HUMAN ACTION AND SOCIALLY-OPTIMAL CONSERVATION: A MISESIAN INQUIRY INTO THE HOTELLING PRINCIPLE

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As defined by the Hotelling *r* Percent Principle (hereafter, the Hotelling Principle), "socially-optimal conservation" of an exhaustible resource is determined by rates of extraction that allow marginal scarcity rent (equilibrium price net of marginal extraction cost) for the resource to grow at a rate equal to an equilibrium rate of interest.[1] Socially-optimal conservation is achieved as individual extractive enterprises apply the Hotelling Principle and select rates of extraction that maximize the present value of scarcity rent yielded by the resource. This prescriptive principle emerged out of Harold Hotelling's attempt to demonstrate *mathematically* how a society optimally conserves a resource assumed to be of a known fixed stock.[2] Optimal conservation is assumed to be a potentially observable state and thus empirically verifiable; hence, neoclassical economists hail the Hotelling Principle as being prospectively operational with the promise of providing a normative basis for "*ideal* [optimal] *standards of resource use* by comparisons with which actual outcomes may be judged and on which policies may be based."[3]

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[1]The "Hotelling Principle" refers to theoretical results obtained in a famous article by Harold Hotelling (1931). Optimal conservation also requires that the resource be totally depleted at the time that the resource attains its maximum price. This latter condition of optimal conservation is explained further below. Hotelling's paper 1931 was arguably an outgrowth of his earlier paper on the theory of depreciation (1925). This earlier Hotelling paper is, of course, open to many of the criticisms leveled in this present article.

[2]More recent literature on exhaustible resource economics challenges the assumptions of exhaustibility (see Adelman 1993; 1995). To some extent, even exhaustible resources are renewable through exploration and discovery. However, this issue is not addressed here.

[3]The term "operational" has a history in the debates of "positivist" economic methodology. Without intending to tread near that methodological morass, the author simply notes that this definition of operational is based on the comments expressed by P.S. Dasgupta and Geoffery Heal (1979, p. 479). While these authors acknowledge difficulties in applying the Hotelling Principle as an operational standard, they are clear in stating their view that such a goal represents an appropriate attempted use of the Hotelling Principle.

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This article explores the answers to two fundamental questions concerning the Hotelling Principle: first, can the Hotelling Principle provide an empirically-based framework within which a "regulating authority" is able to prescribe a program of "optimal extractive conservation?" Second, as it is intended to apply to society as a whole, can the notion of socially-optimal conservation, have any coherent meaning in a world populated by acting human beings? So called mainstream economists would be inclined to answer yes to both questions.

PRAXEOLOGY, EMPIRICISM, AND MATHEMATICAL ECONOMICS

The above issues are examined within the methodological framework developed by Ludwig von Mises, Murray N. Rothbard and other members of the Austrian School of economics. Economic method, as a discipline, provides the framework within which one examines and defines the logical foundation upon which legitimate economic science is based. Ludwig von Mises has labeled the scientific method of the Austrian School of economics as *praxeology. Praxeology* means (roughly), the logic of action and is based on the insight that all economic propositions are deductively derived from the *axiom of action*.[4] This axiom states simply that human beings act to achieve the most highly-ranked, subjectively defined goals and employ means to attain these ends that involve the least sacrifice (subjectively perceived cost). Under Austrian economic method, other economic propositions are derived deductively from this axiom. In this sense, praxeology is an explicit rejection of the inductive method found in *empiricism* and eschews the notion contained in the motto of the Econometric Society: *science is measurement* (Mises 1998, pp. 347–48) .

Empiricism, as applied to economics, is based upon the widely accepted notion that no knowledge of reality can be deductively gleaned and that economic theory must be verifiable or falsifiable by observational experience (Hoppe 1995, pp. 28–29). In this sense, knowledge in the social sciences is always contingent in the sense that it is always subject to be overthrown by the testing of hypotheses with the most recent historical information available. This standard of science is most cogently captured by James Buchanan in the following statement:

> the science must have objective, empirical content. Something must be measurable—at least conceptually—which will allow either the corroboration or the refutation of central propositions. The basic elements of economic theory are, of course, the actions of human beings. The science consists of efforts to predict the effects on human behavior induced by specific changes in environment. Operationality dictates that the behavioral responses be objectively measurable. (Buchanan 1969, pp. 38–39)

By this standard, if testing fails to "falsify," the theory is assumed to be a valid predictor of future action. In this empirical screening of economic theory, no more rationality need be attributed to man than that which may be imputed to a tank of plankton or to a microbe. Under empiricism, the scientific method appropriately

[4]For the development of the application of praxeology to economic science see Mises (1957; 1960; 1962; 1998), Rothbard (1962; 1997b; 1997c), and Hoppe (1995).

applied to the physical sciences is assumed to apply to the social sciences even though man is a conscious, thinking, goal-oriented entity while the objects of the physical sciences possess none of these characteristics. Praxeology makes clear that the failure to draw the latter distinction results in an application of an absurd method in economics. The need to make this distinction has prompted Austrian economists to apply a scientific method that convincingly deals with human action in the passing of time.

However, as the following discussion will show, Hotelling's mathematical economics negated human action and any realistic treatment of time; he relied upon the grossly unrealistic neoclassical assumptions of perfect foresight and inter-temporal equilibrium. The implications of these assumptions are that the future is like the past; time does not exist; the market is frozen in a state in which nothing happens because Hotelling implicitly postulated *a world totally devoid of human action.* Nonetheless, the assumptions of perfect foresight and inter-temporal equilibrium have remained an implicit part of all modern-day treatments of the Hotelling Principle—*even those purporting to address uncertainty*. Ludwig von Mises could well have had the Hotelling Principle in mind when he asserted:

> the mathematical method must be rejected not only on account of its barrenness. It is an entirely vicious method, starting from false assumptions and leading to fallacious inferences. Its syllogisms are not only sterile, they divert the mind from the study of real problems and distort the relationships between the various phenomena. (Mises 1998, p. 347)

While Mises's criticism of the mathematical method is undeniably apt, the Hotelling Principle continues to be viewed as one of the crowning achievements of modern economics. It has become the dominant paradigm within which neoclassical economists and policy analysts presume to understand, explain, and "measure" the optimal economic conservation of an exhaustible resource. This article examines the concept of socially-optimal conservation from the fresh and more realistic perspective of praxeology.

Praxeology as a method of economic science is explicitly grounded on the actions of real, individual human beings, replete with ego, fallibility, a rational structure of mind, a capacity for ignorance, and the ability to choose and work to achieve subjectively defined goals.[5] It reflects a clear understanding that man cannot be scientifically studied and understood through the same *empirical* methods employed to study living cells, molecules, atoms, subatomic particles, or any other non-acting entity capable of examination in the observational sciences. (Rothbard 1997b, pp. 28-57) In addressing the foundations of economic science, Ludwig von Mises noted the following:

> Its statements and propositions are not derived from experience. They are like those of logic and mathematics, *a priori.* They are not subject to verification or falsification on

[5]The nature of acting man is most succinctly described in Mises (1998, chap. 1, pp. 11–29). See also Rothbard (1962, chap. 1).

> the grounds of experience and facts. They are both logically and temporally antecedent to any comprehension of historical [i.e., empirical] facts.[6]

In approaching economic method in this way, Mises (1998, p. 31) explicitly rejected the inductive, empirical method that finds its appropriate application in the natural sciences.

Economic method grounded in the axioms of human action abandons the omniscient, mechanistic *maximizer* that is central in Hotelling's model of objectively definable, exhaustible resource conservation.[7] In the Misesian system, all human action is aimed at or directed toward the future attainment of what the actor views as the most highly valued or most highly ranked end–whether defined monetarily or non-monetarily. The ends chosen by the actor are *not* selected from a predefined set of alternatives that can be apprehended by the external observer. *The alternative ends are subjectively defined only within the conscious and creative mind of the actor.* Praxeology renders no normative judgments with respect to the ends chosen by actors. Action emerges out of an expectation that certain means can be employed to attain chosen ends. In this process, the actor ranks the possible means and strives to gain control over the "subjectively-determined best" ways of achieving the goals sought. Man will always act in the present so as to achieve the greatest future net gain with the means available. Successful action in the present always yields a future *profit* and unsuccessful action yields *losses* (Rothbard 1962, p. 6). However, the nature of the gain is always subjective and certainly not open to observation or scrutiny (Rizzo 1978).

The reality of time in human action is manifested in the actor's awareness of the period elapsing between his actions and the attainment of his chosen objective. Since the length of human life is finite and time is inherently scarce, the actor *always* prefers to attain his most highly ranked goals in the shortest possible time. This *positive time preference* means that voluntary delay in attaining ends must be compensated by the expectation of a sufficient future net gain–subjectively defined. But the actor must also be compensated with a prospective additional future net gain because of the *true or genuine uncertainty* regarding events in the future and the choices made by others. If man were not to experience uncertainty, he would never act; certainty would imply that action is pointless. *All action* is based on the human actor's subjective judgment of future benefits, costs, profits (or losses), and the uncertainty attached to the attainment of chosen ends. As Rothbard has observed in describing the nature of human action, "All his [man's]

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[6]As quoted by Hoppe (1995, p. 8). In noting the controversy surrounding the economic method developed by Mises, Hoppe observes that this *a priori* method was also employed by Lionel Robbins (1932).

[7]See Mises (1998, p. 698):

> The mathematical economist, blinded by the prepossession that economics must be constructed according to the pattern of Newtonian mechanics and is open to treatment by mathematical methods, misconstrues entirely the subject of his investigation. He no longer deals with human action but with a soulless mechanism mysteriously activated by forces not open to further analysis.

actions are of necessity speculations based upon his judgment of the course of future events" (Rothbard 1962, p. 6). As the following discussion will emphasize, the judgments exercised by the actor in addressing uncertainty have definite implications for the possibility of optimal conservation and the operational content of the Hotelling Principle. Moreover, the following discussion shows that other aspects of human action also affect the operational content of the Hotelling Principle and its capacity to suggest optimal conservation policies.

Who is the actor? This question requires a note on terminology since this article addresses human action not only in the context of the extractive enterprise's undertakings but also in a context somewhat broader than exhaustible resource economics." The term *extractive enterprise* is used here to refer to the activities of an existing, ongoing enterprise. However, the term *actor* is employed in the broader context of human action in which planning occurs and resource extraction is only one of several potential alternative uses of the resource-bearing land.

NEOCLASSICAL LOGIC OF THE HOTELLING PRINCIPLE AND ITS VARIANTS

Within the Hotelling framework, an exhaustible resource is a known fixed stock, which means that, as the resource is used, less is available for future use. The fixity of total quantity means that the incremental cost of using the resource in the present must take into account the appraisement of future uses foregone. The present value of this future loss is frequently referred to as "user cost." Hotelling's theory of conservation presumes to define a precise and observable tradeoff between the marginal net benefit of using the resource in the present with the marginal net benefit of having the resource available for future use. Enterprises plan rates of extraction so that the present value of this marginal future net benefit is the same for each future time period in the firm's planning horizon. Optimality is defined in terms of the rate of extraction that allows the actor (and society) to maximize the present value of the exhaustible resource. As extraction proceeds from low-cost to higher-cost deposits, the increasing scarcity is reflected in a continual increase in the discernible and observable marginal scarcity rent (equilibrium price net of marginal extraction cost). There are no profits in this conservation mechanism. For any given resource deposit, extraction is delayed as long as the marginal scarcity rent of the *in situ*[8] resource appears to grow at a rate in excess of the universally-recognized equilibrium rate of interest. If the marginal scarcity rent were not to grow at a rate at least equal to the equilibrium rate of interest, it would be a signal to the actor to develop and produce the resource and to invest the proceeds in order to obtain the higher return yielded by the equilibrium interest rate.[9]

[8]The term *in situ* refers to the un-extracted resource in the ground.

[9]Within a given time period, marginal cost is assumed to increase at an increasing rate with increments in the rate of extraction. The stipulation that marginal cost is increasing at an increasing rate merely establishes that a unique planned rate of extraction in each future time period yields a maximum capital value for the resource deposit. Mathematical economists have attached the

Optimal conservation is achieved when two conditions are satisfied. First, in the aggregate, extractive enterprises must produce the resource at a rate that results in the marginal scarcity rent of the resource growing at a rate equal to the *equilibrium* rate of interest. Second, optimality in the Hotelling Principle requires that society's resource deposits be totally depleted at the time that the price rises to a level at which the quantity of the resource demanded converges to zero.[10]

Even in models pretending to introduce uncertainty into exhaustible-resource economics, stochastic processes are introduced as exogenous but known (prespecified) components of the analysis.[11] Actors are able to respond parametrically to exogenously-given information for prices, costs, and interest rates. The stochastic behavior of the variables in the model is assumed to occur within the context of some type of *stochastic inter-temporal equilibrium*.[12] Within this equilibrium, the actor is able to maximize the *expected* present value of the resource by selecting, *in the present*, an optimal rate of extraction *for all time periods in the extraction horizon*. Not only are exhaustible resources extracted at an optimal rate, but resource deposits are ranked optimally and brought into production on an optimal schedule that "maximizes the value of the resource to society." Such rankings and schedules would, of course, be recognized as "objectively optimal" by all observers and participants in the market. Even under so called 'stochastic uncertainty,' the future is totally determined, and all expected valuations and appraisements are transparently observable.[13]

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label "second order condition" to this requirement. If this condition were not to hold, a unique, "optimal" rate of planned extraction in each future time period could not be defined.

[10]The second condition of optimality relies on an extremely artificial and unrealistic assumption about the nature of the demand function for the exhaustible resource. The process of extraction by all actors means that the resource supply function for the industry is leftward-shifting as the marginal cost of extraction for each actor increases. Declining extraction for the industry means that the leftward-shifting, industry-supply function intersects the demand function at progressively higher equilibrium prices. The demand function for the resource intersects the price axis, thus establishing a finite, maximum price at which the quantity of the resource demanded dwindles to nothing. The optimal time profile of extraction for actors is achieved if the Hotelling Principle is satisfied and, simultaneously, society's deposits are totally depleted at the time that the quantity demanded declines to zero. Actors have all information on all features of both the present and future supply and demand schedules. The actors have sufficient information to"plan" future extraction of the resource so that the resource is exhausted when quantity demanded is zero. For the likely extent of the actor's likely knowledge of his own demand schedule (Mises 1998, p. 375).

[11]This approach to introducing uncertainty is exemplified by a 1980 paper written by Robert Pindyck (pp. 1203–25). Pindyck introduces stochastic processes into the demand function and a function specifying reserves. The actor has complete knowledge of the functions and the underlying stochastic processes. In this latter sense, this model and similar models do not actually address "real world" uncertainty as it would be manifested in ignorance and changing markets.

[12]See Pindyck (1980). At the end of his paper, he offers the following disclaimer: "Of course resource markets are also affected by other types of uncertainty (e.g., several of the oil exporting countries might suddenly cut production), *and the results of this paper should not be taken too literally"* (emphasis added). In this disclaimer he acknowledges that he has not addressed genuine uncertainty and the phenomenon of economic change.

[13]Mises (1998, p. 329) employed the term "appraisement" to refer to the actors' judgment about the current or future market price.

One remaining feature of the optimality defined by the Hotelling Principle deserves some note. In the tight inter-temporal equilibrium that is assumed to exist, the scope of human action is constrained such that alternative use of the resource-bearing land plays no role in actors' ranking of resource deposits. In fact the actors do no ranking. Equilibrium in the Hotelling Principle implicitly means that the land is always allocated to its most highly appraised use. That use is, of course, extraction of the resource; in this sense, the Hotelling Principle rests on the assumption of a closed universe in terms of the scope of human action. But in a disequilibrium world in which real human beings act, the issue of alternative uses is a prominent and even dominant consideration in the planned extraction of any resource and in considering any optimality thought to characterize such plans.[14]

DISEQUILIBRIUM, SOURCES OF UNEASINESS AND INDUCEMENTS TO ACTION

The tidy mathematical results obtained by Hotelling emerge from reliance on a neoclassical equilibrium that is assumed to be *objectively apparent* to all observers. However, by reliance on such an equilibrium, the Hotelling Principle has no relevance to the world of acting human beings. In explaining why empirical methods are inappropriate in the social sciences, Mises was particularly critical of the way in which equilibrium concepts are employed in economics. Though Mises was not commenting on the Hotelling Principle in particular, he implicitly addressed the operational emptiness of mathematical economics and its reliance on equilibrium constructs:

> The predilection with which mathematical economists almost exclusively deal . . . the state of "equilibrium" . . . has made people oblivious to the fact that these are unreal, self-contradictory, and imaginary expedients of thought and nothing else. They are certainly not suitable models for the construction of a living society of acting men. (Mises 1998, p. 257)

In order for the Hotelling Principle to have objective content, actors must be in an equilibrium environment in which they feel no sense of unease and see no opportunity for net gain from any sort of incremental action. But prospects of net gain are an ever-present inducement to human action and a constant wellspring of continuous economic change. Sources of uneasiness that prompt action include the following: (A) *market uncertainty,* (B) *unexploited prospects for net monetary gain,*[15] and (C) *unfulfilled non-monetary aspirations.* These inducements to act

[14]A useful and practical discussion of this latter issue as it arises in the leasing of publicly owned mineral lands has been offered by Stephen McDonald. McDonald (1979, pp. 69–72) does not necessarily arrive at the same conclusions as those drawn in this paper, however.

[15]"Unexploited prospects for net monetary gain" would embrace both entrepreneurial profit and any perceived economic gain from any incremental action. Action arises from the actor facing decisions that "are not at the margin." As Wicksteed (1933, p. 37) observed "only at the margin is there a coincidence between the thing gained and the price paid for it . . . when this point is reached, there is equilibrium." Choices made at the margin imply that no unattained, incremental gain can be achieved through additional action. To the extent that this condition

would necessarily be absent in neoclassical equilibrium; hence, human action and neoclassical equilibrium are starkly contradictory and mutually exclusive.

For the presumed external observer (i.e., analyst, economist, regulating authority, etc.), uncertainty, unexploited profit opportunities, and unfulfilled non-monetary objectives all induce further action and are *all* integral to the market environment in which extraction of the resource is or is not undertaken.[16] Profit opportunities emerge in uncertain, changing environments and are subjectively perceived by actors.[17] But action may also be motivated by non-monetary considerations that can be reflected in market prices of resource-bearing lands. Such motivations may govern the uses to which resource-bearing lands are committed. If these inducements to act are subjectively reckoned by actors can the concept of socially-optimal conservation be given any coherent meaning? The following sections examine this question and explore the concept of optimal resource conservation in a world in which human beings act and the conditions of neoclassical equilibrium are necessarily never attained.[18]

HUMAN ACTION AND THE REALITY OF THE CONSERVATION PROCESS FOR EXISTING EXTRACTIVE ENTERPRISES

An examination of the implications of human action for content of the Hotelling Principle must allow for two different perspectives depending upon whether an extraction enterprise already exists or whether extraction is viewed as one of several potential uses of the resource-bearing land. In the management of the resource, the enterprise would be alert to the exploitation of perceived profit opportunities. However, the scope of human action and subjective choice is

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were ever attained, human action would terminate; *equilibrium would be reached* reflecting a "state of rest." Non-marginal choices imply that the actor is not in an equilibrium and is still striving to avail himself of some subjectively-perceived incremental gain or profit (see, Buchanan 1969, p. 50). The awareness on the part of the actor of "unexploited profit opportunities" necessarily implies "non-marginal" decisionmaking in acting; also, non-marginal decisionmaking in acting implies a type of unexploited profit opportunity. As the following discussion will note, in disequilibrium, no means are available to distinguish between these inducements to action.

[16]One can make the case that objective content also requires that utility functions must exist independently of the act of choice. Also, actors must know their own utility functions. In this connection, Mises (1998, p. 95) makes the following point: "However, one must not forget that the scale of values or wants manifests only in the reality of action. These scales have no independent existence apart from the actual behavior of individuals."

[17]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.

[18]The equilibrium conditions addressed here are distinct from the concept of the *evenly rotating economy* (ERE). In the ERE, "all economic quantities continue indefinitely in an endless round." Like Hotelling's equilibrium, it is also devoid of human action. But as Rothbard (1962, p. 426) has noted, an exhausting resource and continually increasing resource price makes the ERE impossible. Increasing scarcity of the resource means that each new round cannot be identical to the preceding round. Mises (1998, p. 639) makes a similar point: "There is a need to remember again that . . . in order to integrate into this construction [ERE] mining and drilling we must ascribe to the mines and oil wells a permanent character and must disregard the possibility that any of the mines and wells could be exhausted."

always much broader in those instances in which the extraction may not be the only way in which the resource-bearing land can be employed. *Unexploited profit opportunities* or *non-monetary goals* may prompt actors to consider and select uses of the land that may entirely foreclose extraction of the resource. Actors who control the resource-bearing lands choose the most highly appraised use from a subjectively established ranking of alternatives. While these types of actions may be equilibrating in that they move the actor *toward* some subjectively-perceived equilibrium, they never define a move *to* an equilibrium. Nonetheless, the broader scope of human action and the alternative opportunities open to actors must be encompassed in any realistic theory of extractive resource conservation. But before considering conservation in its broader context this section examines the scope and implications of human action for existing enterprises.

Market Uncertainty for the Existing Extracting Enterprises

Recent variants of the Hotelling model that presume to quantify the market uncertainty seek to convert the actor's choices to an exercise in "quantifiable risk management." The concept of "risk management" implies that the market uncertainty facing actors involves the equivalent of what Mises (1998, p. 107) has called "class probability." Class probability refers to situations in which one has "sufficient knowledge of a class of events to allow determination of a precise probability but a general ignorance of any single event within the class." However, market phenomena are heterogeneous, non-reproducible, and unique which means that, in the real world, uncertainty facing actors takes on the features of *case probability*. Mises coined the term *case probability* to refer to those situations in which

> we know with regard to a particular event, some of the factors which determine its outcome; but there are other determining factors about which we know nothing. . . . Case probability is a particular feature of our dealing with problems of human action. Here any reference to frequency is inappropriate, as our statements always deal with unique events which as such—i.e., with regard to the problem in question—are not members of any class. (Mises 1998, pp. 110–11)[19]

Since judgments of case probability represent the actor's best conjecture regarding the likelihood of future market events, case probability is "not open to any kind of numerical evaluation" (Mises 1998, p. 113). As Rothbard (1962, p. 437) has aptly noted, "this uncertainty is a subjective feeling ('hunch' or 'estimate') and *cannot be measured in any way.* The efforts of many to apply mathematical 'probability theory' to uncertainty of future events are completely vain." Rothbard (p. 500) goes on to point out that "[e]stimates of future costs, demands, etc., on the part of entrepreneurs are all unique cases of uncertainty where methods of specific understanding and individual judgment of the situation must apply, rather than objectively measurable or insurable 'risk.'"

[19]As a mathematical economist, Nicholas Georgescu-Roegen (1966, p. 63) has offered a definition of uncertainty that is surprisingly concordant with the Misesian concept of *case probability*: "Uncertainty applies to cases where the reason we cannot predict the outcome is that the same event has never been observed in the past and, hence, it may involve a novelty."

Reckoning of Future Prices, Costs and Rates of Discount in Acting

What will the future price of the extractive resource be? In a world in which human beings act, the case probability associated with future prices brings to bear the actor's subjective judgment of uncertainty (Dasgupta and Heal 1979, p. 247).[20] Any two actors evaluating the same deposit would not necessarily derive and use the same expected prices for any future time period.[21] Moreover, unlike the assumption underlying the Hotelling Principle, actors do not act on the basis of what they think future equilibrium prices will be; as Mises (1998, p. 326) notes, "the 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 also notes that:

> The future price which [the actor] has in mind is, to be sure, not the hypothetical equilibrium price. 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)

One may well add that no market participant or market observer ever knows what an equilibrium price is nor would they recognize such a price were it ever to emerge (Rizzo 1979, p. 78). One concludes that the extractive enterprise's judgments about future price are always conjectural and not amenable to examination or inference by external observers.

In the Hotelling Principle, costs associated with extraction decisions are treated as empirically observable and measurable magnitudes.[22] However, in a world of acting human beings who deal with market uncertainty, their appraisements of opportunity costs are necessarily subjective. Ludwig von Mises ties the

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[20]In their book on exhaustible resource economics, Dasgupta and Heal (1979, p. 246) call attention to the problem created by the fact that different actors see the future differently but then state: "Indeed it is by no means clear what one means when one says that traders expect the future prices of resources to be one thing rather than another. To state it another way, it is not clear how one aggregates individual expectations." The statement seems to suggest expectations, diverse or otherwise, can be observed and measured. This notion is at the heart of the rational expectations hypothesis (REH) which embodies the idea that actors employ forecasts that are the same as the predictions yielded by a universally-used "objective probability distribution." The REH has been exploded by Hoppe (1997, pp. 49–78) and Frydman (1982, pp. 652–68).

[21]Mises (1998, p. 35) addressed the practical aspects of the issue in the following manner: "[T]he market . . . deals with people who are, to different degrees, aware of changes in the data and who, even if they have the same information, appraise it differently . . . different men draw different conclusions in appraising their effects."

[22]During the actual planning of the mine, the level of financial outlay is affected by a broader range of choices other than the selection of the extraction rate. These variables include the planned total volume of the resource to be extracted (scale), the planned commencement date of extraction, and the time period over which planned extraction is to occur. The earlier the planned commencement of extraction, the higher will be the outlay associated with extraction (Alchian 1977, pp. 273–99). Alchian was, of course, not addressing resource extraction but general manufacture.

concept of cost to the subjective act of choice and notes that "*If costs were a real thing, i.e., a quantity independent of personal value judgments and objectively discernible and measurable, it would be possible for a disinterested arbiter to determine their height. . . . There is no need to dwell further on the absurdity of this idea*" (Mises 1998, p. 393).[23] Mises also notes the subjective, conjectural nature of cost accounts in the face of market uncertainty:

> Cost accounting is therefore not an arithmetical process which can be established and examined by an indifferent umpire. It does not operate with uniquely determined magnitudes which can be found out in an objective way. *Its essential items are the result of an understanding of future conditions, necessarily always colored by the entrepreneur's opinion about the future state of the market*. (Mises 1998, p. 346; emphasis added)

Hence, costs of the existing extractive enterprise clearly have absolutely no operational content as far as any external observer is concerned.

The above observations on cost by Mises have particular relevance to the way in which the extractive enterprise chooses between immediate extraction and delay. The core of truth in the Hotelling Principle is that the extractive enterprise will strike a balance between the marginal scarcity rent (current price of the resource less the marginal extraction cost) obtained by extracting a unity of the resource immediately and its appraisal of the *present value* of the growing marginal scarcity rent that the enterprise may enjoy by delaying extraction until some future time period. A decision to extract in the present means that the discounted future scarcity rent is relinquished; hence, the latter becomes the subjectively-reckoned *user cost* of making such a decision. Delay in extraction would be prompted by a judgment that the present value of user cost is too high: in this act of choice, the resource is conserved. *But what is the rate at which the future is discounted in this act of choice?* As traditionally presented, the Hotelling Principle assumes an objectively measurable "equilibrium interest rate," a datum to which enterprises respond parametrically. But acts of choice, based on judgments of an uncertain future, preclude the emergence of a universally-recognized, objective, equilibrium discount rate amenable to empirical scrutiny.[24] Adjustments of the discount rate

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[23]"Costs are a phenomenon of valuation. Costs are the value attached to the most valuable want-satisfaction [foregone] because the means required for its satisfaction are employed for the want-satisfaction the cost of which we are dealing with" (Mises 1998, p. 393).

[24]Roger Garrison (1992, pp. 174–75) comments on the use of interest rates as rates of discount in changing markets:

> under conditions of full competitive equilibrium, costs at the margin are adequately measured by observable market magnitudes. The entrepreneur borrows funds at the market rate of interest and undertakes projects that are just worthwhile. What is popularly called the "cost of capital" refers to both the rate of interest and the rate of return for the entrepreneur whose activities maintain the marginal conditions. But it is precisely these marginal relationships that are nullified by . . . disequilibrium. . . . Disequilibrium drives a wedge between the rate of interest and the newly formed expectations about the rate of return on projects. . . . When capital maintenance turns to capital restructuring, It is a poor entrepreneur whose next best alternative is

are a subjective magnitude (entrepreneurial component) based on the extractive enterprise's understanding of future uncertainty (Mises 1998, pp. 536-538).[25] These adjustments must be anticipated in advance in order to induce the enterprise to delay extraction or to commit to an alternative investment (Rothbard 1962, pp. 697). Hence, "there is no private rate of discount. In fact, there is a whole panoply of rates, each one representing different appraisals of the nature, size and time-frame adhering to different transactions" (Formaini 1990, p. 51).

Unexploited Net Gains from Action and Non-existence of Social Optimality

Hotelling's optimal conservation implies an equilibrium in which no increments to the present value of the extractive enterprise can be achieved by altering the current rate or planned rate of extraction in any time period. Decisions are made at the margin. The entire time profile of extraction is optimally determined on the basis of the equilibrium price growth, costs, and rates of discount. But in a world of acting human beings, all of this is nonsense because states of rest are counter to the ever-striving nature of human action. "For the final state of rest will never be attained. New disturbing factors will emerge before it is realized. . . . Every later instant can create new facts altering this final state of rest" (Mises 1998, p. 246). In the market, the extractive enterprise's calculation of maximum present value of the exhaustible resource is always tentative; it pertains to the enterprise's understanding of the future at one moment in time only. But these calculations must change as the new disturbing factors make previously formulated plans obsolescent. As expected prices and costs change, conservation, in the context of resource extraction, requires flexible adjustments in the timing of planned extractive activities. The enterprise must be in a continuous search for a changing maximum present value as market disturbances induce actors to form new expectations. Hence, the extent to which any timing actions can be considered optimal or at the margin can only have relevance within the context of the enterprise's own understanding of the future; no independent perspective on the future of the market exists that would allow the external observer to legitimately judge one timing decision inferior or superior to another.

New, disturbing market factors mean that for the existing extractive enterprise, the prospective net gains are genuinely uncertain. Hence, the prospective net

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> the bank rate of interest. . . . The activities of entrepreneurs can no longer be explained in terms of marginal conditions and observable interest rates."

[25]Neoclassicists are forced to acknowledge that "*there is no constant exogenous interest rate to which the rate of capital gains on exhaustible resources can be anchored*" (Dasgupta and Heal 1979, p. 246). Unfortunately, Dasgupta and Heal have little stomach for dealing with the logical implications of their insight. In their struggle to preserve the possibility of objective content, these authors go on to resort to the following ridiculous assumption: "that agents have identical expectations and in particular that they have "point expectations": which is to say that they believe that there is no uncertainty about future prices." In contrast, Nobel Laureate William Sharpe (1985, p. 147) notes that "since both risk and return are subjective estimates dealing with the future, there is ample room for disagreement. People differ in their predictions of the future. . . . These differences . . . make it impossible to categorically measure risk and return and the relationship between them."

present value from extraction would be an *amalgam* of scarcity rent and entrepreneurial profit. Entrepreneurial profit will always be a conscious goal in any enterprise's plans and actions and may be manifested as a conjectured undervaluation of productive factors in a particular planned extraction enterprise or as an early awareness of likely future shortages of the extractive resource. Profits are realized from the enterprise's "ability to anticipate better than other people the future demand" (Mises 1998, p. 290). The prospects of a net gain in the extraction of the resource "are subjective phenomena, having no 'objective' basis outside the minds of market participants. . . . It is necessary . . . to treat [these prospects] as unique products of subjective valuation."[26]

The reality of entrepreneurial profit means that the actual process by which the exhaustible resource is 'conserved' must allow for this restless, ever-searching entrepreneurial function. "Optimal timing" of extractive activity is always a subjective judgment unique to the extractive enterprise. These judgments will always be driven by a search for a maximum net present value that combines scarcity rent and entrepreneurial profit. The realities of perpetual disturbances and disequilibrium mean that, for the extractive enterprise, scarcity rent and entrepreneurial profit are not even conceptually distinct in an *ex ante* sense. Frank Knight notes "every real income contains elements of both rent and profit. And with uncertainty present (the condition of differentiation [distinction between profit and rent] itself) it is not possible even to determine just how much of any income is of one kind and how much of the other" (Knight 1921, pp. 271–72). Hence, the concept of *ex ante* scarcity rent is subsumed under the larger possibility of entrepreneurial profit or loss in a way that admits no objective separation.[27]

THE BROADER SCOPE OF ACTION AND THE BROADER SCOPE OF CONSERVATION

In the traditional presentations of the Hotelling Principle, the observer views an already-existing, ongoing extractive enterprise in which the range of choice and

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[26]The quotation is from George Selgin's (1990, pp. 39–40) treatment of entrepreneurial profit. George Selgin has observed that:

> It is necessary, therefore . . . to treat entrepreneurial profit opportunities as unique products of subjective valuation and understanding of actors who will seek their exploitation . . . thus action leads to systematic elimination of entrepreneurial profit and loss; it is *equilibrating.* Subjectively defined, equilibration refers to systematic exploitation of profit opportunities as they exist in the understanding of market participants.

[27]The "entrepreneurial profit" addressed in this context appears to fall into the category described as *strategic rent* by Lewin and Phelen.

> Thus strategic rent that follows from a discovered discrepancy between revenue and cost, and is therefore equal to what we normally understand as profit, applies only in disequilibrium situations . . . Disparate expectations provide the opportunity for disparate expectations (for different appraisals of the worth of resources). (1999, p. 10).

They explain their use of the term "strategic" in the following (p. 9) note: "We use the word 'strategic' here in a manner different from its use in Game Theory, where it can refer to actions taken in an equilibrium playing out of certain strategies. We are referring to situations in which outcomes are radically uncertain as requiring strategic decisions.'"

action are artificially circumscribed by an assumed pre-existing equilibrium. The planning, choosing, and setting aside that would always precede investment in such an enterprise has already been done. But all such enterprises are, at the time of their origins, part of a deliberation in which alternative uses of the resource-bearing lands are ranked. For the actor–owner in the real world, the resource deposit exists in real time and space; it occupies a physical setting in the real world. The actor–owner is aware of the fact that the deposit is part of a larger, spatially-defined land property that he may be able to use for potential alternative, possibly mutually exclusive uses. The owner will rank alternative uses of the resource-bearing land on the basis of the subjectively perceived net gain thought to be obtainable from the respective competing allocations of the property. However, for the individual owner or would-be owners, the definition of net gain may be prompted by a broad range of possible motivations that may range from the acquisitive to the eleemosynary. In choosing the use of the resource-bearing land, the owner may exploit profit opportunities or pursue non-monetary goals, some of which may foreclose future extraction.[28] Hence, one man's conservation may be another man's waste.

Opportunity Costs of Human Action Revisited

The opportunity costs associated with the most highly valued alternative use of these lands *do not* emerge as objective data that would be the same in the eyes of all actors. Appraisement of competing alternative potential uses would be subjective for those actors keeping or seeking possession and control of the land. Hence, what is relinquished or sacrificed in establishing the optimal use of the land is determined by the goal-oriented actions of those willing and able to bear the cost and responsibility of ownership. Human action means that the most highly valued use of resource-bearing land is strictly in the mind of the actor. The net value associated with any chosen use of property is the owner's largest subjective benefit thought to be achievable from his commitment of the resource-bearing land to a particular use, minus his perception of the land's most highly valued relinquished use (Thirlby 1981, p. 215).[29] The subjectivity of these land-use choices clearly forecloses the possibility of empirical scrutiny.

In considering alternative uses for lands bearing an exhaustible resource, the owner *may* appraise the opportunity costs of extraction as any profitable undertaking or highly valued benefit that would be relinquished in committing the lands to extraction. For the landowner facing market uncertainty, the assessment of unexploited monetary profit opportunities foregone will be a subjective conjecture.

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[28]In commenting on the content implications of non-monetary motivations, Mises (1998, p. 234) has commented: "To an economist who would try to restrict his investigation to material aspects only, the subject matter of inquiry vanishes as soon as he wants to catch it."

[29]In citing Mises's *Human Action*, G.F. Thirlby (1981, p. 215) notes the following:

> We should notice . . . to indicate what we mean by cost, we should be driven to say that he [the actor] adopts a course of action which maximizes his *value*, and that the cost is the *value*, from an alternative distribution of the "same resources," that he would expect to achieve if, instead of the accepted course of action, he adopted that course which would yield the second highest *value*.

Even though a resource deposit may be extracted at a very low financial outlay, the profit-seeking actions of landowners may result in the deposit never being extracted. Extraction of the resource may be permanently foreclosed by agricultural, recreational, industrial or residential uses of the land that may promise higher profits to the owner. Hence, an external observer's estimate of the present value of scarcity rents and profit associated with extraction cannot be taken as the presumptive indicator of the land's most highly appraised use.

Actions may also be prompted by subjective non-monetary goals that may foreclose the extraction of the resource. Extraction may involve permanently foreclosed alternative use, the value of which may not be fully reflected in market prices; these may include environmental values or aesthetic amenities that may be sacrificed in the eyes of some by a decision to exploit the exhaustible resource.[30] For example, a resource deposit that appears to be a candidate for a strip mine may also be an ideal site for a wilderness area, sanctuary for endangered species, natural wildlife habitat, or park with beautiful vistas. The loss of such environmental amenities represents a valuable use of the land that may be foreclosed were extraction undertaken. A prospective buyer of such resource-bearing land may be motivated simply by a desire to avoid what he considers as the external cost associated with foregone environmental amenities. In other words, his principal goal is simply to assure that extraction never occurs. Since the opportunity cost is the most highly appraised relinquished use, extraction of the resource may be the foregone use of the land. In the latter case, the opportunity cost would include a subjective reckoning of the combined present value of scarcity rent and entrepreneurial profits. One notes that the scope of possible motivations in acting makes any 'socially-optimal' economic ranking of exhaustible-resource deposits meaningless and empty.

"Optimal" Conservation: An Expanded Misesian Perspective

In applying the concept of the Hotelling Principle to petroleum resources, University of Texas Professor Stephen McDonald has described optimal conservation as "action designed to achieve or maintain, *from the point of view of society as a whole,* the maximum present value of natural resources (or a natural resource)" (McDonald 1971, p. 71). Most of the economics profession would readily accept McDonald's definition without qualification or modification. But one of the implications of the preceding discussion is that such a definition of "optimal conservation" must be interpreted in a way different from the way it is intended. Society as a whole has no operational or quantifiable *point-of-view* or perspective that would be

[30]Mises (1998, p. 234) has said that:

> acting man is always concerned *both* with what he refers to as material and "ideal" things. He chooses between various alternatives, no matter whether they are to be classified as material or ideal . . . every concrete action aims at the realization of both material and ideal ends or is the outcome of a choice between something material or something ideal.

In the traditional presentations of the Hotelling Principle, no allowance is made for actions prompted by anything other than economic motivations.

useful in assessing the extent to which conservation is achieved. McDonald makes reference to *action*, but still seems to cast his definition in terms of a quantifiable, "maximized" state—not a process by which individual actors pursue and attain their chosen ends. A presumed objective content is largely taken for granted by mainstream economists even though no *observable or measurable* content is to be found in the *ex ante* appraisals prompting the actor to extract, delay extraction or employ the land in a competing use. No operational basis exists with which to determine that a particular allocation of the land is optimal independently of the actions of individuals who own or seek to own the land. No empirically-based standard of optimal conservation can emerge from the Hotelling Principle separate from the market results achieved by acting human beings pursuing their own ends.

An appropriately emended definition of conservation would be "action designed to achieve or maintain, *from the point of view of the land owner,* the maximum present value of the lands bearing the resource." The purpose of such action exists only in the mind of the actor who owns and controls the resource-bearing land. The actor will seek maximum present value if he is motivated by future monetary gain; but this anticipated maximum is only a personal, private calculation based on a tentative subjective understanding of the future state of the market. It has no operational content that would accommodate an empirical testing of "performance" with respect to conservation—however the latter term may be defined. This maximum present value may or may not be based on a plan to extract the resource. In some cases, actors may seek to own and control the land for reasons other than future monetary reward. Such actors may be driven by humanitarian or naturalist aspirations in choosing alternative uses of the land. Whatever value is appraised in committing lands to particular uses, it is not a dollar value that can be measured or estimated in an *ex ante* sense by anyone but the landowner or the party with the legal right to control the use of the land.[31] It is a value attained only as individual actors achieve their subjectively defined goals; it is realizable only as the land is committed to its intended use; but at any one moment in time, this intended use can only be known to its owner or prospective owners.

PRESCRIPTIVE POLICY AND THE HOTELLING PRINCIPLE: A SOURCE OF CHAOS

This section focuses on the ways in which particular regulatory uses of the Hotelling Principle are absolutely vitiated by the reality of human action. As noted in the preceding discussion, objective, measurable content is contingent on the existence of equilibrium conditions that *cannot* emerge in the real world of human action. If such equilibrium conditions are not attained, the *appraisements* of actors are totally subjective and not observable or even definable by the external observer. Hence, in an honest examination of the content and use of the Hotelling

[31]The party having the legal right to control the use of the land may be a lessee instead of the full fee owner.

Principle, economists are confronted with a troublesome implication: the Hotelling Principle, in fact, provides the economist with no operational framework within which to predict, monitor, or even regulate the extraction of exhaustible resources.

Absence of an "Operational" Foundation to Regulate Actions

Most economists do not properly address the implications of human action in examining the phenomenon of scarcity rent or user cost. For example, Anthony Scott, in commenting on the measurement of user cost, has observed that "[It] has been suggested that the present user cost function is a subjective concept, depending on individual expectation of prices, sales, costs, and production functions. Its statistical measurement, therefore, is unlikely to produce convincing results." Scott manages to dismiss this idea by noting the incentives that exist to measure user cost and then in the next paragraph states that "the economist . . . applying user cost to . . . aggregate situations may find it an instrument well adapted to balancing actual and alternative net advantages" (Scott 1953, pp. 383–84). Clearly Scott is fundamentally correct in his first statement but essentially wrong in the latter-quoted observation, unless the economist is making an assessment of user cost for himself as the owner and operator of the mine. One is puzzled by Scott's acknowledgment that user cost may be subjective at the level of the individual actor's choices yet have sufficient objective content in "aggregate situations" to allow economists to estimate "actual and alternative net advantages" of alternative extractive agendas.

In order for the Hotelling Principle to fulfill the role envisioned by Scott, a regulating authority must be in a position to prescribe optimal rates of extraction or the timing of exploration. The appraisements that prompt particular actions must be objective and observable. From the preceding discussion, it is clear that the actor's appraisements are subjective in an *ex ante* sense. *Even from an* ex post *perspective*, *the actual appraisements prompting action do not and cannot exist as objective data.* Efforts at retrospective reconstructions of an extractive enterprise's choice-making process do not address the fact that the *ex ante* appraisements cannot be given objective expression even after the fact. One additional logical and irrefutable implication of the subjective nature of the actor's appraisements is that the *optimal timing of exploration, extraction, or the commencement of extraction cannot be meaningfully prescribed for the actor or imposed on the actor through any regulatory mandate. Such regulatory mandates simply cannot have legitimate operational or scientific meaning.*[32]

Government Ranking and Management of Its Own Resources

The Hotelling Principle implicitly carries with it the idea that exhaustible resource deposits are capable of being ranked in an economic sense. If a governmental

[32]Oddly enough, these types of regulatory sanctions form the working basis for leasing arrangements designed to facilitate the extraction of exhaustible resources. (For a criticism of leasing as a form of property tenure, see Rothbard 1970, p. 50.)

ranking of governmentally-owned, resource-bearing lands is to have operational meaning, it must be based on some objective economic criterion. In an equilibrium world, free of acting human beings in which resource-bearing lands have no uses alternative to extraction, those deposits yielding the greatest scarcity rent are exploited first in an "optimal ranking." But in a world of acting human beings, governments cannot establish an optimal ranking independently of the actions of individuals pursuing their own ends. The importance of this issue arises from the fact that governments around the world own or control a significant portion of lands bearing exhaustible resources. In the United States, the Federal government owns and controls about one-third of the land mass (including offshore lands). The government usually issues leases for these lands after having gone through some attempt at ranking so that the best deposits are leased and exploited first. However, these leases are usually issued under the strict proviso that exploration be commenced by a certain date and that uses of the land other than extraction of the resource are strictly foreclosed. Under these strictures, the ranking process becomes a meaningless exercise supported only by decree of law or regulation.

Governments have no means of establishing any rational economic ranking of their own resource-bearing lands separately from or independently of the rankings established by individuals in the market. Total privatization is obviously a 'first best' solution to this quandary. A second best answer is provided by competitive leasing of publicly owned lands. However, if the government presumes to control the timing of activities on the leased lands and alternative uses of the lands, the issue remains unresolved. Functional property rights would still be absent. Economic calculation requires that property rights make sufficient allowance for uncertainty and alternative motivations on the part of lessees or prospective property owners. A rational economic ranking emerges only through actions of individual lessees. However, this ranking process can only occur as lessees are able to take advantage of total latitude in their timing of activities and in using lands in accordance with their subjectively defined goals and view of the future.

Is such a rational result possible if the private use of these lands involves social cost or external cost? As Mises has noted, the phenomenon of external costs arises from the fact that:

> The laws concerning liability and indemnification for damages caused were and still are in some respects deficient . . . some people choose certain [actions] merely on account of the fact that a part of the costs incurred are debited not to them but to other people . . . where a considerable part of the costs incurred are external costs from the point of view of the acting individual or actors, the economic calculation established by them is manifestly defective. (Mises 1998, p. 651)

However, even with more appropriately defined property rights, costs, whether external or internal, are essentially subjective and thus not measurable by any external observer including the government. Nevertheless, the Coase Theorem lends credence to the view that in those instances in which external costs are present, leases with appropriately-broad property rights generally provide a solution superior

to any governmentally-imposed decree.[33] As the discussion here has suggested, economic ranking emerging from market transactions is possible even in the presence of external costs. A governmental social ranking of resource-bearing lands employing the Hotelling Principle or the Coase Theorem is meaningless in light of the fact that prospective holders of property rights have heterogeneous motivations and different judgments regarding market uncertainty. The market may rank some low-cost resource deposits last because lessees or prospective future owners of public lands choose competing alternative uses for the land. Even with the presence of social costs, such a market ranking of resource-bearing lands could not be considered sub-optimal.

The Policy Analyst's Estimated Supply Schedule for the Resource

During the so called energy crisis of the 1970s and 1980s, various government agencies were engaged in the task of estimating aggregate supply schedules for fossil fuels. Some of this activity continues to this very day within the U.S. Department of Energy. The rationale for these efforts centers on the presumed urgency of having some 'central planning' in the allocation of energy resources and the possible need to implement subsidy programs to induce 'desired' levels of domestic production of these fuels. The information on aggregate supply schedules was thought to be important in estimating the subsidies necessary to achieve the desired levels of fossil-fuel production.

An estimated supply schedule must have not only a price-quantity dimension but also a time dimension. To be used for the purposes described above, the supply schedule must not only estimate the supply responsiveness to a subsidized price but also the time horizon over which supply is forthcoming. The entire preceding discussion presented highlights the absurdity of such an exercise. The elements entering into the capital appraisements of resource-bearing properties are subjective since each is a product of conjecture, judgment and speculation regarding the future. Since the individual actor cannot fully know the future, neither can he know before the fact when he will act nor what alternative choices will be made at some time in the future. Hence, no empirical basis can exist for the estimation of any future supply schedule. Nonetheless, there is every reason to

[33]A property-rights solution to social costs would be an example of the Coase Theorem in action (Coase 1960, pp. 1–44). But like the Hotelling Principle, the Coase Theorem is also not operational; in a given instance, the actions that may reflect Coasian behavior are not prompted by valuations or appraisements with any objective content. The gist of the Coase Theorem is that "it makes no difference how property rights are allocated in cases of conflicting interests, provided that some property is assigned to someone and then defended." The assignment of property rights determines who pays [bribes] whom. From this assignment of property rights a "social efficiency" is supposed to emerge in which external costs are "internalized." In situations involving external costs, the Coase Theorem is also thought by its adherents to be a tool of jurisprudence in which judges are able to arrive at a socially efficient assignment of property rights. Efficiency is defined as the *imposed* legal solution that minimizes "costs." However, in light of the fact that costs are always subjective, such an application of the Coase Theorem is clearly not operational. A considerable literature criticizes the Coase Theorem (Block 1977, pp. 111–15; Rothbard 1985, pp. 55–99; Rizzo 1979, pp. 71–89; Rothbard 1979, pp. 90–95, and Littlechild 1978, pp. 77–93).

believe that the Federal government will continue to pursue such supply-estimation efforts for fossil fuels.

AN AUSTRIAN CRITIQUE OF ATTEMPTS TO TEST THE HOTELLING PRINCIPLE

Economists view some version of the Hotelling Principle as an empirically testable or "operational" construct even though extractive resource markets are characterized by constant economic change. Proper testing of the Principle is seen as being a matter of collecting the "correct data" and skillfully applying quantitative techniques. The Hotelling Principle has been the focus of considerable empirical research. No attempt is made here to critique this entire body of literature. The foregoing analysis provides sufficient general criticism of these attempts. However, some of these endeavors have drawn more attention than others.

Needless to say, all attempts to empirically test the Hotelling Principle are unmindful of the subjectivist implications of human action. Attempts to test the Hotelling Principle inadvertently reveal the extent to which the traditional "empiricist approach" is misguided. A 1985 paper purported to test the extent to which the Hotelling Principle is actually reflected in the actions undertaken by extractive enterprises (Farrow 1985, pp. 452–87). The analysis employed a strictly objectivist perspective with respect to the variables of the Hotelling Principle including extraction cost. A major portion of the paper was devoted to an econometric estimation of a "cost function" for extractive firms. The hypothesis that the Hotelling Principle describes the behavior of extractive firms was finally rejected. The dubious nature of this empirical examination was brought into sharp focus by the fact that in testing three variations of the model, the econometric analysis revealed that the firms were employing *negative discount rates*. But in lamenting the results, the author was not led to question the measurability of cost and other variables:

> In a broader context, rational resource policy debates are impossible if available models are not consistent with the actual behavior of firms. If an accurate description of behavior is unavailable, there is no basis on which to argue that firms extract too much, too little or just the correct amount. Therefore, further research is indicated to construct models . . . that do describe the actual behavior of firms that extract natural resources. (Farrow 1985, pp. 480)

The correct interpretation of the analyst's results is that econometrically measured cost functions fail to reflect the locus of subjective opportunity costs associated with extraction. As Mises has noted:

> Attempts to establish cost accounts on an "impartial" basis are doomed to failure. Calculating costs is a mental tool of action, the purposive design to make the best of the available means for an improvement of future conditions. It is necessarily volitional and not factual. In the hands of an indifferent umpire, it changes its character entirely. (Mises 1998, pp. 346–47)

Efforts have also been made to examine and test what has been labeled the "Hotelling Valuation Principle" (HVP) (Miller and Upton 1985, pp. 1–25; Watkins 1992, pp. 1–24; and Adelman 1993). The HVP is a restatement of the Hotelling Principle; it is based on the assumption that extraction rates are already "optimally adjusted in an inter-temporal sense." In other words, some sort of neoclassical equilibrium is assumed to have been attained. If the HVP is satisfied, *the present value of marginal scarcity rent should be constant in all future time periods in the production horizon.* If the latter assumption were literally satisfied, the *accounting reconstruction of net price* per unit (price net of marginal extraction cost) recovered from current production should be approximately equal to the per-unit market price at which the *in situ* or unextracted resource is traded. The latter presumed equality forms the basis of the hypothesis tested.[34] The hypothesis would be accepted if the former accounting reconstruction of current net price were approximately equivalent to the per unit *in situ* market price of the resource.

Much of the research employing this testing procedure suggests that the HVP is not reflected in the current market price of *in situ* reserves. In fact, the market price of unrecovered reserves appears to be about half the marginal net price estimated with the use of the HVP. Various reasons have been offered to explain this discrepancy. The explanations include the view that the applicability of the HVP to oil and gas production is diminished by the institutional milieu as reflected, for example, in contractual arrangements (Watkins 1992). A variation on this idea is that production regulations prevent firms from choosing rates of extraction that would be consistent with the HVP (McDonald 1994, pp. 1–17). Another explanation of the discrepancy centers on the misleading assumption that firms view the stock of recoverable reserves as fixed. Exploratory activity and technological change allow actors to view oil reserves as being renewable rather than as a resource with fixed and known quantity (Adelman 1993, 1995) .

The above explanations of these test results have some merit; no effort is made here to rebut or critique these interpretations. However, one should note that accounting reconstructions of the net price (net of current, per-unit production cost) must be an accurate reflection of the marginal net value of current incremental extraction *as perceived by the actor*. As outlined above, such an assumption rests squarely on the likelihood that actors are making choices in an equilibrium environment in the virtual absence of human action. Of course, human action means that no neoclassical equilibrium is possible. In the absence of neoclassical equilibrium, the marginal net value of current extraction will be subjective, in part, because marginal cost is subjective. Additionally, as Ludwig von Mises (1998, p. 327) has noted, "All prices we know are past prices. They are facts of economic history. In speaking of present prices, we imply that prices of the

[34]One expedient employed by Miller–Upton and also by Watkins is the assumption of constant returns in current and future extraction. With this assumption, average cost can be substituted for marginal cost in the estimation of current marginal net price. Obviously there is no evidence to warrant such an assumption.

immediate future will not differ from those of the immediate past." In other words, an element of subjective conjecture is also involved in the notion of what may be considered current price. Hence, in a world of human action, the marginal net value of current extraction itself becomes essentially subjective. One is forced to conclude that these estimation procedures cannot be viewed as valid tests of the Hotelling Principle. One can properly conclude that research agendas based on empirical testing of the Hotelling Principle are flatly nullified by the reality of human action.

CONCLUSIONS

The Hotelling Principle defines socially-optimal conservation of an exhaustible resource in a mathematically-defined, equilibrium environment in which no human action can occur. Nevertheless, the economics profession generally tends to view the Hotelling Principle as offering the promise of being operational and to have potentially sufficient empirical content to serve as the basis of prescriptive policies for the socially-optimal conservation of an exhaustible resource. We have examined the Hotelling Principle from the Misesian perspective of praxeology and the axioms of human action and find the following conclusions:

1. As a mathematically derived economic theory, the Hotelling Principle relies on the assumptions of perfect foresight and neoclassical equilibrium which are both inconsistent with a world in which conscious human beings act to achieve their own subjectively-defined, future goals.

2. Human beings act and are motivated to act by uncertainty, unexploited profit opportunities, and non-monetary (i.e., non-material) objectives; these motivations define the nature of the disequilibrium world in which actions are undertaken.

3. Under conditions of true market uncertainty (case probability), the elements of the Hotelling Principle such as prices, costs, and rates of discount are all subjectively established in the understanding of the existing extractive enterprise.

4. In this disequilibrium, actions bearing on the extraction of the resource are motivated by the goal of attaining the largest possible surplus inclusive of scarcity rent and entrepreneurial profit.

5. The surplus does not exist as an objectively discernible magnitude in an *ex ante* sense and hence extraction decisions can only be defined as *privately* optimal; social optimality of extraction decisions cannot exist in any operational sense.

6. Prior to the commencement of resource extraction, unexploited profit opportunities or unfulfilled non-monetary goals may prompt owners to divert the resource-bearing land into preferred uses that deliberately foreclose extraction.

7. The subjectively-reckoned opportunity cost associated with another preferred use for the land may include a profit-rent surplus associated with extraction; rankings of alternative uses are strictly in the mind of the actor; no socially-optimal use of the resource-bearing land can exist independently of the goal-seeking actions of individual owners.

8. No means exist with which to test whether actions are consistent with the Hotelling Principle; hence, it provides no operational foundation for regulating private action nor does it provide an empirically-based tool for the ranking and management of publicly owned, resource-bearing lands.

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