

***RESOURCE EXHAUSTIBILITY: A MYTHOLOGY REFUTED
IN ENTREPRENEURIAL CAPITAL MAINTENANCE***

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ABSTRACT

Contrary to myth, extractive resources are replaceable capital goods in the context of entrepreneurial plans to maintain capital. *The existence of extractive-resources has no economic significance outside of this context.* Aggregate resource stocks have no bearing on human action. The exhaustion myth ignores entrepreneurial action and reflects preoccupation with global exhaustion and presumed 'un-replaceability.' But entrepreneurial capital maintenance refutes this myth. Capital is the entrepreneur's net capitalized appraisal of 'entrepreneurial rents' obtainable through strategic investments in capital goods. Hotelling rents are subsumed in entrepreneurial rents. As extraction costs increase from site-specific depletion, entrepreneurial firms strategically maintain capital by choosing the scale, timing and location of investments in exploration, development and other means to resource replacement. But capital maintenance is not necessarily limited to physical replacement of depleting capital goods and cannot be limited to exploration and development. A final section examines existing institutions that impede this capital-maintenance process.

RESOURCE EXHAUSTIBILITY: A MYTHOLOGY REFUTED IN ENTREPRENEURIAL CAPITAL MAINTENANCE

John Brätland¹

I. INTRODUCTION

The concept of *myth* is defined as “an unproved collective belief that is accepted uncritically.”² One such myth is the idea that extractive resources are exhaustible in an economic sense. This paper examines the issue extractive resource availability as the latter is affected by what is commonly referred to as ‘resource exhaustion.’ Most particularly, the paper explores the legitimacy of the concern over future resource exhaustion and reasons for dismissing this idea as a misguided mythology. The mythology centers on the deeply and widely held notion that all extractive resources are subject to eventual exhaustion and that this prospect should be cause for public alarm. This alarm has been reflected in academic research on extractive resources; for example, the fear of ‘running out’ prompts much policy discussion on alternative fuels. Also, the mythology has strongly conditioned theoretical thinking about public policy in connection with sustainability.³

The exhaustion myth has its origins not only in the nature of ‘mainstream neoclassical economics’ but also, more specifically, in the assumption of resource fixity that has been imbedded in to the economics of extractive resources. While neoclassical economists have been the most prominent perpetuators of the myth, Austrian economists have not been immune to adopting the same erroneous assumption.⁴ In part, this fallacious notion can be traced back to failed efforts to understand the implications of depletion on a macro or aggregate level rather than in the context of the marginal actions of the individual entrepreneurs attempting to maintain capital. Analytical habits of viewing exhaustible resources as a form of ‘aggregate national capital’ lead one away from an accurate appreciation of the resource-replacement process and the principal motivations prompting *entrepreneurial firms* to maintain capital. An *entrepreneurial firm* can be defined or described as a team that that seeks to acquire managerial control of resources that afford a competitive advantage in earning profits by producing and marketing a

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² *Random House Dictionary of the English Language: The Unabridged Edition*, 1969. New York, NY: Random House, Inc. p. 946.

³ John Brätland. 2006. “Toward a Calculational Theory and Policy of Intergenerational Sustainability.” *The Quarterly Journal of Austrian Economics* 9(2) pp.13-43.

⁴ Murray N. Rothbard. 2004. *Man, Economy and State with Power and Market*. Auburn Alabama: The Ludwig von Mises Institute, p. 496- 498.

product.⁵ For the extractive firm, these resources would include entrepreneurial ability, managerial ability, technical expertise in applying and developing new technologies and the acquisition of superior prospects for finding, developing and producing resources.

In the context of the action undertaken by the individual firm, a narrow concentration on strictly replacing physical resources takes the focus off the ultimate objective of entrepreneurial capital maintenance. This objective is the maintenance of the firm's income. In the remainder of the paper, this income will be referred to as entrepreneurial rent. If the firm is viewed as an entity in itself, it can be viewed as earning a rent that is contingent upon the selection and implementation of plans under conditions of uncertainty and change. Successful plans earn rents. It is discussed and defined at greater length later in this paper. Entrepreneurial rent is more inclusive than Hotelling rents or scarcity rents and refers to the incremental net income that accrues to the firm as a result of choices and decisions that give the firm a sustainable competitive edge in the management of resources. In a changing, uncertain disequilibrium world, the existence and emergence of Hotelling rents is inseparably contingent on entrepreneurial decisions and in no way can be quantitatively distinguished from entrepreneurial rent as a whole.⁶

In an entrepreneurial context, there is no reason to believe that minerals, of whatever sort, should ever be exhausted at the margin. But this reality can never be fully appreciated outside of the context of action undertaken by entrepreneurial firms under assumptions of disequilibrium. If resource prices warrant, entrepreneurial investment will always be channeled into replacing depleting deposits of extract resources. The matter of how much of an extractable resource ultimately remains in the earth's crust at any particular moment in time is of no direct concern to anyone. The only relevant economic importance of exhaustion is the degree to which entrepreneurial efforts to find and develop new discoveries are successfully induced by declining entrepreneurial rents from deposits already being extracted. Producing reserves of any particular extractive resource are found in privately controlled inventories managed by firms that are always intent upon maintaining the capital of the entrepreneurial enterprise. The requisite investment to maintain capital will include a commitment of resources to direct purchase of developed resources, exploration, development of discovered deposits and the building of the facilities required to extract, process and transport the raw resource. Entrepreneurial firms undertake these incremental investments because eventually the rents associated with extraction at any particular site will decline. As the rents from depleting deposits decrease, entrepreneurial firms are prompted to replace these inventories by one or more of the listed alternative means.

Site-specific resource depletion means lower rents per unit of the resource produced. *But, at the same time, entrepreneurial firms are driven to maintain rents.* The resource replacement process involves investment in various stages of production including both exploration and development.

⁵ Peter Lewin and Steven E. Phelan. 2000. "An Austrian Theory of the Firm." *Review of Austrian Economics* Volume 13, p. 70. These authors observe that "all businesses surely have their origins in the resources of the entrepreneur (innate or otherwise) and the resources that the entrepreneurial team controls, creates, can potentially acquire and finally combines."

⁶ John Brätland. 2000. "Human Action and Socially Optimal Conservation: A Misesian Inquiry into the Hotelling Principle." *The Quarterly Journal of Austrian Economics*, 3(1) p. 15.

These efforts are undertaken to maintain rents obtainable from future resource production. It is a perpetual process involving a continual restructuring of assets within each extractive enterprise. This restructuring process forces the firm to exercise entrepreneurial judgment in selecting the stages of production toward which to direct investment. The exhaustion myth is refuted by investment undertaken by extractive firms to maintain future enterprise income by maintaining capital. To the extent that these efforts are successful, capital is maintained. However, investment processes that are narrowly focused on a mechanistic cycle of physical replacement are not necessarily valid examples of capital maintenance.

One can conclude that a future cessation in the production of extractive resource will occur not because of exhaustion but because the prospects for profitable resource renewal are exhausted. One such plausible scenario could arise if customers, with access to substitutes, were no longer willing to pay for the consumer good produced from extractive outputs. But more plausible scenarios can be anticipated in: (1) property institutions that fragment the ability of entrepreneurial firms to manage resource deposits as capital assets; and (2) policies imposed by governments that have the effect of coercively foreclosing the access to lands that would permit entrepreneurial replacement of extractive resources. Policies designed to nationalize resources and to impede accessibility of lands for exploration can severely impede the entrepreneurial replacement process to ward off exhaustion. The last section of this paper will address these institutions and policies.

II. PROGENITORS AND PERPETUATORS OF THE EXHAUSTION MYTH

Economics has fostered the myth of extractive-resource fixity or resource exhaustibility. This resource exhaustion myth appears to have been borne in states of public-policy hysteria over resource availability. William Stanley Jevons undertook the earliest research on extractive resources in the nineteenth century by raising alarm over the prospect of depleting fossil fuels.⁷ But, the myth has been perpetuated in more recent times of public angst during the twentieth century resulting in public funding of largely useless efforts to achieve 'energy independence' and to formulate of mathematical models of resource exhaustion. These efforts have generally been characterized by a continued focus on aggregative thinking and neglect of entrepreneurial action. However, as the following examination will show, the myth that extractive resources are exhaustible has also misdirected thinking in the Austrian school of economics.

A. Jevons, Gray and Hotelling

Somehow the exhaustion assumption as it legitimately applies to individual resource deposits has somehow become a metaphor for exhaustion on a scale encompassing the planet as a whole. It is an implicit but largely unexamined premise of theory and public policy proposals on extractive resources. Little attention seems to have been directed toward the idea that, for a cost, extractive resources are legitimately replaceable. An important reason for the relative neglect of extractive-resource replacement is found in the fact that the earliest work done by economists in this area

⁷ See in particular: W. Stanley Jevons. 1865. *The Coal Question: An Inquiry Concerning the Progress of the Nation and the Probable Exhaustion of Our Coal Mines*. London, UK: Macmillan & Co.

actually cultivated or fostered the notion of exhaustion. The first neoclassical economists to address the economics of extractive resources included W. Stanley Jevons, Lewis C. Gray, and Harold Hotelling. In the title of each of their major works on the subject of extractive resources, reference is made to ‘exhaustion.’⁸ Stanley Jevons’ 1865 analysis of threatened coal shortages in England touched off what some have labeled a ‘coal panic.’⁹ The oil panic of the 1970’s renewed interest in Harold Hotelling’s 1931 paper, with its premise being global exhaustion manifested in increasing prices of increasingly scarce extractive resources.¹⁰ In other studies such as the 1914 study by L.C. Gray, exhaustion is introduced by the incorporation of increasing costs of extraction occurring with the passage of time.¹¹ But what seems to be missing from these analyses is any allowance for or description of an entrepreneurial response to changes in extraction cost and the process by which such changes induce investment in the replacement of depleting deposits. Even late into the last century, the exhaustion myth persisted in the neoclassical modeling efforts addressing the issue of intergenerational sustainability. Even more puzzling is the fact that the myth appears in the analysis of at least one very prominent Austrian economist.

B. The exhaustion myth in the contemporary economics of sustainability

Sustainability theory is premised on the urgency of formulating a ‘principle of investment’ to be applied by governments for the benefit of future generations. The presumed exhaustibility of extractive resources has spawned the notion that policies must be imposed on society to provide for the needs unborn generations of people. For both John Hartwick a Canadian professor of economics; and Robert Solow, a professor of economics at MIT, one of the more straightforward applications of his ‘investment principle’ is in what is perceived to be the *problem of exhaustible resources*. A principal tenet of this investment principle is that the sufficient investment must be undertaken by the current generation to assure at least a constant level of consumption for each future generation. Part of the so-called logic is that we (the current generation as an acting entity) must replace what we deplete or exhaust. John M. Hartwick has outlined one aspect of this investment agenda. He suggests the following: “Invest all profits or rents from exhaustible resources in reproducible capital such as machines... This injunction seems to solve the ethical problem of the current generation shortchanging future generations by ‘over-consuming’ the current product currently ascribable to current use of exhaustible resources. Under such a program the current generation would have an obligation to convert exhaustible resources into

⁸ In addition to W. Stanley Jevons referenced above, other writers include Lewis C. Gray and Harold Hotelling. See: Lewis C Gray. 1914. “Rent Under the Assumption of Exhaustibility.” *Quarterly Journal of Economics*, May 1914.; and Harold Hotelling. 1931. “The Economics of Exhaustible Resources.” *Journal of Political Economy*, vol. 39, pp. 137-175.

⁹ Robert L. Bradley. 2006. “Resourcehip: An Austrian Theory of Mineral Resources,” unpublished paper.

¹⁰ Harold Hotelling. 1931. “The Economics of Exhaustible Resources.”

¹¹ Lewis C Gray. 1914. “Rent Under the Assumption of Exhaustibility.” *Quarterly Journal of Economics*, May 1914. See also: Chandler Morse. 1976. “Depletion, Exhaustibility and Conservation.” William Vogely (ed.) *Economics of the Mineral Industries*. New York, NY: American Institute of Mining Metallurgical and Petroleum Engineers, pp. 236-240.

machines and ‘lives off’ current flows from machines and labor.”¹²

Hartwick has not been challenged in his assumption of eventual exhaustion. Rather, Hartwick has received plaudits; in commenting on Hartwick’s Rule, Robert Solow observed “the policy of investing resource rents in reproducible capital suggests irresistibly that some appropriately defined capital stock is being maintained intact and that consumption can be regarded as the interest on that stock. This interpretation turns out to be quite right.” The Hartwick-Solow prescription for investment is premised on the urgent need for centrally controlled reinvestment of resource rents to achieve a golden rule of ‘capital maintenance.’ In affirming the Hartwick-Solow prescription, Geoffrey Heal has actually asserted: “if a country invests an amount equal in value to the market value of its use of exhaustible resources, then it solves the Rawlsian problem and achieves the highest possible level of utility for the least well-off generation.¹³ Remarkably, it also achieves the highest feasible constant level of utility given the economies initial stocks of capital and resources.”¹⁴

But the Hartwick-Solow prescriptions are untenable for several reasons. *First*, both economists embrace the traditional supposition that resources are available in a fixed stock the size of which is somehow known by ‘planners.’ They have not sought to challenge the exhaustion constraint and the assumption that every unit of the resource used today means a loss of a unit available for later generations. Increasing current use of the exhaustible resource is assumed to mean increasing scarcity for future generations. *Second*, the Hartwick-Solow perspective largely ignores market uncertainty and the fact that scarcity rents of the Hotelling variety do not appear as some ‘objective datum’ as would be the case in some non-attainable equilibrium.¹⁵ In real-world markets, the Hotelling rent, like the depreciation of private capital goods, is always a judgement because the future of the market is always uncertain. *Third*, the prescription seems to disregard the implications of private property and the incentives facing individual property owners confronted with the implications of resource exhaustion.¹⁶ This latter issue is the principal focus of the remainder of the latter part of the paper.

¹² John M. Hartwick. 1977. “Intergenerational Equity and Investing of Rents from Exhaustible Resources.” *American Economic Review*. 67(4): p.972.

¹³ In his philosophical treatise, *A Theory of Justice*, John Rawls prescribed a ‘social investment agenda’ intended to maximize the ‘well-being’ of the ‘least well-off generation.’ See: John Rawls. *A Theory of Justice*. Cambridge, Massachusetts: Harvard University Press, pp. 284-293.

¹⁴ Geoffrey Heal. 1998. *Valuing the Future: Economic Theory and Sustainability*, p. 8. Utility for either an individual or a generation of people is an absurd notion. Valuation is only a subjective ranking on a single *ordinal scale* established by each individual depending upon the range of choices. Hence, valuation has nothing to do with utility. It is not simply a matter of utility being unmeasurable; utility, as traditionally employed in economics, does not exist.

¹⁵ John Brätland. 2000. “Human Action and Socially Optimal Conservation: A Misesian Inquiry into the Hotelling Principle,” pp. 12-15.

¹⁶ John Brätland. 2006. “Toward a Calculational Theory and Policy of Intergenerational Sustainability.” *The Quarterly Journal of Austrian Economics*, 9(2) p. 39.

C. The exhaustion myth in Austrian economics

But the Austrian School of economics has not been free of the unfortunate fixation on resource fixity. The Austrian school has resorted to a misleading effort to differentiate land and capital goods and in the process try to make the case that ‘depletable resources’ are not capital goods but rather fall under the category of ‘land.’ One such example is found in the work of the Austrian economist, Murray Rothbard. Rothbard’s distinction was premised on the idea that investment is of no avail in replacing what is thought to be an un-replaceable resource. In reference to land, Rothbard notes: “it is clear that permanent improvements do not need to be replaced.”¹⁷ He draws a sharp distinction between ‘catallactically permanent, non-reproducible land’ and capital goods, which he defines as being non-permanent and which must be reproduced again to continue to produce productive services. Rothbard then places depletable resources in a special category: “Resources that are being depleted obviously cannot be replaced and are therefore land, not capital goods.”¹⁸ Making reference to resources such as various kinds of minerals, Rothbard observes:

Here the factor is definitely original and nature given; it cannot be produced by man. On the other hand it is non-permanent, but subject to depletion because any use of leaves an absolutely smaller amount for use in the future. It is original but nonpermanent. Shall it be classified as land or a capital good? ... The crucial test of our classificatory is to ask: must labor and land factors work in order to reproduce the good? In the case of permanent factors this is not necessary, since they do not wear out. But in this case we must answer in the negative also, for these goods, though non-permanent, *cannot* be reproduced by man despite their depletion. Therefore, the natural resource comes as a special division under the land category. ... The point is that resources subject to depletion cannot be replaced, much as the owner would like to do so.¹⁹

Several observations come to mind in looking critically at Rothbard’s conclusions. One notes first that at the time that Rothbard wrote these words, the phenomenon of exploration and discovery of all minerals was a well-established fact in all of the mineral industries. Replacement of mineral deposits had been occurring routinely for centuries. These accomplishments have always been achieved through an investment in labor, land and capital resources. Secondly, Rothbard made the same mistake as many other economists in focusing on aggregate or global stocks of a resource rather than on entrepreneurial action. This stock, whatever mineral it may be, is meaningless in terms of the actions necessary to augment the market supply of the resource. Rothbard was not thinking praxeologically. Scarcity only has a meaning in the context of entrepreneurial action. *The central issue is entrepreneurial action at the margin, the implication of which means that scarcity or ‘fixity’ of any good or resources is*

¹⁷ Murray N. Rothbard. 2004. *Man, Economy and State with Power and Market*. Auburn Alabama: The Ludwig von Mises Institute, p. 484.

¹⁸ Ibid., p. 484.

¹⁹ Ibid., pp. 496-497.

praxeologically established by the prospective subjectively reckoned net gain from the pursuit of additional production. Aggregate limits are meaningless and irrelevant to the actions of the individual entrepreneur.

Certainly no one would argue that individual deposits of extractive resources are not exhaustible. Deposits are clearly exhaustible in the sense that, at some point, incremental costs of further extraction may overwhelm incremental revenue obtainable from continued operations. But what is less well understood is the fact that any situation in which the marginal costs of extraction become greater than incremental revenues is an inducement to action on the part of extractive firms. When the history of this myth is viewed from a very broad perspective, one notes that scientists in general and economists in particular have generally been able to acknowledge the reality of site-specific exhaustion yet remain essentially oblivious to the manifest evidence of routine deposit replacement by entrepreneurial firms seeking to maintain capital. The failure to acknowledge both of these apparent realities has somehow fostered the persistent myth there is a fixed aggregate stock of each respective extractive resource that is binding in some way upon a world economy. The implicit but fallacious assumption seems to be that eventually exhaustion must be inevitable since every physical feature of the planet is ostensibly finite; the apparent inference is that the ‘stock’ of the mineral resource must be finite and exhaustible.

III. RESOURCES AS ‘RENEWABLE CAPITAL’ MINUS ENTREPRENEURIAL ACTION

Two economists have dealt with extractive resources in a more realistic manner by at least partially transcending the exhaustion myth and avoiding errors made by Rothbard and others. Stephen McDonald and F.A. Hayek both view markets in an essentially equilibrium context and treat extractive resources as a form of replaceable or renewable ‘capital.’ They both seem to view the concept of capital in basically aggregate terms largely ignoring or at least suppressing the vital and requisite actions of individual entrepreneurial firms in this renewal process. Yet their respective views of the capital concept appear to be quite different and what they each mean by ‘replaceability’ is sharply dissimilar. McDonald implicitly treats extractive resources as form of ‘aggregate capital’ that can be physically replaced through ‘socially optimal’ levels of exploration and development while Hayek views extractive resources as an asset that is not necessarily renewable in a physical form but must be renewed in some form to maintain a time-stream of income. These aspects of their thinking warrant separate examination.

A. Stephen McDonald on ‘optimal renewability’ of global resource stocks

Stephen McDonald, professor of economics at the University of Texas, deserves separate attention in light of the fact that he has avoided errors made by assuming that extractive resources are a form of ‘capital,’ and are indeed, replaceable, or, to use McDonald’s term, “renewable.”²⁰ Yet McDonald makes his own mistakes seeming to ignore the actions of the

²⁰ See: McDonald, Stephen. 1967. “Percentage Depletion, Expensing Intangibles and Petroleum Conservation.” Mason Gaffney, ed. *Extractive Resources and Taxation*. Madison, WI: University of Wisconsin Press, 269- 288. See also: McDonald, Stephen. 1971. *Petroleum Conservation in the United States: An Economic Analysis*. Baltimore: The Johns Hopkins Press, chapters 4, 5 and 6.

entrepreneur and being preoccupied with aggregate resource stocks and global optimality in the rates of aggregate renewal. Hence, like Rothbard he is not focused on the implications of marginal entrepreneurial action but unlike Rothbard he attempts to bring the extractive-resource renewal process under the umbrella of a type of aggregate notion of ‘physical capital theory.’ In other words, he essentially talking about extractive resources as ‘capital goods’ not capital in the legitimate sense of the word:

The approach taken here is in the well-established tradition of treating the economics of conservation as a particular application of the theory of capital and its use. Capital theory is addressed to the time dimension of the economizing problem, i.e., to the efficient allocation of satisfactions among different points in time. ... Although the term conservation as ordinarily used often connotes the avoidance of some wastes that have no particular time reference, its dominant connotation is the avoidance of those particular wastes that arise from inefficiently distributing the use of natural resources over time. ... While investment uses current resources to produce goods that will yield future satisfactions, conservation provides future satisfaction by transferring the use of some existing durable goods from the present to the future. ... In light of the forgoing remarks, conservation may be defined in two senses, as a state and as a form of action. As a state it is defined as the optimum time distribution of use of natural resources. As a form of action, it is defined as action designed to achieve or maintain the optimum time distribution of use of a natural resource.²¹

Clearly McDonald is characterizing a highly idealized ‘social optimality’ in this ‘conservation process.’ McDonald avoids reference to any institutional context bearing on property rights or the institutional barriers imposed governmental ownership or intervention. Moreover, the ‘satisfactions’ to which he makes reference seem to be a premised on the existence of a type of social utility enjoyed by society as a whole. There is no sense that entrepreneurs are making decisions within the context of a market process. Implicitly, his theory seems to be premised upon and presented within a general equilibrium framework in which entrepreneurial firms play no role. In bringing ‘capital theory’ into the process, he recognizes no need to make a distinction between capital goods and capital. But more fundamentally, by building his theory on the assumptions of a general equilibrium, he is paradoxically describing a world in which capital does not exist. Capital cannot exist because in McDonald’s construction because entrepreneurs do not exist. This latter issue is examined at greater length below.

While McDonald certainly addresses the issue of resource replacement in these works, his repeated reference to resource stocks (i.e., ‘remaining stock’) seems to suggest that he retains the assumption of an ultimate limit on recoverable resources and inter-temporal equilibrium. In this sense he too seems to be in the grip of some sort of exhaustion myth. For example, in McDonald observes:

Where the known stock of a particular resource is renewable through exploration, as with oil and gas, the optimum time distribution of use embraces two separate

²¹ McDonald, Stephen. 1967, pp. 271-272.

but interrelated levels of optimization. The first pertains to the rate at which resources are devoted to the renewal effort, hence given the discovery function, the rate at which the remaining unknown stock is appropriated into the known stock. The present value resulting from the optimum time distribution of use of the known stock in relation to the expected costs of renewal affect the rate of the renewal effort. The time distribution of use of the whole stock, known plus unknown, is optimal when the marginal yield on postponement of use in the known stock and the marginal yield on exploration for renewal are both equal to the marginal rate of time preference adjusted appropriately in each case for risk and uncertainty. Expected costs of renewal reflected in expected future prices affect the optimum time-distribution of use of the known stock. ... Conservation, as defined, pertains to the whole stock and thus [to] optimality at both known stock and the renewal level.²²

Several aspects of McDonald's resource renewal model are troubling when examined from a market process perspective. *First*, the 'process' that he describes seems to be devoid of any individual human action; there are no entrepreneurs facing 'realistic market uncertainty' as they implement plans regarding the timing, scale or location of individual investments. His references to expected costs and expected future prices suggest a risk-based or class-probability approach to market uncertainty.²³ But almost in self-contradiction, McDonald's reference to 'optimum time distribution of use' seems to be premised on some 'already-known' deterministic view of the future of the market.²⁴ A *second* concern related to the first is that although in a superficial sense McDonald attempts to deal with extractive resources as 'capital,' it is clear that he has in mind a physical conception of capital and not the entrepreneur's reckoning of the appraised worth of a planned extraction operation. *Third*, McDonald makes no mention of property or the institutions of property rights. Prices and cost do not exist in any rational sense without private property. Moreover, no capital exists without entrepreneurial plans that are, in turn, impossible without implicit premises regarding institutions of ownership. *Fourth*, McDonald's focus on what could be called global optimality is entirely misplaced. Implicit in his observation is the notion that an aggregate of the known or unknown stock of resources has

²² McDonald, Stephen. 1967, pp. 272-273.

²³ The concepts of risk and uncertainty are distinct. Ludwig von Mises designates these respective concepts as 'class probability' and 'case probability.' See Ludwig von Mises. 1998 [1949] *Human Action: A Treatise on Economics, The Scholar's Edition*, pp. 105 -118. 'Class probability can be applied to the quantifiable probabilities associated with, for example, geological discovery of a deposit, for example. 'Case probability' is properly applied to the subjective inferences regarding essentially unique market events the incidence of which is not amenable to quantitative estimation.

²⁴ Professor McDonald seems to take a more defensible posture in a later publication: "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 reflecting sacrifice and gains of satisfaction (costs and prices) change over time.@ Stephen McDonald. 1971. *Petroleum Conservation in the United States: An Economic Analysis*. Baltimore: The Johns Hopkins Press, pp. 83-84.

some welfare significance for society as a whole. The aggregate stock of a resource, whether known or unknown, is quite meaningless.²⁵ As noted earlier, attempts to address the aggregate known stock of an extractive resource are as pointless as attempts to aggregate the capital stock of a nation. Even if such an aggregation of some ‘stock’ were possible, it would have no bearing on entrepreneurial action. The only relevant concern bears on the privately reckoned costs and benefits associated with the management of privately owned resources.

Resources are plentiful or scarce at the macro-economic or aggregate level depending on the private entrepreneurial profitability of marginal investment in replacement of extractive resource deposits. In an economic sense, a deposit of an exhaustible resource is largely an entrepreneurial judgment. It only has meaning within the context of an entrepreneurial plan. For a pessimistic entrepreneur, the value may be low; for an optimistic entrepreneur the value could be high. In an entrepreneurial world of change and uncertainty, an individual resource deposit will not have the same economic meaning to competing entrepreneurs. As emphasized in this paper, the critical focus in dealing with resource renewal bears solely on the marginal actions of the entrepreneurial firm to maintain capital by replacing depreciating assets. ‘Optimality’ only has *ex ante* relevance in terms of the way in which the entrepreneur views his decisions which means that estimates of global resource stocks is nonsensical.

B. F. A. Hayek on extractive (depletable) resources as ‘replaceable capital’

A theoretical disagreement between Friedrich Hayek and Murray Rothbard on the applicability of capital maintenance to extractive resources bears centrally on the issues examined in this paper. Recall Murray Rothbard’s erroneous classification of ‘depletable resources’ as land, not capital goods. In his classification, Rothbard was apparently embracing the exhaustion myth as resolutely as Harold Hotelling had in his 1931 paper on exhaustible resources. Rothbard posed the question: “must labor and land factors work in order to reproduce the good?”²⁶ Rothbard goes on to answer his own question by responding ‘no’ since “these resources cannot be reproduced by man despite their depletion.” Rothbard concludes that depletable resources must be treated as a distinct category under the ‘land’ classification. “The point is that resources subject to depletion cannot be replaced, much as the owner would like to do so.”²⁷

But Hayek takes a different approach and categorizes extractive resource deposits as a non-permanent but ‘replaceable capital’:

But for determining what resources are functioning as capital at any given moment, the essential point is not that the particular resources have been produced; it is that

²⁵ Morris Adelman notes: We cannot rescue the concept of a fixed mineral stock by making it the ‘economic portion’ of the unknown total in the ground. That is circular reasoning. For the ‘economic portion’ depends on future costs and prices. One cannot estimate future costs and prices by starting with the result. The ‘economic portion’ is a forecast, an implicit unverifiable prediction of how much inventory is worth creating and using. Morris Adelman. 1993. *The Economics of Petroleum Supply*. Cambridge, Massachusetts: MIT Press. p. 271.

²⁶ Murray N. Rothbard. 2004. *Man, Economy and State with Power and Market*, pp. 496-497.

²⁷ *Ibid.*, pp. 496-497.

they are not permanent, but of limited durability, and there for must be replaced by some new resources if the income stream is not to decline. ... the point that is relevant for our problem is not that certain existing resources can be replaced by others which are in some sense technologically similar to them but that they have to be replaced by something whether similar or not, if the income stream is not to decline. A deposit of metal ore is no less capital because it cannot be reproduced, ... What determines the special common characteristics of capital goods is not that they can be reproduced, but how they can be used: namely that they can be made to yield all their services in the comparatively near future.²⁸

Rothbard mistakenly attempts to challenge Hayek' perspective:

“Hayek criticizes the criterion of reproducibility for classifying a capital good. ... But this is confusing value with physical considerations. We are attempting to classify physical goods here, not to discuss their possible values, which will fluctuate continually. ... Hayek raises the question whether an [income] stream is land if a new stream can be created ... Here again, Hayek misconceives the issue as one of maintaining a ‘constant income stream’ instead of classifying a physical concrete good.”²⁹

Rothbard is certainly in error in attempting to rebuke Hayek on the issue of classification of depletable resources. Hayek is largely correct in his classification and the underlying rationale for the distinction that he makes. And he is most assuredly correct to assert that reproducibility is not the sole criterion for classifying assets as capital but rather that assets must be non-permanent and of limited durability.

But clearly Hayek commits some errors similar to those made by Rothbard. Nowhere in Hayek's discussion is there any hint that the entire reproducibility or replacement process revolves around the actions of entrepreneurial firms seeking to maintain income or entrepreneurial rents. He certainly makes a valid point in noting that deposits of extractive resources are in fact replaceable as ‘capital’ and routinely replaced though a process of income maintenance. However, he does not seem to acknowledge the fact that this replacement process is fundamentally grounded in the actions of entrepreneurs. He does not acknowledge that entrepreneurs have a viable means of maintaining capital by replacing old depleting deposits are with new deposits through a process of investment in exploration and development. Moreover, Hayek seems to view ‘income’ from the depletion of extractive resources as some vaguely defined aggregate to be managed on some ‘national level.’ This interpretation is lent greater credence by the following sentence in Hayek's discussion of ‘exhaustible resources’: “But it should always be kept in mind that *any exhaustible resource represents just one item of the national capital ...*”³⁰ (Emphasis added) Of course, nations cannot be acting entities and cannot

²⁸ F. A. Hayek. 1950 [1941]. *The Pure Theory of Capital*. London, UK: Routledge & Kagen Paul Ltd., pp. 90-92.

²⁹ Murray N. Rothbard. 2004. *Man, Economy and State with Power and Market*, p. 497.

³⁰ F. A. Hayek. 1950 [1941]. *The Pure Theory of Capital*. London, UK: Routledge & Kagen Paul Ltd., p. 88.

in any legitimate way be considered ‘owners of capital.’ Hayek seems to ignore the fact that the extent to which extractive resource deposits are an element in the reckoning of ‘capital’ depends on the private rights of property held by entrepreneurial firms and the role these deposits play in the plans of entrepreneurial firms – not in the policy aspirations of nations.

IV. CAPITAL, CAPITAL GOODS AND RENT MAINTENANCE AS CAPITAL MAINTENANCE

To examine the economic process by which deposits of extractive resources are replaced, one must focus not on the resource itself but rather on the entrepreneurial firm and the actions that it must undertake to maintain capital. The entrepreneurial firm exists only in a disequilibrium world in which the future of markets is necessarily uncertain and economic change is perpetual. In this environment, firms are necessary for allocating the services of depreciable, non-permanent capital goods between time periods.³¹ Entrepreneurial firms survive on the basis of the quality of judgments brought to bear on resource use over time. The entrepreneurial firm’s objective in this competitive process is the ‘sustaining’ of entrepreneurial rents.

A. Hotelling rents subsumed in entrepreneurial rents

In a disequilibrium world, the appraisal of resources by various entrepreneurial firms may well differ and will usually be reflected in differing expectations of what the future prices of these resources will be. One of the implications of these differing perspectives is that the appraisal of a resources within the context of an entrepreneurial plan may well differ from what the market prices of the resource is at any moment in time. A further implication of disparate views of resource worth is that the opportunity costs of employing resources in one planned use as opposed to the next most profitable alternative use will be subjective and will differ between entrepreneurial firms. In other words, firms will value resources on the basis of the next most profitable use foregone in committing the resources to the chosen production plan. *Hence, entrepreneurial rents can be described as the difference between the entrepreneur’s ex ante judgment of what the resources are worth in their ‘best’ use relinquished and the ex post revenues generated from the plan actually implemented.*³²

How do Hotelling rents relate to entrepreneurial rent? Hotelling rents are usually thought of as a type of scarcity rent arising from increasing global scarcity of the resource and the increase in net resource price generated by this scarcity. While there is no evidence of increasing global scarcity for mineral resources, the relevance of these rents is also called into question by the fact that the theory of the Hotelling Rule is cast in an equilibrium framework in which an ‘optimal rate of depletion’ is achieved when the net price increases at a rate equivalent to the rate of return obtainable on the next most profitable investment of comparable risk. The equilibrium

³¹ Peter Lewin. 1999. *Capital in Disequilibrium: The Role of Capital in a Changing World*. London: Routledge, pp. 162-165.

³² Peter Lewin describes what he refers to as strategic rents which he defines the following way: “strategic rents are profits and are earned only in disequilibrium (profits are the difference between *ex ante* prices of resource stocks, their costs, and their *ex post* value in use, the revenues they generate.” Peter Lewin and Steven E. Phelan. 2000. “An Austrian Theory of the Firm,” p. 71.

reckoning of Hotelling rents is largely meaningless and irrelevant in a disequilibrium world in which the entrepreneurial firm must make appraisements under conditions of genuine market uncertainty. There exists no hypothetical framework in which Hotelling rents can be separately discerned. In the real world of uncertainty and change, these appraisements would be subjective judgments. Hence, it would be misleading to think of Hotelling rents as have any separate existence apart from entrepreneurial rents. To the extent that Hotelling rents play any role, they emerge only from a broader set entrepreneurial decisions made by the firm under in uncertain and changing markets.³³ For example, the extractive firm may conjecture that it may be able to lower the opportunity costs associated with any phase of a project by delaying the commencement of operations. Such delay would minimize the cost increases that may arise from bottlenecks during exploration and development.³⁴ In the context of capital maintenance by the extractive firm, any reduction in cost must be viewed in a larger context of entrepreneurial rents which are, in part, also contingent on other decisions such as the scale of the plant installed to facilitate extraction.

But maintenance of capital and protection of entrepreneurial rents may involve speculative delay in further investment on some extraction projects. For example, an important reason to delay activities on a project may arise from volatility in the appraised worth of a sequence of prospective investments associated with these projects. In such a case, the entrepreneurial firm may treat the investment (in an unexplored mineral lease, for instance) as a series of options each of which can be exercised in stages or timeframes. The entrepreneurial firm will take account of the fact that the amount invested in successful exploratory ventures is at least partially sunk and cannot be recovered if the firm decides not to proceed further with development of a discovered deposit. In taking advantage of the option to delay, the firm will be aware of any historical and projected variability in the market value of the asset sought in subsequent investment. For

³³ Peter Lewin and Steven E. Phelan do not address Hotelling rents in particular but make the following observation with respects to other rents that may be subsumed in entrepreneurial rents: "... rents, from this perspective, include all rents earned in disequilibrium. They encompass Ricardian, Marshallian, opportunistic and any other imaginable rents in disequilibrium situations." Peter Lewin and Steven E. Phelan. 2000. "An Austrian Theory of the Firm," p. 72.

³⁴ As this insight applies to production in general, see Armen Alchian. 1959. "Costs and Output." In *The Allocation of Economic Resources*. Moses Abramovitz ed. Stanford, California: Stanford University Press, pp. 23-40). Alchian's observation is borne out in the research on leasing of Federal offshore lands on the Outer Continental Shelf (OCS); Walter Mead and his colleagues note the following:...

the attempt to develop leases more rapidly could lead to increased costs If development of the resource is required in such a short period of time, bottlenecks would surely develop in acquiring the skilled labor and specialized capital equipment necessary for OCS exploration and production....in the short run, both labor and capital equipment are available in relatively inelastic supply. This means that the stimulus of more demand for inputs would be felt primarily in higher input prices, with limited additional quantities of these inputs being provided to the market ... by allowing more time for lease development, the labor and capital equipment markets can respond to increased demand for these inputs with increased production at prices lower than those that would prevail under more pressing time constraints.

Walter Mead, Asbjorn Moseidjord, Dennis Muroaka, and Phillip Sorensen, *Offshore Land: Oil and Gas Leasing and Conservation on the Outer Continental Shelf*, pp. 110-112.

example, the asset sought in exploration investment would be discovered resources or, in the case of investment in development, the asset sought would be developed resources. In each case, the entrepreneurial firm may find it advantageous to delay any further commitment to the project until evolving market conditions reveal more information about the future of the market and the potential profitability of the investment.³⁵ While these types of decisions do not bear in any direct way on Hotelling rents, they are certainly important in protecting and maintaining the firm's prospective entrepreneurial rents.

B. Distinction between 'capital' and 'capital goods' in entrepreneurial action

Contrary to the arguments of some economists, deposits of extractive resources are capital goods. If extractive resources are renewable or replaceable, the process must be premised on some coherent theory of capital and capital maintenance. The premise of this paper is that extractive resources forming part of the business plan of an entrepreneurial firm are in fact capital goods that can be replaced as would be possible with any capital good. But the focus on equilibrium and aggregate capital stocks in the mainstream (neoclassical) tradition has sidelined any theory of the entrepreneur, which, in turn, has meant that no satisfactory theory or coherent distinction has between capital and capital goods has emerged. A typical definition of capital is the following: "in classical and neoclassical economic theory, capital consists of durable produced goods that are in turn used in production. The major components of capital are equipment, structures and inventory."³⁶

But do these listed things really represent 'capital?' No; the list of things itemized in the previous paragraph are not capital, they only have the potential of being *capital goods*. Capital goods are those objects that come into existence because of plans made by both savers and entrepreneurs. Capital, as distinct from capital goods, as an economic concept is virtually meaningless without the plans and actions of individual entrepreneurs.³⁷ By neglecting the entrepreneur and denying the realities of market uncertainty and disequilibrium, the neoclassical school finds no need to make a distinction between capital goods and capital. In equilibrium, there are no entrepreneurial plans because there are no entrepreneurs. There is no market uncertainty and hence no role for entrepreneurial judgment in choosing from among alternative plans. The assumption of equilibrium offers a superficial reconciliation between a listing of disparate things and what one might loosely characterize as the 'aggregate capital stock.' Since, in the neoclassical paradigm, all of these physical things are assumed to have equilibrium market prices, these prices can simply be added to form this stock of capital. But equilibrium is nothing more than an abstract tool for thinking and never emerges in real market processes. Not only do capital goods not have equilibrium values, the plans of entrepreneurs may ultimately prove to be incompatible with the investment plans of other entrepreneurs. Hence any attempt to use

³⁵ Avinash Dixit and Robert Pindyck, *Investment Under Uncertainty* (Princeton University Press: Princeton, New Jersey, 1994) p. 4.

³⁶ National Research Council. 1999. *Nature's Numbers: National Economic Accounts to Include the Environment*. Washington, D.C.: National Academy Press, p. 208.

³⁷ Israel Kirzner. 1996. *Essays on Capital and Interest: An Austrian Perspective*. Cheltenham, UK: Edward Elgar publishing Company Ltd., p.124.

tabulations of capital goods as ‘capital’ is meaningless and empty.

What is a coherent definition of ‘capital?’ The clearest and most coherent statement on the distinction between capital and capital goods has been offered by Ludwig von Mises: “*Capital is the sum of the money equivalent of all assets [capital goods] minus the sum of the money equivalent of all liabilities as dedicated at a definite date to the conduct of the operations of a definite business unit.* It does not matter in what these assets may consist, whether they are pieces of land [inclusive of extractive resources], buildings, equipment, tools, goods of any kind and order, claims, receivables, cash or what ever”³⁸ (emphasis added). This Misesian definition highlights important issues. *First*, this definition of capital by Mises implicitly suggests that the neoclassical definition is empty; it is simply a listing of types of capital goods, not capital. Such a listing can never be a definition of capital because it is essentially an agglomeration of heterogeneous things that have no coherent meaning outside of the business plan of the entrepreneur. *Second*, the definition also notes the fact that capital itself, though it clearly involves capital goods, is strictly a net monetary reckoning of equity that is given coherent meaning within the context of the monetary (calculational) reckoning of the entrepreneur’s balance sheet.

Capital goods represent those resources that the entrepreneur has marshaled for the implementation of his business plan, whereas *capital* represents the entrepreneur’s best judgment of the present-worth appraisal of the income that can be sustained or increased by the plan itself. But one may well ask: if capital is a net present worth reckoned within the context of a balance sheet, why is capital not adequately represented as a tabulation of the market prices of capital goods? While it is true that many of the items that show up in this type of tabulation such as extractive resources have prices reflecting market worth of the particular resource, these prices only provides a rational framework within which the entrepreneur is able to formulate a subjectively conceived plan. To this extent, capital simultaneously represents both a balance sheet reckoning and an entrepreneurial idea. As Mises notes “capital is a praxeological concept ... its place is in the human mind. It [capital] is a mode of looking at the problems of acting, a method of appraising them from the point of view of a definite plan.”³⁹

In the real world in which entrepreneurial judgment is critical, a capital good becomes a consideration in the reckoning of capital only within the context of an individual plan. From the perspective of the extractive enterprise, a balance-sheet tabulation of the type described by Mises may well include mineral deposits of extractive resources. But in an economic sense, a deposit of an exhaustible resource is largely an entrepreneurial judgment. It only has meaning within the context of an entrepreneurial plan. For a pessimistic entrepreneur, the value of a deposit may be low; for an optimistic entrepreneur the value could be high. An individual resource deposit will not have the same economic meaning to competing entrepreneurs. However, these imputations are not revealed as objective data in business audits, hence, one must always be aware that they

³⁸ Ludwig von Mises. [1949] 1998. *Human Action: The Scholar’s Edition*, p. 262.

³⁹ *Ibid.*, p. 512.

are conditioned by the entrepreneur's judgment about future market conditions. Hence, the accounts are, in fact, speculative judgments or 'refined conjectures' regarding the profits that can be earned in the market: The central function of capital accounting is to provide a framework for the entrepreneur to assess the way in which alternative actions and investments bears upon his ability to sustain the income of the entrepreneurial enterprise: "[t]he question it answers is whether a certain course of conduct increases or decreases the productivity of our future exertions."⁴⁰

C. Rent maintenance as capital maintenance for extractive firms

In the context of entrepreneurial action, *rent* can be viewed as the correlative of *capital*. To the extent that the entrepreneurial firms make prudent choices in their investment decisions that at least sustain prospective rent, capital is maintained for the 'enterprise.' But the word 'choice' necessarily implies that rent-sustaining capacity of capital does not emerge as a given fact in real-world markets. It can fail. The entrepreneurial firm is never presented with a situation in which he can mechanically undertake select from among elements of objective data. Entrepreneurial judgment is required every step of the way. Capital maintenance, as it applies to such resources, is itself a praxeological concept that is unique to the entrepreneurial firm's business plan and the firm's understanding of the future of the resource market and other markets in which it may invest.

A central issue for any entrepreneurial firm attempting to sustain or expand its rent involves the issue of depreciation or depletion of its capital assets under conditions of uncertainty and change. Addressing this issue hinges on the judgments required in any effort to replace depleted resources, the rent generating potential of which is diminished by current extraction. In this reckoning, the owners of capital assets attempt to establish, at the margin, a balance between the valuation of current benefit of using capital goods and his valuation of future productive benefits relinquished because of current use. These future relinquished benefits have come to be called 'user cost.' This user cost is based on the acting entrepreneur's market expectations. In a realistic disequilibrium world, no two actors are likely to see the future of the market in exactly the same way.⁴¹ Hence, user cost is subjective. In other words, the user cost imputed to the current use of capital goods will reflect the highly personal outlook of owner-entrepreneurs who may embrace optimism or pessimism, boldness or timidity at any one moment in time in which they must make decisions. The entrepreneur must make critical choice with respect to the replacement of capital with the ultimate objective of sustaining or expanding rent. *Hence, the accomplished fact of having physically replaced particular capital goods is not necessarily in itself an action that successfully maintains capital.* Entrepreneurial judgment is required in deciding the extent to which projected rent is maintained or expanded by planned investments. As Ludwig Lachmann has emphasized, these are speculative decisions because the consequences of one's actions cannot be known with certainty, highlighting the fact that plans for maintenance may be unsuccessful.

⁴⁰ Ibid., p. 511.

⁴¹ Ludwig Lachmann. 1986. *The Market as an Economic Process*. New York, NY: Basil Blackwell, Ltd, pp. 66-67.

These entrepreneurial decisions can only be made in a coherent, rational way within an economy of private property and monetary exchange. Only property owners functioning in such an economy are capable of making the prudent rankings of the net advantages that may be yielded by alternative employments economic resources. Monetary calculation allows the owner to make such distinctions with respect to all classes of capital goods -- whether man made or natural assets. Private property and monetary exchange provide the requisite institutional framework for the owner of capital to make *rational* decisions with respect to maintenance of capital. In other words, rent is a goal of entrepreneurial action; it is undertaken on the basis of the best available information and judgment on the uncertain future of the market. Hence, as capital is only manifested in the entrepreneur's mind as part of a plan, the same is also true for rent itself. It is made such by the entrepreneur's mental reckoning of the implications of economic change and market uncertainty.

D. Entrepreneurial strategies for the extractive firm in maintaining capital

Morris Adelman has done more than any other economist to demythologize the exhaustion myth. While his work is open to criticism (discussed below), he has avoided many of the errors of other economists having done work on what has been erroneously labeled the 'economics of exhaustible resources.' While Adelman's work has produced an ingenious and practical theory of resource replacement as it applies to petroleum, his theory has a very general applicability to all extractive resources. For several reasons, his work represents a dramatic improvement over previous work in the economics of extractive resources. *First*, Adelman debunks the notion of aggregate resource stocks and the presumption of eventual exhaustion with increasing global scarcity. *Second*, he focuses strictly on the actions of firms making choices regarding the least expensive means of replacing a unit of the resource produced in the present. *Third*, his analysis goes part way in addressing the ways in which the incremental expenses of alternatives is affected by the choices made at the margin.

Adelman's criterion for 'optimality' is centered on the 'least costly strategy' in replacing a unit of the resource produced and sold today. In his focus on petroleum resources, Adelman observes:

The cost of creating reserves by various methods should approach equality at the margin. The cost of creating new reserves through more extensive or intensive development of known pools can be called marginal development cost and should in equilibrium equal marginal finding cost, which should equal marginal user cost. [For Adelman, user cost per unit of the resource is the difference between the *in situ* value of the developed resource minus the prospective development cost per unit.] Discovery, development and purchase are all competing outlets, alternative methods of acquiring reserves. If the operator chooses to develop a known pool more extensively, increased development cost is the penalty for using not holding. He should not incur a penalty greater than the value of an undeveloped barrel, i.e., user cost.⁴²

⁴² Morris Adelman. 1993. *The Economics of Petroleum Supply*. Cambridge, Massachusetts: MIT Press. p. 243.

One should note that Morris Adelman's treatment of opportunity cost is essentially 'objectivist.' To this extent, his approach to cost implicitly minimizes the role of entrepreneurial judgement. Financial outlays are implicitly assumed to represent the opportunity costs involved in committing to a certain course of action. However, in a changing, uncertain disequilibrium environment, this approach to opportunity cost is untenable.⁴³ Opportunity cost is necessarily the extractive firm's subjective valuation of what is relinquished in undertaking one of the actions described by Adelman in the quoted paragraph. Hence, the extent to which equality of marginal cost for the three replacement options emerges is not open to empirical examination. These actions have subjective opportunity costs that are known only to the entrepreneur.

However, for the purposes addressed in this paper, one must also acknowledge that Adelman's analysis is a rather mechanistic process geared to the physical replacement of the resource at minimum 'expense.' *In other words, it is essentially a theory of physical replacement of capital goods.* It suggests an approach to resource replacement that may or may not constitute capital maintenance for the entrepreneurial extractive firm. Successful capital maintenance strategies are those that sustain entrepreneurial rents. And, as the following discussion will reveal, a focus on cost minimization is a misleading criterion in explaining actions necessary to maintain capital. The simple replacement of resources or capital goods will not necessarily achieve that objective. Alternative strategies to maintain entrepreneurial rents would include a comparison of the following types of investment strategies:

- (1) Find new deposits and proceed with development and extraction of these new deposits.
- (2) Develop and extract already discovered discoveries.
- (3) Purchase already developed deposits from other firms and proceed with extraction of the purchased resources.
- (4) Purchase, develop and extract undeveloped deposits initially discovered and owned by other firms.
- (5) Because of price volatility and uncertainty over the value of additional investment in particular extraction projects, the extractive firm may engage in speculative delay in additional exploratory efforts with respect to strategy (1) or investment in development as in the case of strategy (2); delay is prudent in this case since at each stage of a project, investment outlays are sunk, volatile market conditions may signal the firm to discontinue the extraction project.

⁴³ James M. Buchanan. 1969. *Cost and Choice: An Inquiry in Economic Theory*. Chicago: Markham Publishing Company, pp. 49-50.

- (6) Continue with extraction deposits and reinvesting proceeds in assets not directly related to the extraction of resources or even the extractive industries.

Each of these investment strategies for capital maintenance has an opportunity cost that is unique to the extractive firm and each has certain implications for the entrepreneurial rent that the firm seeks to maintain. In fact, for the extractive firm making a choice of one of these strategies, the opportunity costs will necessarily include a subjective reckoning of the entrepreneurial rents thought to be obtainable from the next most profitable relinquished strategy. A few additional words of clarification may be important with respect to these options. First, in terms of maintaining entrepreneurial rent, one may be tempted to conclude second strategy, (2), would be superior to (1) the first strategy since it does not entail the uncertainty and cost that would necessarily be involved with finding new resources. However, such would not necessarily be the case; mining firms searching for new and more profitable deposits to replace depleting extractive-resource deposits. In choosing a capital maintenance strategy, the extractive firm compares the marginal expected opportunity cost of finding, developing and exploiting new deposits with the marginal expected opportunity cost of developing and extracting an existing known deposit. If the former costs are less than the latter, a decision to find new deposits promises a greater yield in terms of entrepreneurial rents.

The third strategy, (3), is very common in the petroleum industry but for any mineral, this type of a transaction may entail the outright purchase of an existing extractive operation from another firm. The extractive firm would be inclined to pursue this strategy if the quality (lower cost) of the deposits available for purchase were superior to those under the firm's immediate control. One important aspect of this third strategy is that it would reflect a decision on the part of the extractive firm to deliberately delay exploration or development of the property and resources to which already has access. In other words, the firm would be exercising speculative latitude in the timing of these actions. The strategy (4) is probably a relatively rare occurrence *unless* a substantial level of delineation drilling were to follow discovery. This latter caveat would apply to both solid mineral deposits and petroleum reservoirs since extensive delineation drilling would provide the requisite information on the minimum volume of the resource discovered. Arguably, in the case of a petroleum discovery, development must usually be undertaken to arrive at a reasonable estimate of the quantity of reserves being considered for purchase. Again, as in the case of strategy (3), the latter strategy of purchase, (4), would indicate a decision to exercise speculative delay with respect to prospects to which the firm already has access.

Option (5) of exercising speculative delay may be an important strategy for the extractive firm facing conditions of market price volatility for the resource being extracted. This price volatility for the resource will be reflected in volatility in the market value of discovered but undeveloped resources as sought in the first or exploratory stage of strategy (1). This price volatility will also be reflected in the market value of the developed resources sought in the second state of strategy (1) or in the first stage of strategy (2). In these cases, the extractive firm derives a benefit from delay since both exploration and development outlays are irreversible (sunk) and the volatile market for the underlying assets (discovered resources or developed resources) may reveal information prompting the extractive firm to proceed no further with the project. Delay affords the extractive firm these options. However, delay would normally not be a consideration with

respect to strategies (3) and (4) since such purchases would not be made unless the extractive firm were prepared to commence operations immediately.

Strategy (6) helps to highlight the reason that cost minimization in the replacement of physical capital goods is not necessarily equivalent to capital maintenance. The real motivation for investment to maintain capital is not to minimize cost but to maintain or preferably increase income or entrepreneurial rent. In the case of strategy (6), the two may be quite different since ‘cost’ minimization (or expense minimization) does not take into account gross revenues made possible by investment in capital goods that may be unrelated to the firm’s historical specialization. Such a shift in the physical composition of capital goods sought in replacement investment could be prompted by unforeseen changes or previously unrecognized entrepreneurial opportunities in other markets. F.A. Hayek captures the entrepreneurial motivations for such shifts in investment: “... when we proceed to consider in detail the reaction of capitalist to unforeseen changes, is that as soon as we go back to the *rationale* of maintaining capital intact, the quantity of capital drops right out of the picture as a directly relevant magnitude. Its place is taken by a direct consideration of the size of the income streams that may be expected at different dates.”⁴⁴ (The italics are in the original text.) It is in this sense that Adelman’s focus on the physical replacement of resource deposits conveys a misleadingly narrow interpretation of the investments necessary to maintain capital for the extractive firm.

The extractive firm may be constrained in its choice of replacement investments by realities of ‘capital complementarity.’ If the firm invests in capital goods not directly related to extraction, must it not be mindful of the degree to which such capital goods ‘mesh’ with existing capital goods that may exist principally in the form of deposits of the extractive resource? Obviously, the answer to this question is ‘yes.’ But this concern over ‘meshing’ is not necessarily an issue of physical complementarity of capital goods. The central concern is the extent to which the particular investment alternative promises the largest addition to entrepreneurial rent for the enterprise as a whole. For any particular future investment that the extractive firm may consider, replacement of resource deposits may or may not be the best means to attaining that objective. Expected profitability would always establish economic complementarity and overwhelm issues bearing of physical complementarity for the extractive firm.

V. Institutions and Policies Impeding Resource Replacement for Firms

While capital maintenance by extractive firms tends to refute the exhaustion myth, this refutation is contingent on: access to lands, entrepreneurial latitude in managing resources, and secure rights of private property. Conditions and circumstance can hinder and impede the entrepreneurial actions of extractive firms striving to maintain capital. These hindrances arise from unfortunate institutions of ownership and jurisprudence that bear negatively on the resource replacement process of extractive firms. These hindrances include: (A) land access foreclosed by government ownership of mineral lands; (B) entrepreneurial latitude foreclosed by court-imposed covenants enforcing obligations to surface owners; and (C) in the case of petroleum, the inability of the extractive firm acquire full control and ownership of reservoirs that it has

⁴⁴ F. A. Hayek. 1950 [1941]. *The Pure Theory of Capital*, p. 300.

discovered. The first of these impediments bears on access to land and the latter two impede the ability of extractive firms to manage resource deposits as capital assets.

A. Land access foreclosed by government ownership

Maintenance of entrepreneurial rents requires a replacement of the capital goods critical to continued operation within the same industry. This entrepreneurial process requires that the firm have access to new resources that are extractible at lower cost. Resource replacement is critically dependent upon contractual arrangements between property owners and entrepreneurial firms seeking to find and develop new deposits. Through an unhampered market process of free exchange between private property owners, resources tend to gravitate to their highest valued use. The one obstacle facing the entrepreneurial extractive firm in its efforts to maintain capital is that properties are controlled by landowners that totally foreclose access rights to extractive firms. These owners are invariably governments that have merely nationalized lands through acts of political power without any actions establishing legitimate ownership. Once these lands are under the political control of governments, access is established through a political process. In modern democracies, this conflict is manifested in political struggles to marshal the power of legislatures to assure certain politically popular uses of lands and foreclose less popular uses.

This political selection of popular uses of nationalized lands is one of the more pernicious features of democratic processes. Once lands are nationalized, alternative uses of these lands are chosen with the intent of appeasing 'stakeholders.' For the purposes of this inquiry, the important question is: who is a stakeholder with respect to the use of public lands? Unfortunately, political self-selection is the only criterion used to establish who has a legitimate 'stake' in decisions on alternative uses of government lands. Stakeholders are voters with diverse and subjective views on what for them constitutes an environmental amenity and the way in which they are affected by its presence or absence. But this political process takes the focus off legitimate environmental issues and, instead, motivates allocative decisions on the basis of the political placation of a certain self-selected political constituency. This participatory process has little to do with rational environmental policy or the commitment of resources to their highest valued use.

Political advocates of policies that foreclose access are unencumbered by the opportunity costs of such sanctions. In this sense, choosing and hence forsaking the value of the next most highly valued opportunity never impinges upon the actions of non-owning bureaucrats, politicians or environmentalists seeking to foreclose certain uses of government lands. *Problems of resource exhaustion and a failure of firms to replace resources deposits can arise from the fact that the weighing of opportunity costs plays virtually no role in foreclosing lands to exploration and development.* In bearing little of the opportunity costs of political foreclosure of access, self-selected stakeholders have incentives to become extremist in exaggerating preferences and overstating claims. Whatever the benefits of foreclosing exploration and development may be, these benefits are provided as a 'free good' through the process of political control.

B. Entrepreneurial latitude foreclosed by obligations to surface owners

The preceding discussion also highlights the fact that the extractive firm must have ample timing

latitude if resource replacement is to be successful. But an early juridical declaration of surface owner rights has tended to preclude this speculative latitude. 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."⁴⁵ The modern day implication of this interpretation of the surface owners rights is that the surface owner as a lessor is entitled to a fixed percentage royalty on the gross proceeds from the sale of the extracted mineral. *The central issue is that the fixed percentage royalty confronts the royalty-owning lessor and the investing lessee with mutually and fundamentally incompatible objectives. Hence, any the lessor will want to see the extraction operation managed so that the present value of the operation's gross revenue stream is as large as possible.*⁴⁶ Speculative timing of activity on the part of the royalty-paying lessee is anathema to those interests since responsible speculation may involve delay.

Court-imposed implied covenants protect the land-owning lessor from any action or lack of action that delays the surface owner's receipt of royalties. However, uncertainty and economic change mean that speculation is critical in managing capital assets. The management of the lease as a capital asset necessitates the timing of lease activities so that present value of entrepreneurial rents is maximized. By not allowing speculative latitude in the timing of these activities, the covenants reduce the net present value of petroleum resources and impede the ability of the extractive firm to maintain capital. For the investing firm, the option of delay in exploration, development or production is almost always critically important to achieving this objective.

(C) Inability of the petroleum firms to acquire ownership of discoveries

This source of hindrance in capital maintenance devolves in major part from the Blackstone declaration of surface ownership rights. Essentially the Blackstone declaration stipulated that the land-surface owner also owns all minerals within and below the boundaries of his property. However, this interpretation of mineral ownership encountered difficulties in its application to *in situ* petroleum and the unusual characteristics of petroleum reservoirs. 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. Hence, a *rule-of-capture* has evolved such that a discovered reservoir *never becomes a capital good to be managed by the entrepreneurial firm.* The petroleum itself is not actually owned by anyone until it is actually captured at the surface. The rule of capture applies irrespective of the fact that the petroleum resources may have migrated from beneath another surface owner's property.

⁴⁵ William Blackstone. 1908. *Commentaries on the Laws of England*. Philadelphia, PA: J. B. Lippincott Publishing Company, pp. 404-405.

⁴⁶ John Brätland. 2001. "Economic Exchange as the Requisite Basis for Royalty Ownership of Value Added in Natural Gas Sales." *Natural Resources Journal*. 41(3), pp. 694-695. In the context of the petroleum lease, the lessor's (i.e., surface owner's) economic interests are defined by the attainment a rate of revenue recovery that maximizes the present value of the royalty-receivables revenue stream. Delay only diminishes this present value. Hence, expedited recovery of royalty revenue is always optimal for the surface owner as a lessor.

The state of petroleum law can be blamed in part on William Blackstone's views on the spatial scope of land ownership which seems to bar the homesteading of subsurface discoveries. While in the case of petroleum lands, the application of Blackstonian Principles has not meant that the surface owner owns subsurface petroleum, it does mean that the surface owner is always entitled to a percentage share of gross production or a percentage share of the gross sales proceeds of production. But court imposed covenants protect the financial interests of the surface owner. The covenants mandate that in the case of petroleum leases, the lessee has a duty to *protect the lease property from drainage* by drilling 'offset wells' or protection wells and securing the production that would otherwise be lost to competing leases. But in this competition, everyone can lose. Not only is wasteful incremental drilling undertaken but the present value of the producing reservoir can be diminished. One 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. *Of course all of the other covenants would continue to be binding upon the petroleum operator managing the reservoir.*

Unfortunately, these covenants generally have the effect of superseding the most basic decisions regarding the management of petroleum leases as capital assets. In fact, the implied covenants have the effect of dissipating rent. 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 losses in entrepreneurial rents 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 mandate to undertake these activities at an earlier moment in time means that the opportunity cost associated with these activities will be increased.⁴⁷ Under normal market circumstances, a decision to expedite exploration or development would only be made if expediting these investments were to increase the estimated capital value of the project. Clearly any attempt to impose artificial schedules on decision makers can only create confusion, chaos and economic inefficiency.

The conflict, ethical breaches and implied covenants devolving from Blackstonian property law would not exist if the discovered petroleum deposit were to become the sole, exclusive property of the entrepreneur making the discovery. In this latter case, the 'homesteading principle' would supplant the Blackstonian perspective on the scope of the surface owner's property rights.⁴⁸ Of course in this situation, some consent to surface access would still need to be obtained from some surface owner to make exploration possible.⁴⁹ Court-imposed covenants would no longer

⁴⁷ See: Walter Mead, Asbjorn Moseidjord, Dennis Muroaka, and Phillip Sorensen, *Offshore Land: Oil and Gas Leasing and Conservation on the Outer Continental Shelf*, pp. 110-112.

⁴⁸ This proposal was first put forward by Murray Rothbard. See: Rothbard, Murray. 1998 [1982]. *The Ethics of Liberty*. New York: New York University Press, pp. 71-72. Robert L. Bradley has outlined the way in which this procedure would work in practice. Robert Bradley, *Oil, Gas and Government: The U.S. Experience* (Rowan & Littlefield Publishers, Inc. for the CATO Institute: Lanham, Maryland, 1996) pp. 69-74.

⁴⁹ In most cases, a single surface owner would not be able to extort a royalty concession from an exploring entrepreneur seeking to 'homestead' a subsurface discovery. Directional drilling would be permitted such that a

impinge on the entrepreneur's ability to engage in speculative timing in the scheduling of investments in the project. In this case, the surface owner would have no contingent claim on production. This situation would represent the normative ideal from both an allocative and ethical perspective.

VI. CONCLUDING COMMENTS

The myth of resource exhaustion has persisted into the modern day: its origins and nature of are to be found not only in the inherited economic theory of exhaustible resources but more broadly in the nature of contemporary neoclassical equilibrium theory with its neglect of entrepreneurial capital maintenance. The theory of exhaustible resources has focused on aggregate stocks the assumption of eventual global depletion. However, since resources only have meaning within a particular entrepreneurial plan, aggregations of resources across all firms are largely meaningless in terms of the presumptive aims of public policy and the actions of entrepreneurial firms.

The analysis presented in this paper is premised on a Misesian definition of capital as the entrepreneurial firm's monetary appraisal of its equity committed to a particular business plan at a given date in time. The balance-sheet entries of asset worth are reflective of the entrepreneur's appraisal of the overall plan entrepreneurial plan itself. An entrepreneurial theory of capital maintenance necessarily accommodates but is not limited to a process by which capital goods such as resource deposits are replaced within the firm. All capital replacement is aimed at the maintenance of capital meaning that it is ultimately directed toward expansion or at least the maintenance of the firm's expected entrepreneurial rent.

The theory of entrepreneurial resource replacement occurs routinely because of declining rents related to gradual depletion of deposits. The firm is constantly replacing its stock of resources through exploration and development of new fields. However, since capital maintenance is always aimed at maintaining the time-stream of entrepreneurial rent, the extractive firm may invest in capital goods not directly complementary to its existing grouping of capital goods. Nonetheless the means by which resources are replaced emerges out of the entrepreneur's judgment of how entrepreneurial rents are affected by each of the respective strategies.

The resource-replacement process is fundamentally entrepreneurial and is dependent upon access to land and managerial flexibility in maintaining capital and entrepreneurial rents. But entrepreneurial capital maintenance as applied to replacement of resource deposits is impeded by three institutions: (1) direct or indirect nationalization by governments of much or most of mineral-bearing land around the world; (2) regulatory sanctions imposed by the courts to protect the surface owners presumptive rights to a portion to minerals produced or proceeds from extraction and sale of these minerals; and (3) in the case of petroleum, the inability of the extractive firm acquire full control and ownership of reservoirs that it has discovered.

particular subsurface structure could be accessed from a multiplicity of surface locations. Competition between surface owners would weaken the bargaining power of any single surface owner.

