Mexico 2002: America's Expanding Frontier [OCS Report MMS 2002-021]*. New Orleans: U.S. Government Printing Office).
36. Watkins, G.C... 1992. "The Hotelling Principle: Autobahn or Cul de Sac?" *The Energy Journal*. 13(1): 1-23.
37. Weaver, Jacqueline Lang. 1986. *Unitization of Oil and Gas Fields in Texas: A Study of Legislative Administrative and Judicial Policies*. Washington, D.C.: Resources for the Future.
38. Williams, Howard R. and Charles J. Meyers. 1993. *Oil and Gas Law: Abridged Edition*. New York, NY: Matthew Bender Co., Inc.