Editor's Conclusion

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Contributions of the Symposium

Matters of Consensus

An editor assumes some risk in declaring a consensus, since his interpretation of others is fallible. But if there was not unanimity on the following points, there was wide support for them and no contradiction. The degree of consensus was a delightful surprise to all concerned, since they were prepared for some battles, which turned into revival meetings. The discovery of consensus is always useful. It builds an advanced base from which further progress is possible.

1. Exhaustible resources should not be exempt from the rule of consumer sovereignty. No one questioned the propriety of discounting future values at a market-determined rate of interest, and requiring that postponement of use should yield a market rate of interest. There was little or no Malthusian anxiety expressed, but a general recognition of excess capacity. There was concern over the overuse of resources without tenure protection, but this was concern over the errors of man, not the stinginess of Nature.

Everyone agreed that market interest rates should guide intertemporal conservation decisions. Some would deny any meaningful differences between investments in natural and man-made assets. Others, while agreeing that postponement of use should yield a return like any other investment, were interested in pursuing differences in effects on unemployment, etc. Some conferees were skeptical that the structure of interest rates is a good expression of consumer sovereignty over intertem

poral choices, since interest rates are socially manipulated for macroeconomic ends. Other conferees emphasized credit rationing, and the problem of selecting "the" market interest rate. These felt that the issues of conservation and of concentration of economic power were linked through the phenomenon of credit rationing.

No one defended monopolization or cartelization to defer output for conservation ends. Most conferees were critical of prevailing cartel practices, from both a conservation and a distributive point of view. No one advocated designing tax systems to defer output, although some cautioned against taxes that might unduly accelerate output.

The conferees' ideas of reform were premised on clearing away obstacles to consumer sovereignty—obstacles such as uncertain tenure, indivisibilities, taxes with deadweight excess burdens, state-enforced prorate or allowable systems, imperfect market structures, and credit rationing. Several wrote of the desirability of "internalizing externalities" or otherwise adjusting for external economies.

The conferees regarded "efficiency" as an optimal balance among several forces tugging in different directions. Efficient intertemporal allocation was regarded as a compromise between interest costs urging immediate use and several factors urging deferral, such as increasing costs of accelerated extraction, rising future prices, and falling future costs.

2. Everyone agreed that the rational firm and economy should use superior resources first, rather than hold them in reserve for the future. Superior extractive resources are sterile surpluses which we should liquidate and put to work earning interest. That does not represent a blanket endorsement of all the barbarities and ravages committed in the last two hundred years, but a more sympathetic understanding of what needs doing now, and a remarkable reversal of the scolding attitude that used to prevail among intellectual conservationists. Our conferees were more inclined to scold institutions which prevent liquidation of superior resources and thereby divert demand to premature scanning, preempting and developing of marginal resources, freezing social capital instead of adding to it.

3. Prevailing institutions have created an underused excess capacity in many extractive industries. The capacity is excessively capital-intensive; there is excessive lead-time between exploration investment and liquidation as well as an excessive fixed capital in well and mine shafts, etc. The capital is also excessively dispersed in space.

Cartel systems tend to boomerang over a long period by stimulating excess capacity. Ultimately this lowers prices, inflates costs, and at great social cost dissipates a good deal of the potential economic rent which the resources might yield. This pattern manifests itself in inordinately high ratios of reserves and other durable assets to output and to labor in mineral industries.

4. The tax-paying capacity of mineral industries is considerable. Some part of the income imputable to resources is pure rent over and above replacement costs. This serves no useful economic function and could be socialized through taxation or public ownership. However, the issue is clouded by the uncertainties of exploration, and successful socialization of this rent would require methods of distinguishing functional from non-functional income which are more advanced than we have yet agreed on.

Taxation may interfere with consumer sovereignty, but if skillfully devised may raise revenue without so interfering. Some conferees thought taxation might even be better than neutral, and positively abet consumer sovereignty by helping offset antisocial market controls that prevent early liquidation of sterile superior resources. Some conferees felt that definition of net rent is the key to devising neutral or positive taxation. Some others felt that net rent so discovered would constitute a small revenue source and that a feasible alternative was the use of broad-based wide-spectrum taxes which seek to achieve neutrality by making tax avoidance impossible.

5. Exploration is an important economic function and requires its economic motivation. Few were satisfied that present institutional arrangements do an adequate job of dispensing economic rewards so as to stimulate optimum outlays, but we lacked time to discuss what should be done.

6. Concentrated ownership of mineral resources is an important lever of market power in some industries. High reserve-output ratio is one good index betraying the use of resource ownership to control markets. Some conferees suggested the use of property taxation, based on the assessed value of reserves, to encourage liquidation, subdivision, and sale to weaken monopolies. Others were concerned with the effect of such taxation on conservation, and regarded property taxation as a minor anti-monopoly device.

There was little reluctance on distributive grounds to tax natural resources, as all conferees recognized that their ownership is highly

concentrated, particularly that of the superior resources. At the same time it was recognized that small and marginal ownerships of certain resources were widely diffused, and that this created strong political support for state valorization policies, cartels, import barriers, tax privileges, and other obstacles to economizing.

7. Outright public ownership of subsurface resources, with leasing to private operators, is a thinkable alternative within the framework of private enterprise. Optimal leasing arrangements comprise a mixture of payment methods that are analogous to the various standard alternative tax bases. Under public ownership government replaces the passive landowner but not the producer, as, for example, in the offshore domain.

But the alternative of public landownership, while thinkable, is not necessarily better than asserting the public interest by taxation. There are examples of frightful public mismanagement, and the choice would hinge on particular circumstances.

Unresolved Issues and Research Needs

A conference has its failures and omissions as well as its achievements and coverage. It uncovers discord as well as harmony, irresolution as well as decision, ignorance and neglect as well as knowledge and attention. But "sweet," quoth the Bard, "are the uses of adversity." Revealed weaknesses are also achievements, for they direct us to future work of the highest urgency and supramarginal productivity. The following matters would repay our early attention:

1. How may we most clearly distinguish functional from non-functional income to owners of exhaustible resources which must be replaced by exploration?

2. We need a workable philosophy of transit between policies if we are not to be perpetually bound by the careless errors of the past.

3. We need to integrate conservation economics with macro-economics. The symposium approach was almost entirely micro-economic. It was virtually impossible to find economists to write on macro-economic aspects of conservation.

The present papers are, therefore, vulnerable to the criticism of sub-optimization. They assume full employment and take as given the market rate of interest. But there is unemployment, and interest rates are socially manipulated to enhance employment. Our contributors emphasize the similarity of investments in exhaustible resources and other investments; but in macro-economics the latter are positive in-

come-creating expenditures, while the former are not and even disemploy labor by reducing the flow of raw materials to industry.

Macro-economists for their part have ignored conservation. The national income accounts do not recognize depletion. Business cycle analysts have not adequately studied the cycles of overexpansion and collapse of cartels in extractive industries and their contribution to overall economic instability. The development of excess capacity and the slow growth of pressures to liquidate, which finally become irresistible, is a pattern that has all the elements of a cycle; and the synchronization of several such cycles is an observable historical fact.

Finally, it may be useful to integrate such cyclical analysis with the problem of transition-making. After a system has collapsed and the value of vested interests been deflated by the self-destructive machinations of their very owners, reform should be a good deal easier.

4. Tax capitalization was neglected. J. P. Jensen, in his classic work on property taxation (*24*, Chap. 3), demonstrated that the capitalization of property taxes on inexhaustible land would lower the price just enough so that the combined burden of taxes and interest would be the same with or without taxes. Capitalization of taxes on exhaustible resources would not proceed that far, because of finite life expectancy; but it would proceed quite far and modify generalizations which are made about the effect of property taxes and other taxes on the rate of use.

5. We need a consensus on the optimal balance of fiscal leverage and fiscal risk-sharing. There are arguments for using some of each, but the question of how much remains open. The case for fiscal leverage is no doubt strongest where the relative importance of location in determining value is highest, because the importance of location is usually a product of social investments whose costs are functions of time rather than use. But this topic needs to be given some precision.

6. The question of the neutrality of expensing capital outlays, while raised at the conference, remains partly clouded. Does expensing achieve tax neutrality by exempting the returns to capital and so limiting the tax base to economic rent, as alleged by the editor; or because of its being offered as a part of the broad-based value-added tax as maintained by Professor McDonald; or as a partial step towards an expenditure tax à la Irving Fisher, a position taken by Professor Vickrey in discussion?

7. The definition and measurement of depletion remains a question. Depletion is a decline in market value caused by use, but of what unit? The unit of property whose value is in question is the decisive factor. If

the reserve-output ratio is large enough there is no material decline and therefore no material depletion cost of use.

Concepts of cost-recovery depletion and percentage depletion avoid that problem but raise others and in general this topic cries out for sharper analysis.

8. We need attend more explicitly to the social efficiency of the appropriative principle as an economic motivation. In some manifestations, like the rule of capture applied to underground pools, it obviously leads to waste.

In another manifestation the "rule of discovery" (finders keepers) similarly leads to waste at a different level. The probable potential of gain over costs from successful exploring in areas of supramarginal likelihood of success (as appraised *ex ante* by explorers) is a fugacious opportunity subject to preclusive capture by rivals. Is there a proper analogy between that and the rule of capture applied to fishing, and oil pools, which would create a systematic bias towards premature, excessive, and duplicating exploration?

In the absence of any tenure, clearly Yes, as is evident where prospectors range and roam certain public lands open to mining claims by anyone. Where explorers may buy exclusive lease rights to prospect defined areas an optimal rate of exploratory effort might ensue, but no one has ever proved it publicly; he would have to integrate production economics with some probability analysis plus some study of landlord-tenant relations, at least, and this under conditions of oligopsony with imperfect and unequal knowledge. That is, a few oil companies know more than the many lessors. At times, it must be that underpriced leases are subject to a "rule of capture" as some majors snap up leases to take — in that wonderfully revealing phrase of industry bafflegab — "a defensive position," i.e., to get in before those other fellows do. The other fellows are their fellow oligopsonists, better financed and informed than the splintered lessors.

Oil and mining firms rank at the top of any list of firms in assets per employee[1] — a fact which is not inconsistent with a hypothesis that our

[1] See *Fortune* (*13*, p. 251). The ten highest are Coastal States Gas, Amerada, Tennessee Gas, Commonwealth Oil, Tidewater Oil, Sunray DX Oil, Union Oil, Marathon Oil, Skelly Oil and Gulf Oil. The figures are inaccurate because asset values are not reported at current levels in many cases. However, that makes it the more striking that natural resource companies head the list, because it is natural resources whose value most tends to be understated by carrying real estate on the books at historical cost. Just for example, Weyerhaeuser's 3.6 million acres of woodlands is estimated

institutions force them to devote excessive resources to advance searching for reserves. There is great need to test that hypothesis and evaluate its consequences.

9. We need to evaluate a reverse kind of bias which discourages adequate exploration in areas where the surface property has been subdivided. Because our law ties together surface and underground rights unless explicitly divided, the successful prospector on subdivided land cannot capture most of the value of his discovery, which underlies the lands of others. That undermotivates him.

While this bias is a reverse of the previous one, it is not ideally countervailing. In particular, it biases exploration away from closely settled areas, contributing (along with several other factors) to the extreme geographic dispersion of extractive industry, and the needless transportation costs thereby imposed.

So we need research in the motivation of exploration and how it might be improved.

10. We need a better idea of where we are now in the pattern of long swings of overexpansion and collapse which have characterized extractive industries. The present growth of secondary recovery, and the rising pressures to raise property taxes, hint at growing pressures to liquidate. But economic forecasters have shown little interest in how that might bear on aggregate conditions.

11. We need more analysis of probability and uncertainty, especially in the prospecting process.

12. We need to begin to school ourselves in the arts of workable international cooperation through international administration of exhaustible ocean resources — fish and minerals, primarily. Currently oceanic tenure conditions are underdeveloped, a condition that leads to premature exploration and claim-staking — a kind of *de facto* principle of prior appropriation prevails.[2] Not only is that uneconomic; it poses continual threats of international conflict.

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to be worth 2 billion dollars, or 20 times its book value of 100 million dollars. For that and related information see Merrill Lynch *et al., Natural Resources and the Investor* (32).

[2] The Geneva Convention of 1958 would extend the territorial jurisdiction of riparian nations out beyond the three-mile limit to a depth of 200 meters (650 feet) (3). On this basis the North Sea nations can divide it up. However, the Convention has not been universally ratified. The nation that establishes *de facto* occupation of its zone by early production, therefore, has a clear advantage. In a modified sense, open tenure still prevails, putting a premium on early occupation.

Treaties are a possible way out. Conventions are better. A more ambitious approach is modeled on the thirteen American colonies which quitclaimed their overlapping western land grants to the new federal government of the United States. The nations today might quitclaim their offshore lands beyond the three-mile limit to the United Nations. Whether we want the United Nations to have its own revenues and whether it could administer its watery domain, are interesting questions – the ones we need to explore.

Editorial Findings

One of the delights of study is observing one's position evolve as it comes into conflict with the facts. Editorship accelerates the evolution. The editor receives stimuli not only from facts forced upon his unwilling, preconditioned mind, but also from the keen, informed minds of fourteen assertive contributors. Those stimuli interact with his own prior notions to generate some new insights and conjectures that seem worth recording here. These are the editor's individual conclusions, carefully sealed off from earlier materials which reflect his responsibility to the contributors. *The following are entirely the personal conclusions of the editor,* inspired by the editing itself. For an overview, I begin with an analytical outline.

Analytical Outline of Editorial Conclusions

Readers who are impatient with models and theory should turn directly to policy conclusions (pp. 367–416).

The Analysis of Time-Indivisibility and the Recovery over Time of Durable Investments

A major need so far unsatisfied by this volume is an analytical apparatus to cope with the treatment of durable capital and exploratory outlays (and their recovery with interest) in the definition of net *in situ* mineral rent. The following pages (342–67) undertake to fill the need. Then we can specify the tax treatment of durable capital outlays (including exploratory outlays) that the norm of tax neutrality requires. En route we gain new insights into the meaning of "reserves"; determine the optimal life of mines; define depletion under conditions of staggering; analyze the process of changing the reserve-output ratio (R:O); explore the function of reserves for amortization and for cushioning; and lay out the major economies of scale in mining, social and antisocial.

Mineral reserves have been likened to inventories, but the analogy is far from perfect. Minerals are neither discovered nor removed in one-year bundles. The conventional term "fund resource" is partly at fault: it is disarmingly persuasive in its simplicity and familiarity. But an infinite fund is the same as a flow, and a sixty-year fund is not very different. Only mines near exhaustion are really much like simple warehouses.

In fact, most mines share the traits of funds with those of land. Like other land, they are "indivisible in time."

But that consideration opens up a whole set of questions we have been glossing over. Mineral reserves are not like stockpiles of canned goods, whose liquidation rate may rise or fall easily and reversibly; which may be shipped from glutted stores to empty ones. Mineral deposits take several years to recover; they are tied to specific outlets in the form of capital improvements on a site; and the outlets are irreversible once built. One of an owner's mines plays out while others have years of life remaining, yet he cannot shift reserves from one to another any more than a local draft board that runs out of bachelors can call up those in other jurisdictions. So the possession of fifty years' reserves may not stop an immediate drop in output – reserves are non-poolable and so is capacity to mine them. If a miner decides to change his reserve-output ratio, it probably involves changing the use-rates of several staggered mines over their whole lives, and takes several years to consummate.

Under staggering by a going concern "reserves equal to n years' output" or "n years' reserves" is an ambiguous concept, a point the

literature on mineral reserves neglects to clarify. Suppose an owner has 40 mines of years' future life (YFL) ranging from 1 to 40 and staggered evenly – i.e., with one mine of each age from 1 to 40. The mean years' reserves is 20; but the first mine stops this year and the last goes on 40 years. Therefore, the "20 years' reserve" could not maintain the present rate of output for 20 years, but only one; nor will it be completely exhausted in 20 years, but 40. The owners have a limited choice of the time distribution of future withdrawal.

In order to check and expand our previous conclusions, which by and large have avoided conscious recognition of this aspect of the question, let us lay out a basic analytical apparatus and vocabulary needed to cope with the economic relationships that would obtain in a simple model of mining with discoveries and production decisions being "indivisible in time," and the miner staggering his mines to smooth out the bumps. We need to modify the simpler model in a number of ways. We will see that the basic ideas already developed still hold but can be perceived more precisely and realistically and satisfyingly. As a major gain, we will be much better able to deal with the deduction of capital outlays for tax purposes. The added complexity is a small price for the added realism and reduced vagueness which we will gain. Vagueness, which leaves the inquiring mind groping for order, is the worst complexity of all.

Begin by postulating a simple going-concern model wherein an owner has 40 identical mines, each of 40 years' whole life. For simplicity, each yields a constant physical quantity at constant current cost until it abruptly stops yielding. The owner has them evenly staggered, with one mine of each YFL from 1 to 40. Each year he closes one exhausted mine and opens a new one. The mean YFL is the half life of the representative mine, 20 years; and that is also the reserve-output ratio (R:O).

How does that staggered model differ from a simpler but unrealistic inventory-analogy model in which an owner has 40 even-aged mines, each with 20 years' reserves, which reserves are replenished yearly by new discoveries for use in year 20? Let us enumerate the important traits of the staggered model and explore their implications.

1. Yearly depletion from staggered mines is equivalent to losing one whole mine.

Each year an old mine closes and a new one opens. The new one replaces much more than the final unit taken from the closing mine. It also replaces the units taken in the year from each of the several

mines: the 40th year of future life from the mine opened last year, the 39th from the next one, and so on back to the second year of future life from the mine to be retired next year.

Thus, under perfect staggering, where each mine has the same original life (40 years), the new mine exactly replaces the sum of the losses from the 40 operating mines, not just in quantity but in time distribution and therefore in present value. Putting it the other way, one year's depletion or user cost from 40 staggered mines is the same as the loss of one complete new mine.

Thus, if an owner or an industry or a nation has 20 years' reserves, replacing one year's use is not finding one full year's supply to use in year 20, but a mine or mines of 40-year life to go on stream immediately.

The above confirms the concept advanced earlier that depletion is the yearly decline of present value, and that that decline (Scott's user cost) is of lesser amount when reserves are longer. The staggered model and the inventory-analogue model are both of balanced going concerns wherein an owner maintains a constant reserve by replacing used reserves yearly. In the inventory analogue he replaces reserves with 40 units to be used in year 20. In the staggered model he replaces with 40 units in a single mine to be used in years 1 to 40, the mean year being the half life, 20. In either case the year's depletion cost equals the value of its replacement. It is encouraging when the pieces of intricate puzzles fall together in the pleasing, symmetrical, internally consistent way that marks correct solutions.

However, the staggered model also modifies the inventory analogue. The values involved are moderately different. The loss of one year's use from each of 40 staggered mines is similar to losing the 20th year from 40 mines, since the half life (20) is the mean life. But actually the value of the staggered depletion is moderately higher, because of discounting. To confirm our intuition, let us show the analysis.

Under perfect staggering, the user cost in one year is moderately higher than if the same volume of ore were withdrawn from even-aged mines of the same total reserves. The user cost of 40 perfectly staggered mines is the same as the loss of one complete new mine of 40 YFL.

$$U = \frac{1 - (1 + i)^{-40}}{i} \tag{1}$$

That, in turn, is higher than the user cost of 40 even-aged mines of 20 years each:

$$\frac{1-(1+i)^{-40}}{i} > 40\,(1+i)^{-20} \qquad (2)$$

The truth of (2) may be demonstrated from the interest tables, at 5 per cent:

$$17.2 \overset{?}{>} 40 \times .38 = 15.2$$
$$17.2 > 15.2$$

More generally, it is geometrically obvious from a graph (Fig. C.1) showing the present value of one dollar in any year. The yearly user cost of 40 mines of staggered YFL is the area under the solid curve from

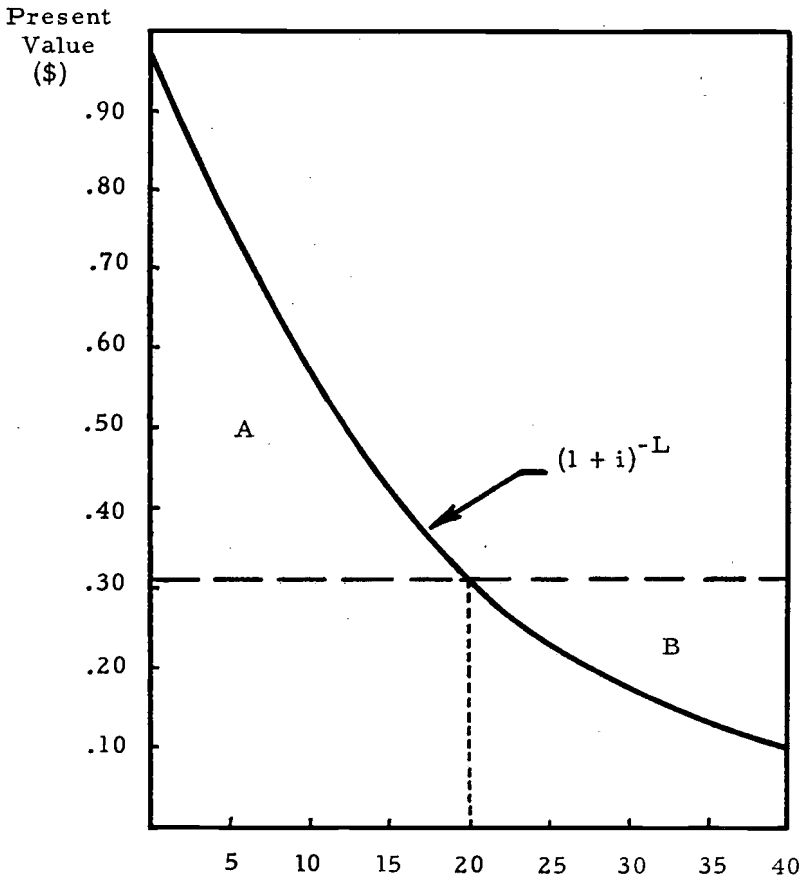

FIGURE C.1

Present Value of Depletion, Comparing 40 Staggered Mines and 40 Even-aged Mines of the Same Total Reserves

0 to 40. The yearly user cost of 40 even-aged mines of 20 YFL is the area under the horizontal dash curve from 0 to 40. The former is larger, since the area $A > B$. That is due to the downward convexity of the solid curve, and holds generally for all values of L. For low values of L the difference nearly vanishes.

The fact that the difference is small is more striking than that there is a difference at all, and is of practical importance to tax policy. It means that we can treat 40 staggered mines of 40-year life as though they were one large unit of 20-year life and emerge with virtually the same value for the depletion allowance. We can pool reserves for tax purposes without distorting matters seriously. Thus the Treasury can, if necessary, treat large, vertically integrated firms as tax units for computing depletion, and at the same time treat owners of single independent mines as units, without introducing any inequity between them except a progressive element so minor as to be if anything too small to serve the needs of equity and workable competition.

The need for doing that emerges clearly in the case where large firms hold idle discovered or semi-discovered reserves attached to no shaft. To maximize depletion allowances they might deliberately detach reserves from operating units that way. The Treasury's best move is then to pool the firm's owned reserves for computing depletion values, a matter we return to later.

That slightly moderates, without basically changing, the principle that firms with longer reserves should charge less per physical unit of depletion than firms with shorter reserves.

A second moderate difference between staggered and even-aged reserves is that the staggered ones are worth a little less. The present value of 40 mines of staggered YFL from 1 to 40 is slightly less than the present value of 40 mines of 20 YFL. The point is geometrically obvious from a graph (Fig. C.2) showing the present value of a one-dollar annuity as the life increases from 1 to 40.

The value of 40 mines of staggered YFL is the area under the solid curve from 0 to 40. The value of 40 even-aged mines of 20 YFL is the area under the horizontal dash curve from 0 to 40. The former is obviously somewhat smaller, since the area $A > B$. It is due to the upward convexity of the curve and holds generally for all values of L. For low values of L the difference nearly vanishes. As a numerical example, at 6 per cent the 40 mines of 20 YFL are worth $460, while 40 staggered mines are worth $413.

2. Reserve-output ratio (R:O) is not determined by discoveries but by rate of recovery.

The process of lengthening reserves is not the same under the inventory analogue and the staggered model. In the first, one would simply

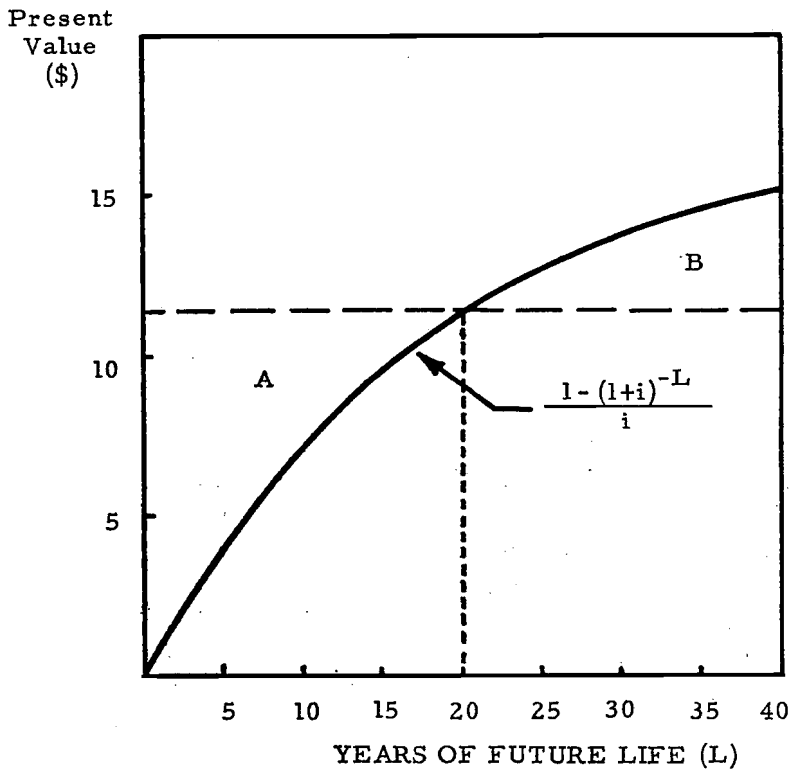

FIGURE C.2

Present Value of Mines, Comparing 40 Staggered Mines and 40 Even-aged Mines of the Same Total Reserves

devote more effort to discovery and, in addition to replacing the 20th YFL, add a 21st. In the second, discovery above replacement would not much increase R:O because the extra new mine discovered would go right into use and add to output as well as reserves.

The staggered miner therefore does not control his R:O by finding more or less new deposits, nor by deferring the first use of current finds. *The key decision rather is the rate of use of deposits once found.* That, in turn, is determined by the size of the investment when a mine is new.

It is true the rate of use is subject to some short-run control, particularly under monopoly or a cartel with the force of state law at its disposal. But the primary real cost determinant (that which would prevail in a free market) is the capacity built into the original basic mine shaft and other durable capital improvements in year zero.

So basic to our subject is this irreversible opening move in mine use that it will pay us to spell out the factors that control it.

3. Rate of recovery is determined by maximizing present value.

We have moved well beyond the basic perception of conservation economics, that one holds a "unit" of ore so long as it appreciates faster than the interest rate. Units of ore are not available individually. They are indivisibly linked in a mine, an integrated recovery operation over time, which itself may be staggered as part of a larger going concern. The key decision determining R:O and thus the value of new mines, and of depletion, it seems now is the decision that determines the life of a mine.

Rarely, that might be outside man's control. Nature might have a bottleneck limiting how fast man may recover a deposit. But usually the main bottleneck is the capacity man builds. The miner can enlarge, duplicate and quadruplicate any given size and number of adits, shafts, or other works. The owner who carries long reserves does so by choice.[3] Let us consider the determinants of the choice.

The simple rule for determining mine life is maximization of present value. This is one of the few cases in economics where the present value rule is applicable in its simplest form: because there is normally no reuse value of the site to consider, but only a single time horizon; and the key decision is indeed to be made in time zero, the "present" at which value is to be maximized. To be sure, secondary recovery under improved technique often constitutes a second-generation use beyond the simple primary time horizon, one which might prompt one to shorten the first cycle if it interfered with the second. But let some later toiler refine that point, which need not divert us now.

I will proceed by showing a priori how the present values of revenues and cost vary with life.

Revenues first. Suppose a deposit contains a recoverable amount A, independent of life L. Yearly revenue is A/L: as one doubles life he

[3] The choice is sometimes socially imposed by prorate. The present point is that the choice is under human control.

halves yearly revenue. The present value gradually falls from an (unattainable) maximum of A, as A is broken into smaller parts and pushed farther into the future.[4] Present value of revenues (PVR) is the yearly revenue annuity times the present value formula:

$$PVR = \frac{A}{L}\frac{1-(1+i)^{-L}}{i} \tag{3}$$

Plotting the log of L horizontally, PVR describes a curve starting like a flat hilltop, sloping down to the right, and flattening out again in a valley, like the right half of a bell or an inverted S, with a point of inflection (B on Fig. C.3).

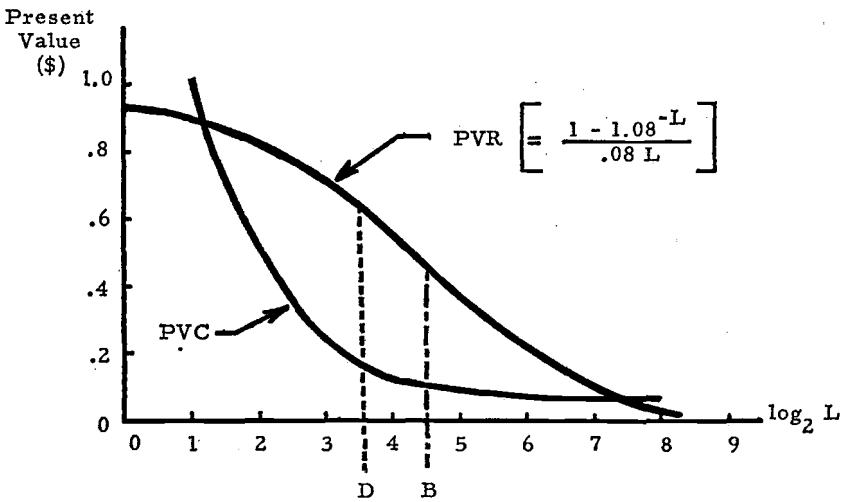

FIGURE C.3

Present Values of Revenues (PVR) and of Costs (PVC) as Planned Life (L) of a Mineral Deposit Increases

The simplifying assumption that recoverable mineral (A) is independent of life (L) would often not hold strictly. Changes in A would modify the PVR curve in detail but not violate its general contour. Just how A varies with life is too involved an empirical question to settle here. A may tend to decline as life lengthens because shorter life requires more shafts, etc., giving better overall access. On the other hand, slower recovery of oil may let pressure sweep the matrix cleaner, as in McDon-

[4] Professor McDonald in Chapter 11 of this book suggests part of the framework of this model. See also the model developed by McDonald with James McKie (31, pp. 101–10).

ald's model in this book. The issue merits another book.[5] Here we skirt it by assuming A constant as life varies.[6]

At $i = 8$ per cent, the point of inflection (B) comes between $L = 16$ and $L = 32$. The number of years is an important datum, because visual inspection of Figure C.3 suggests it is probable (although not certain) that optimal life (D) precedes the point of inflection.

The present value of costs (PVC) involves less discounting, because most costs are incurred in year zero as capital outlay. PVC falls as life lengthens because less capacity is required.

Beginning from a short life of say four years, doubling life should cut costs almost in half because half the capacity is required. The capacity for fast recovery in only four years would probably entail parallel, duplicating shafts or other capital units, and one would simply eliminate half of them for a life of eight years.

But as life lengthens, doubling it from say 16 to 32 years will not halve PVC. For as capacity falls, one meets three basic diseconomies:

First, dropping capacity means not just fewer shafts but smaller ones, losing economies of scale.

Second, adding longevity begins to cost something after a point. A shaft to last 10 years may cost only 10 per cent more than one to last 5 years, a difference so small that probably no reader winced at my opening allegation that doubling life halves the cost of capacity. But capital does wear out, especially the moving parts, and a 40-year shaft might cost 50 per cent more than a 20-year shaft of the same capacity — especially if we include in the symbolic term "shaft" the associated pumps, excavators, stripper shovels, shafts, rails, hoses, and other obviously depreciable elements involved. Longevity, like everything, comes at a cost; and adding 20 years is likely to add more to cost than 5 years.

The cost may take the form of higher initial capital cost of the more durable facility; of outright replacement before the end of the 40-year

[5] A standard criterion used in state regulation is the Maximum Efficient Rate (MER), which is defined as the rate maximizing "ultimate recovery," i.e., maximizing our A, which is presumed to rise with life. MER is without economic content. Even with zero interest, it would never make sense to maximize ultimate recovery. MER serves mainly to lend some aura of "engineering" authority and "conservation" ideology to cartel restrictions. The lengths to which restriction has gone are manifest in the rarity of prorate boards' letting producers go as high as MER.

[6] An illuminating discussion of the question in oil fields is found in McKie and McDonald (*31*). Accelerating output from given wells may reduce ultimate recovery, while adding wells may let one accelerate without such loss.

program of recovery; or of higher variable costs in later years; and most likely a mixture of all three forms. In any case, the extra years of life will tend to come at a higher added cost; and it takes more and more additional years to halve the capacity required.

Combining the two points above, a 40-year shaft may be regarded as two 20-year shafts teamed in series rather than in parallel. The cost saving is from the method of teaming: economies of longevity are greater than economies of scale. But as longevity rises and scale falls there remain few gains of longevity to achieve, and the miner begins to lose economies of scale.

Third, as the number of shafts falls the cost of transporting material from its locus to the shaft rises, increasing operating costs.[7] This constraint is related to the loss of scale with added longevity. One might overcome the loss of scale by adding more reserves behind a mine. But that meets added internal costs of moving materials over more distance.

Remember, too, that discovery cost may for many purposes be included among capital costs; and they are a constant, not falling with life (L).

The PVC curve in Figure C.3 assumes the profile of a scoop snow-shovel or half-U or a ski-slope, concave upwards and to the right. It falls steeply at first and then flattens out. It would flatten out even if doubling life continued to halve costs indefinitely. But it flattens out sooner because of the three rising costs of longevity.

Maximum net present value of the deposit, which is optimal planned life, is life D in Figure C.3, where the two curves are parallel and their vertical difference is a maximum.[8]

From the shapes of the curves it seems most likely that, if they are

[7] The increased costs may take, among others, the form of reduced ultimate recovery, but this is not strictly admissible because I have postulated a simplifying assumption that total removal, A, is not affected by rate of removal.

[8] The highest possible value of D may be estimated by simple calculation. The highest possible value is that which would obtain if there were no diseconomies of longevity, so doubling L always halved PVC. Let K be the PVC if $L = 1$. D is then found by maximizing

$$\frac{A}{L}\frac{1-(1+i)^{-L}}{i}-\frac{K}{L}$$

By differentiation, that is when

$$L(1+i)^{-L}+\frac{1-(1+i)^{-L}}{i}=\frac{K}{A}$$

The right side is a ratio and the left side is a function of L easy to tabulate from standard tables. For example, at 8 per cent, if $\frac{K}{A}=14$, $L=20$ years.

going to cross at all, the maximum net PV will come before B, the point of inflection in PVR. That is not conclusive, but it gives us some a priori cause for viewing with suspicion any firm holding enough reserves behind an individual mine to keep it going for 50 years, or any "conservationist" laws requiring it to do so. At 8 per cent the point of inflection comes at about $L = 24$.

If optimal life were at B, 24 years, the half-life would be 12, and that would be the R:O. That is an exceedingly rough figure, of course, but it suggests what short reserves it might be optimal to maintain.

Not all firms will arrive at the same optimal life. Stronger-financed firms, with lower internal interest rates, will find maximum PV(R–C) at longer planned lives than will firms of weaker financial position. In Figure C.3, at lower discount rates, the hillside-shaped curve of PVR slopes down less steeply, moving maximum PV(R–C) to the right. Thus the stronger firms arrive at higher R:O. It is an industry truism that weaker firms are more concerned with rate of recovery, and stronger firms with holding reserves.

It might seem a paradox that the better-financed miner, who has the wherewithal to invest great capital in mine improvements for quick recovery, should be more inclined toward slow recovery. But it is simply the old familiar economic paradox of comparative advantage. In this case the analogy fits. His relative strength compared to less affluent owners — the thing at which he is not just better but "more better" — is in holding assets for future liquidation. The advantage of a lower internal firm interest rate grows with the futurity of the assets being purchased. For example, comparing internal rates of 5 per cent and 6 per cent, the lower i lets one bid 1 per cent more today for $100 due next year, but 60 per cent more for $100 due in 50 years ($8.72 vs. $5.42).

So the advantage of financial strength, expressed in a lower internal i, motivates the strong to substitute more for less longevous assets. In mining that means substituting mineral reserves for mine improvements. So the owner with abundant capital at his disposal will not tend to favor heavy investment in mine improvements. These usually have shorter lives than mineral deposits; they also shorten the lives of deposits by speeding recovery. He will tend to hold back on improvements and instead acquire more reserves, by purchase or discovery, for future slow recovery.

The slow miner is the economic counterpart of the farm or city landowner who combines land with less capital and payroll than others, not

because he loves capital less, but land more. There is a marginal rate of substitution between land of high longevity and capital of lower longevity, and his finances prompt him to substitute land for capital. So he does not use his land resources as intensively as others of weaker finances. He has the money to improve any given acre more than others can, but he generally prefers to acquire more land instead.

In the inventory-analogue model, it is not clear that the possession of longer reserves implies slower present use of any given deposit. In the present time-indivisibility model it is clear, because to defer the liquidation of future reserves entails slower use from the start. The entire recovery program is an indivisible unit over time – units of ore line up behind and march through a capacity choke in measured cadence. In this model the key decisions in mining are seen as being more like key decisions in other land use.

This land-use analogy is not perfect either, because of the exhaustibility factor. Rather, mineral deposits uniquely combine some land-like qualities and some inventory-like qualities. The curves in Figure C.3, properly interpreted, should convey the unique economics of mineral exploitation without wholly accepting or rejecting either analogy.

4. Changing reserve-output ratio (R:O) is slow, especially when it is long to begin with.

Another distinctive feature of the staggered model is the lag it implies in adjustment to new conditions. If interest rates fall, prescribing longer lives and higher R:O, the miner's primary adjustment is building less capacity and longer life into new mines. The life of old ones is largely determined by the original capacity, which is not reviewable until the new replaces the old. It takes mining longer to respond to new economic stimuli, therefore, than it takes the new stimuli to be replaced by still newer ones, so the industry is chronically maladjusted, lagging its times by many years.

It is not really staggering as such, but time-indivisibility, that causes the lag. If we had 40 even-aged mines of 20-year life we could not adjust any mine at all, except one year in 20 when we could change every one. Staggering merely spreads this problem evenly so that each year we can make some change.

Staggered or not, a longer life of mines means a longer lag in adjusting to changed parameters. Oil reserves queued up behind shafts of low capacity are by no means on tap to meet emergency needs, either for minerals in particular or capital in general. Today interest rates stand

double what they were fifteen and twenty years ago. Many mines and wells producing today are geared to that slower pace. The owners cannot benefit from earlier recovery of their money, and needy borrowers cannot benefit from the additional funds thus released.

The comforting thought that long reserves give us great flexibility to meet contingencies we must partly abandon, therefore. There is some short-run flexibility in each given mine, but it is not increased by having longer reserves behind each mine. Most of the adjustment occurs in the new mine opened yearly.

This adjustment is in fact slowed by longer reserves. With 40-year life of the representative staggered mine, and one mine turnover yearly, we retire and replace 1/40 of our output yearly and complete the changeover in 40 years, by which time, no doubt, new adjustments will be long overdue. With 20-year life it takes 20 years, and so on. With the shorter life, and still 40 mines, we must now retire two yearly; or we could get along on fewer mines (and somewhat larger jolts to our going concern). But no matter; in either case a shorter initial life means faster turnover and faster response to new economic stimuli.

The adjustment from longer to shorter reserves may be rapid if we drop the assumption that each producing mine finish out its preordained life cycle before replacement. An owner with very long reserves behind his mines in effect has completely idle, uncommitted reserves which he can bring to life quickly. An 80-year reserve behind one mine, for example, is more like one 40-year reserve and one idle deposit, and this owner can double output by throwing the uncommitted 40-year units into the breach. Forty years is long enough to exhaust most economies of longevity in mine capital. He simply needs to duplicate existing capital and double output.

Thus a firm of high R:O can break the pattern of perfect staggering and by an energetic wrench increase output promptly. Anaconda Copper, which has 40 per cent of world copper reserves compared to less than 14 per cent of the output, is currently investing heavily in new mine improvements to raise output by 50 per cent from existing reserves (*35*) – simple enough when your R:O is more than four times the rest of the industry's. But that is better conceived as putting idle reserves to use than as shortening a systematic pattern of staggering. In the absence of idle reserves, a faster turnover clearly accelerates change, and thus substitutes for holding sterile reserves. A high turnover firm or

industry achieves its adaptability by subjecting a high percentage of its production to redesign each year, a procedure which achieves the end without the high social cost of idle reserves.

The adaptable firm also needs to be able to reduce output quickly in response to lower prices. A firm needs no advance reserves to do that; but the shorter reserves it has, the higher percentage of its capacity it retires each year. Furthermore, mines of few years of future life (YFL) can economically be turned on and off in response to changing relations of present to future prices. A small price advantage is enough to warrant substituting near-future production for present production. With longevous mines, on the other hand, sacrifice of present production adds nothing to near-future production, but only to remote future production whose present value is too low to be worth much present sacrifice.

The adaptable firm also needs to guard against obsolescence. Here again a short life of mine and a high replacement factor each year is the best policy.

5. A firm's reserves may have zero marginal value.

All the above is hidden from us when we regard reserves as simple inventories. In the inventory-analogy model, the reason for holding long reserves is left to the imagination, but presumably is to absorb economic shocks, like any inventory. In the staggered model, with time-indivisibility, the function of reserves is seen in a different light: it is to amortize the capital in heavy initial mine improvements. (And at one remove in mills and refineries, although that is a debatable point in each case depending on how tightly they are integrated.)

In the example above (p. 354), where 80-year reserves were converted to 40-year reserves by doubling capacity and output, we saw that the second 40-year unit had been effectively idle. Its contribution to amortization was negligible, so it could be fructified immediately at no increase of unit costs.

Generalizing that, we can say that any firm (or other unit of interest) that can increase output from owned reserves at no increase of unit costs has been treating its reserves like free goods, goods of no scarcity value whatever. That firm is analogous to the farm landowner who has combined his labor and equipment with so much land that added land brings no net increase of output. It is a basic principle of production economics that at the low intensity of land use at which the elasticity of production response to non-land inputs equals unity (that is, where

their marginal product equals their average product, and a 1 per cent increase of these inputs yields a 1 per cent increase of output), the marginal return to additional land is zero.

The farmer in question has no productive reason to spend anything for more land. The mineowner has no business spending another nickel acquiring more reserves, whether by purchase or exploration. His treatment of present reserves indicates they have a zero value to him.

Here, the indivisibility-in-time model gives an insight that was obscured in the inventory analogue, because the former is more enlightening about the primary function of advance reserves in mining. A miner might rationally hold a reserve for use after 40 to 80 years if he believes its value *in situ* will rise yearly by more than the interest rate. *But he cannot be assumed to believe this if he is busy mining identical or inferior ores now.* It is highly suspect if others are mining inferior ores now, and empirical studies given and cited in this volume tell us that is a common state of affairs. So he lacks a legitimate speculative (or conservationist — it is much the same) motive as well as a productive motive. That begins to cut it down to unworthy purposes such as market control, price maintenance, preclusive aggrandizement, perpetuation of management, premature acquisitiveness under conditions of imperfect tenure, etc.

Here we must beware of drawing easy inferences from available data on reserves, for these data are sometimes based on physical mineral units and "grades" without due regard for other value factors such as location or cost of extraction. We cannot assume them "identical" with ores presently "being mined" (i.e., planned for removal by existing capital capacity) simply because they are of the same geological "grade." But the criterion holds as stated initially: a firm that can increase output from owned reserves *at no increase of unit costs* has no business acquiring more reserves, except for antisocial ends.

Turning the statement around, this same firm has no business claiming any depletion when it uses ore. For what has it lost by use? — a resource whose lack of legitimate value to the firm is revealed by the owner's non-use. More generally, the longer reserves a firm holds the less is the warranted outlay on replacement and the less the warranted depletion charge — the two are roughly equal. I later recommend letting depletion charges decline as R:O rises.

6. Reserves for amortization double as cushions.

Staggering of mines achieves a smooth yearly flow of discovery effort

(the input) and recovery of mineral (the output). Discovery and recovery occur concurrently. One of the perennial fallacies of capital theory is that this concurrence somehow erases the lapse of time between the input and the resulting output – that they become simultaneous, and the capital-output ratio is independent of the time lapse between input and output.

In fact, it should be abundantly obvious that a longer waiting period means more reserves on hand at any time for a given output. If we halve the life of 40 mines from 40 years each to 20, we double output from the same reserves, thereby halving R:O.

Thus, staggering does not mean we are operating without reserves. However, there is a question whether reserves which are primarily committed to amortization can also serve the other function of reserves, as economic shock absorbers. Or do we need additional reserves to cushion against a long dearth of new discoveries or a surge of demand?

Reserves committed to amortization can be useful as cushions in a number of ways: (a) They permit short-run increase of output from fixed capacity, albeit at rising marginal cost. (Under the allowable system this advantage is lost to the individual, but retained by the state and magnified by excess capacity.) (b) The longest reserves, behind the newest mines, can be quickly mobilized by adding capacity. A rise of price would make some of this adjustment economical. (c) The longer reserves are, when they are staggered, the smaller percentage of capacity is lost yearly by retirements, and the easier it is to compensate for a dry prospecting year.

Thus, time-indivisibility does not completely commit and immobilize reserves, nor destroy their value as cushions. It does restrict their mobility greatly, so we cannot say all reserves serve the second, or cushioning, function at no cost to the first, or amortizing, function. But if the amortizing function calls for 20-year reserves, it seems a fair guess in most cases that that would afford enough slack so the owner would secure the benefits of the cushioning function virtually free as a by-product. Common sense suggests that a good manager should be able to wring at little cost enough flexibility from 20-year amortizing reserves to equal at least two or three years' worth of pure uncommitted reserves. Other stages of production somehow struggle along and make do with much less than that.

And so it is doubtful that owners hold idle reserves in any volume for this cushioning function. Dual-purpose reserves, primarily com-

mitted to amortization, afford free as much cushion as is likely to be needed.

There is a very important exception to that rule, however, in an industry such as oil, where the states control monthly output under the allowable system. That takes away the owner's option of advancing use dates from heavier use of existing capacity.

The prorate allowable system prevents owners' using their reserves as reserves to the extent that it prevents their advancing use dates at will. A control system based on the well unit would, to be sure, permit of parallel wells; but a many-acre spacing requirement might prevent much real double-tapping of given resources.

In the last case, the owner cannot count on his 40-year well as a reserve for early contingencies. The monthly flow is rigidly fixed by law. That might force owners to hold some deposits completely idle as reserves to throw into a breach when demand surged or current discoveries lagged. It magnifies the aggregate reserves miners must hold.

When we add this to its other sins, the allowable system is a remarkable device for inflating capital requirements and driving small business out of oil. For a given flow of oil it requires one to have (a) more wells; (b) longer reserves under each well; (c) a larger overall operation, to achieve staggering with longer reserves; and now (d) some idle reserves to use as operating cushions, or operational inventories. This all adds up to an invidious prohibition on entry and survival aimed against those who lack long reserves of assets to hold in cold storage.

7. Time-indivisibility and staggering multiply optimal firm size and jeopardize market freedom.

The staggered model gives added insight into economies of scale in mining, and the market structure that tends to develop around them.

An owner seeking to achieve economies of longevity in mining a given deposit tends to lose, as we have seen, economies of scale. To achieve the first without losing the second he can, however, increase the overall size of his reserve deposit, nature permitting and neighboring owners willing. The minimum size of reserve necessary to achieve longevity and scale economies jointly is the lower limit on size of workable deposit or ownership.

As an owner increases his R:O by increasing the absolute amount of reserves behind each mine, however, he meets another limit in the dimension of space. Transportation of ore from its locus in matrix to the mine shaft foot adds cost until a limit is reached. He may also meet

problems of land assembly when he tries to enlarge a unit. He may have to spend more time setting up necessary pre-conditions for the optimal unit than it is worth to achieve the optimum. Balancing out these major factors, and several minor ones, he arrives at an optimal scale for each mine.

But now he must consider how many such mines to combine and stagger in order to achieve the economies of constancy – the "going concern" economies. It is here that his answer will be most affected by market structure – and in turn affect it in a cumulative feedback pattern, so that a small change in the independent determinants has multiple effects either way.

If there is a free market in ores, an owner's need for staggering is minimum. The market as a whole pools risks. A refinery may feed from several sources.

The mining firm needs steady work for exploring personnel and equipment, as well as for miners. But it need not perform all its own staggering by carrying the full ownership burden of the reserves required for a fully staggered cycle. It can sell excess new discoveries to other firms, or do contract exploring for landowners and do no mining at all. It can buy mines from others and work them. Capital recovered from one mine may be invested in other businesses or any generalized security, and new capital may be pulled in from the general pool. Miners may move from one firm to another; retiring miners may go unreplaced, or net new ones be recruited. A family firm may exploit one deposit only, keying its life to the life cycle of a work force, and shunt recovered capital into other investments altogether. In a free market the entire mining operation may be broken into hundreds of small parts, coordinated and synchronized through the market mechanism, and integrated with the rest of the economy.

The owner who must do his own staggering is the one who operates in unfree markets, and who must maintain the immortality of a "going concern." He must control enough reserves to assure himself, from his owned resources, his own steady supply. The surpluses of others are not available to meet his shortages, but are simply sterile; while he must carry enough fat to meet his own shortages and cannot rely on others to relieve his gluts.

The ownership unit in the absence of free markets must then be large enough to achieve its own internal economies of staggering. It must in effect be an entire industry in microcosm. The more insulated it is from

the rest of the world, and the more institutionalized, the fewer shocks it can tolerate and the more perfectly staggered it must be.

Now staggering increases the scale of ownership by a very large factor, something like ten or twenty times. There are a number of unfortunate effects:

First, the number of potential entrants becomes very few as the aggregate capital and size requirement rises. It is true, as shown in Figure C.2, that staggering slightly lowers the present value of mines and so eases the interest burden of holding reserves. But the effect is too small to count for much. Staggered or not, the burden is staggering and enough to drive large numbers of small owners out of mining, or into mergers.

The capital requirement may speciously be lessened by the firm's acquiring reserves by long-term contract rather than immediate outright purchase. The practice is common between gas transmission companies and producers, for example. However, the practice implies high faith by the seller in the buyer's credit rating and financial strength; otherwise the seller is giving up his chance of later windfalls with no corresponding protection against price drops. It is basically an extension of mortgage credit from seller to buyer, like sale of any real estate by land contract. Like mortgage credit, contract sales are extended on preferential or privileged terms to stronger buyers and contain the same bias toward favoring larger over smaller firms.

Second, the aggregate need for reserves rises because each firm must have enough to achieve internally the pooling and smoothness that a free market would provide externally. (I expand this point later under "How We Overmotivate Exploration," pp. 394–95).

Third, as each firm races for reserves in order to assure its survival it removes reserves from the free market pool that might be available to all and forces other firms to race too. "Racing" differs from competition in the laudatory sense in that races end; and the premium is on jumping the gun. (There are few rules in this race!) Racing bids up the price of reserves and encourages speculative expectations of further price increases as close control of reserves is seen as a likely prospect.[9] The

[9] Even in a market ostensibly still partly open, crude oil, the importance of a firm's own reserves is manifest in the common practice of bartering oil for oil (*8*, p. 100). The practice of barter suggests a species of market limited in access to those who already own crude reserves to barter. The common practice of "posting" prices which are then undercut for buyers with bargaining power, like a make-or-buy option, suggests the same kind of pattern.

financially weak (and numerically strong) release reserves to the strong hands of giant majors, who can afford to speculate.[10] Here is the cumulative feedback process alluded to earlier: the expectation of reserves' being cornered has qualities of the self-fulfilling prophecy. As the free market begins to crumble the race accelerates to merge and achieve economies internally by agglomerating reserves. After some critical point the resulting chain reaction quickly leads to the destruction of an open market in ores, and to universal vertical integration.

Thus, time-indivisibility and staggering help lead to corporate giantism[11] and consequent loss of economic freedom. The remedies lie in public policies making it costly to hold idle reserves, and so lowering the life of mines; and in fostering free markets, for competition grows or withers cumulatively by feedback, whereby small exogenous causes have great effects.

8. Either the operating or the ownership unit may be used to assess the value of depletion for income tax deduction.

Another contribution of the staggered model is to help in selecting the proper unit for the purpose of putting a value on depletion. I agree with Harold Hotelling that ". . . the rate of decline in value of a mine seems a logical quantity to define as depletion and to deduct from income. . . ." (*23*, p. 170). Scott's user cost involves the same idea.[12] Use

[10] As an example, the self-sufficiency ratios of oil refiners increase with size of the refiner; i.e., the smaller refiners have to buy a larger share of their crude (De Chazeau and Kahn [*10*, p. 18] as cited in Paul Davidson [*8*, p. 98 n. 15]). Think how relatively much more self-sufficient the giant majors would appear if (a) state prorates let them produce freely from the superior deposits they hold, and (b) they could import freely from their immense foreign holdings. In fact, the majors are more than self-sufficient. They sell crude to others.

[11] When firms are ranked by assets rather than gross sales, Standard Oil of N.J. outranks General Motors. Of the top eleven non-financial firms six are mineral firms: Standard Oil of N.J., U.S. Steel, Texaco, Socony Mobil, Gulf Oil and Standard Oil of California (*12*, p. 226). Conventional understatement of values of mineral reserves acquired in the past tends to bias the ranking if at all against the mineral firms. For example, among the holdings of Standard Oil of California are 102.9 million (*sic*) net acres (about the area of California) of producing or prospective oil and gas land. For complete data see Merrill Lynch *et al.* (*32*, p. 15). *Fortune* lists book value of company assets at only 4.2 billion dollars.

[12] Böhm-Bawerk also favored this concept. See his discussion of the quarry (*1*, p. 335). For a similar position see Mason Gaffney (*18*, pp. 555–57). Herbert Dorau has worked on an unpublished theory of building depreciation premised on the same fundamental notion. Michèle Consigny and I have developed and will soon publish a depreciation formula for income taxation which would be neutral among different lives, and it too entails this basic concept of depreciation.

of this definition for income-tax purposes would result in higher taxes on owners with longer reserves, leading toward subdivision, quicker recovery, and interfirm equalization of R:O. Strong hands would weaken and release idle reserves to financially weaker hands, and new hands, accelerating recovery and whetting competition. Putting it more fairly, it is the present approach to depletion, based on undiscounted spot values, which grants the deduction to those whose mines are too longevous to depreciate with use, which contains the non-neutral bias towards slow recovery and monopoly.

I will later conclude that the entire depletion approach to capital recovery is a third choice, less desirable than either the expensing approach or best of all a modified property tax that exempts improvements. However, so long as we do continue to favor the depletion approach, it would be well worthwhile to modify it in line with Hotelling's and Scott's definition of depletion. That poses a further problem of identifying the unit of property the change in whose value is to be counted as "depletion." This section addresses that problem.

In most cases the mine operating unit does tolerably well as an identifiable entity. Thanks to indivisibility, and locational stability, most reserves are unambiguously attached to a given "shaft," our symbolic term for any large identifiable capital unit. When all reserves are attached to some shaft — i.e., none are purely idle — this would be a simple and adequate way to solve the problem of units. Operating R:O's do not fail to reflect ownership conditions: owners with long owned reserves and market power tend to tie longer reserves to each mine, keying their operations to their strong financial circumstances. Use of the operating unit basis, therefore, would accomplish the same ends as use of the ownership unit. As to the problem of aggregation, we have also seen that the sum of user costs from a set of staggered mines equals the decline in value of the full ownership unit.

However, the operating-unit basis leaves a loophole for income-tax avoidance by letting firms detach some reserves from any shaft at all. Thus they could magnify depletion allowances from producing shafts; later they would tap the idle reserves with new shafts. This loophole is a variant of the more general principle that any tax with a progressive aspect may be reduced by subdividing the tax base. Real subdivision in this case would not be objectionable — on the contrary. But holding idle reserves would be factitious subdivision, of no redeeming social value.

The solution is to require that the taxpayer assign all owned reserves

to some operating unit. Idle reserves, unreachable by existing shafts, could be assigned to some mill or refinery, and *its* reserve position be evaluated as a whole, even though the reserves were contained in several separate mines and deposits. Or if necessary an entire firm could be taken as the unit, its reserves being regarded as attached to its marketing system.

That means pooling the firm's reserves for tax purposes, and that in turn means a minor legal fiction, because reserves from different mines cannot in fact always be pooled. It means that a mine of 2 YFL would get little depletion credit if pooled with other mines of 60 YFL, or with idle reserves. The mine of 60 YFL, on the other hand, would get more depletion at a rate based on the mean R:O.

We have seen (Fig. C.1) that under perfect staggering such pooling would slightly lower the value of the depletion allowance, even in the absence of idle reserves. That is, the yearly decline in value of 40 mines of 20 YFL is a trifle less than that of 40 mines of staggered YFL. But we also saw that the difference is minimal. What difference there is works in a progressive direction by lowering depletion allowances more for larger firms, and might be desirable on grounds of distributive equity and aid to competition. But the effect is minor, in any event.

Administrators will make errors estimating life of mines, of course. Owners will conceal reserves and plead exhaustion. But if the year of alleged exhaustion arrives, and the mine produces unabated, there is a remedy: no more depletion. The owner seeking to overstate depletion is boxed between two limits. If he understates life he also must put a low figure on the present value, which limits the total depletion he can claim over life. If he claims a high value and long life, he must defer depletion until later, and later it might not all be allowed when the original overstatement becomes manifest. This information should also be made available to state and local assessors for property-tax valuation.

Thus, the tax collector is not a babe in the woods to be systematically outthought by the owner. The owner has little room to maneuver between the walls of his box, and whether he succeeds in exaggerating or understating his reserves, he has little to gain over making a correct estimate. Simple errors, too, would be subject to renegotiation near the end of life.

As new reserves are continually discovered and added to the base, there is scope for a good deal of tax evasion by understating the reserve

until other reserves are gone, and then revaluing it upwards. The remedy here lies in subjecting the revaluation windfall to taxation.

No doubt taxpayers will contrive other ingenious loopholes, as with any tax with a progressive feature. Only the *in rem* ad valorem property tax is invulnerable to that kind of maneuver. But so long as we rely on realized income as the tax base, and so long as we handle capital recovery by the depletion approach, the suggestions above should give a tax based on a true definition of resource income and with wholesome effects on market structure.

I later conclude, however, that we need to improve on the depletion approach to capital recovery, which suffers from basic incurable faults.

9. A tax on mineral rents may be made neutral as to discovery as well as to conservation.

Herfindahl and Vickrey have expounded the intertemporal neutrality of a tax on net realized mineral rent. Their exposition has been in terms of a net value above costs, where revenues and costs were assignable to individual years. Steele has intimated the difficulties of this concept where heavy initial capital costs must be spread over many years, and McDonald has brought out the central importance of the tax treatment of capital investment.

Figure C.3 above helps solve those difficulties. If a cycle of mineral investment and recovery be evaluated as a whole, the optimal time-distribution maximizes present net value of the resource. A tax taking a fixed percentage of the net would not change the life which yields maximum net present value, and so would be substantially neutral. Such a tax might best be levied as an annuity whose PV equals the tax rate times the PV of the mine, and whose life approximately equals the life of the mine.[13]

[13] Applying that to equation (3) and Figure C.3, the tax annuity would have the value:

$$\frac{T}{t} = \frac{A}{L} - C_0 \frac{i}{1 - (1+i)^{-L}} \tag{4}$$

where T is the yearly tax, t the tax rate. (Costs in years after o should be discounted to time o and included in C_0.)

(4) is derived by two steps: first, subtract C_0 from (3), giving present value net of capital costs; second, convert the lump sum to an annuity by multiplying by

$$\frac{i}{1 - (1+i)^{-L}}$$

(4) converts the lump sum PV to an annual net rent, the cash flow $\frac{A}{L}$ less the "capital recovery factor" $\frac{i}{1 - (1+i)^{-L}}$ times capital cost. Note that the annuity (4) is not something to maximize by changing L. A higher annuity is possible by

The neutrality of this tax extends further than its effect on the time-distribution of use of the known stock. It is also neutral on the timing of discovery and development. These two decisions are also critical in their timing, and the criterion is the same as for conservation of the known stock, to wit, maximization of present value (as of any given year). That is, the time to begin developing a proven reserve is when the value *in situ* stops rising faster than the interest rate, so its PV is a maximum. Again, the time to begin prospecting lands with suspected reserves is when their leasable value stops rising faster than the interest rate. This is the same principle, but with discovery costs added to development costs.

This is an important extension of the principle of the neutrality of proportional taxes on mineral rent. Not only do they not affect time-distribution of use of the stock which is known and already tapped; not only do they not affect the time of beginning the removal; but they also leave unchanged the timing of discovery itself.

There remains the possibility that they may reduce the optimal exploratory outlay, even while preserving the timing. But the presumption of temporal neutrality is that discovery costs be fully deductible when laid out — i.e., be expensed — either directly or by the device suggested above of making the tax an annuity whose present value is the tax rate times the PV of the mine. The same presumption preserves their quantity. The quantity that maximizes rent before tax also maximizes rent after tax.

There are two ways to tax rent: the base may be realized rent, as with an income tax that expenses capital outlays; or putative, assessed rent, as with a property tax that exempts improvements. The suggested annuity tax has features of both modes. It would let the federal income tax take on a bit more of the character of a property tax, for the level of the annuity, at least at the start, would have to be based on some sort of advance appraisal of the mine. Later, like an income tax, it might be readjusted to reflect experience with the mine.

Another approach to taxation of mine rent is simply to allow full deduction of all non-land costs, including capital outlays in full in the year of outlay.[14] The practical problem here is that, if the tax rate were

shortening L, but it would have a lower PV_0 because of there being fewer total annual payments.

[14] The Treasury thus lends the taxpayer a tax deferment that grows at compound interest to equal the value of the taxes when due. See also McDonald's discussion of expensing in Chapter 11 of this book.

high, the government would first have to contribute a large share of the initial capital investment, which would count as negative income in year 0; and later have to take a large share of *gross* income to recoup its investment, impairing taxpayer incentives. At a 100 per cent rate the government would supply the entire capital outlay and recover 100 per cent of the later cash flow above current costs — if there were any. But then why would a private investor care if there were or not? To avoid such a problem, the annuity approach is better. Under this regime the miner pays a steady constant yearly tax, a percentage of yearly rent, and keeps everything above that to motivate him.

In application, the annuity approach might give the income tax some of the levering character of a property tax based on presumptive rather than realized income. Constitutional lawyers may frown at such a use of the Sixteenth Amendment, but waiters and gamblers are already taxed on presumptive income and it might make more economic sense to extend the precedent to landowners.

As a final caution, note that the *in situ* income tax, as discussed here, implies the absence of any depletion deduction. The taxpayer's capital recovery is handled by setting his tax rate as though he were allowed to expense capital outlays when incurred. Any depletion deduction above that would be double counting and simply leave rent in private hands. Depletion and expensing are substitute approaches to capital recovery, not complements.

The considerations of what unit to use to assess the value of depletion, therefore, would apply only where expensing is not or has not been allowed.

As between the two approaches to capital recovery — expensing and depletion — expensing (or its annuity equivalent) is more compatible with the taxation of economic rent. Expensing real costs enables us to distinguish between actual capital formation and lease acquisition. Thirty years later the two kinds of outlays have merged into the market value of a mine, and depletion is likely to cover both, without, however, exempting from tax the interest return on productive outlays as expensing does.

If we must use the depletion approach, then the methods suggested for assessing the value of depletion for income tax deduction should be useful. They might also have a place in a transition period. But on balance the expensing approach with an annuity tax seems an interim

goal toward which to move; and a property tax based on an accurately assessed putative value net of discovery costs seems an ultimate goal.

Policy Conclusions

Forearmed with the formal analysis, we may now draw policy conclusions and in a more relaxed and literary mood explore several points in more depth. Like the points made above, these are individual conclusions of the editor and do not purport to express any consensus among the conferees. The editor acknowledges a deep debt to the contributors, however. Their thinking and criticism improved his mind and directed him to many of the issues whose significance he did not previously hold in proper perspective. Correspondence from Professors Vickrey and McDonald has been especially deep and provocative.

Beyond Neutrality. "Neutrality" is a good norm of tax policy, but not the best. Some taxes may be better than neutral; that is, they may positively improve on the pre-tax allocation of resources by helping to make imperfect markets less faulty, by countervailing biases that characterize some markets, etc.

For example, severance taxes might be used as price surrogates to limit demands on open-access resources like fisheries. Conversely, taxes may be used to improve access to or allocation of resources which the private market has partially frozen or removed from commerce. Taxes on the capability or rentability of land may tend to weaken monopoly. More generally, they and other taxes on rent lower the financial requirements for land acquisition, letting people pay for access to resources one year at a time, instead of in one lump sum, thereby short-circuiting the otherwise serious economic barrier of credit rationing. These taxes also may stimulate economizing behavior by reducing the liquidity and the total holdout power of sleeping landowners too affluent or diverted to be concerned with making the most of the assets at their command. They apply leverage, sharpening the incentives of the market and sharpening the definition of maximum profit positions.

Marginal Resources and Neutrality. We may recognize neutral and better taxes (given perfect tenure) by their lack of effect on marginal resources, and marginal decisions on all resources. (In the absence of tenure protection over resources, better-than-neutral taxes would be user charges and would affect marginal decisions.) Taxes falling on the net income or rent or value of resources meet that test, because on marginal resources the tax base equals zero, and there is no tax, hence no destruc-

tion of marginal output. Tax bases other than natural resources generally lack this virtue because there is no free marginal supply. Taxes on gross output lack this virtue because they hit producers on marginal land. (I am indebted to David Ricardo for pointing this out a hundred and fifty years ago in Chapters 10 and 11 of his *Principles.*) Minnesota's recent taconite amendment, for example, guaranteeing upper limits on taxes on the *production* of taconite, was followed immediately by several commitments to build new plants in northeastern Minnesota, a graphic example of the impact of unneutral taxation on marginal decisions. Any severance or excise or royalty or other tax based on *gross* output (or gross input) will hit marginal land and render it submarginal.[15]

Neutral and better taxes may be increased to 99 per cent rates without worsening allocation or incentives. That simple *reductio ad absurdum* forces us to face up to distortions we are tempted to overlook as negligible or undemonstrable when rates are very low. At 99 per cent rates, taxes on gross receipts or value added, for example, would close down production completely.

Taxes on the net income of extractive resources are better, but at 99 per cent would leave no effective incentive to realize the taxable income. High rates would put a heavy premium on uses yielding untaxed psychic income to the owner, so the tax is not really neutral. Unpleasant extractive resources such as coal mines, that yield little psychic income,[16] might be taxed effectively on the net money income. Similar taxes, however, on forests or fisheries or farms would motivate the owners to devote

[15] The profession proved remarkably perceptive of this point in its reaction to one mistake in an otherwise excellent paper by Professor Paul Davidson. He analyzed percentage depletion like a negative excise tax — a sound analogy — but then minimized its influence on exploration and extension of the margin by saying the emergence of rent on previously submarginal land would absorb all the surplus — again correct — and thereby completely offset the incentive to develop new land. The last is a basic error. New rent only absorbs the gain above costs, it does not prevent the outlay of the costs themselves. Davidson's analysis would have made any tax neutral by denying its effect on marginal lands and by implication on marginal production on all lands. In fact, excise taxes on marginal lands make them submarginal, and negative excises do the reverse. See Paul Davidson (*8*), and Campbell's (*7*), Steele's (*39*), "Comments" and Davidson's reply thereto (*9*); McDonald (*30*, p. 110, n. 143); and A. E. Kahn (*26*). On p. 130 of his reply, Davidson seems to agree in principle that a negative excise may encourage exploration. See also Allyn Lockner (*28*).

[16] Masochistic personalities may get psychic relief from coal mining. They may even enjoy paying taxes. I do not think, however, that most of us would prefer to live in a society geared to their needs.

the entire resources to personal recreation and subsistence farming. Untaxed residential and recreational land use would be expanded, commercial and industrial uses choked off. Trade and specialization would give way to self-contained subsistence economies, and the Treasury would be empty.

In addition, any tax based on *realized* cash income invites deferment of realization to defer tax liability, a form of tax avoidance that has become so universal one might fairly call it the single most pronounced allocative effect of income taxation.

To avoid those problems at high tax rates we have to resort to a tax based like the property tax on the assessed market value or "rentability" of resources. Those elusive leprechauns called implicit, imputed, psychic, and accrued undistributed income are firmly capitalized into the price of land, and may be taxed through the traditional property-tax mechanism. This tax may be better-than-neutral, as mentioned above. Here, however, we meet the problem of exhaustibility.

Property Taxes and Depletion. Many suspect the property tax of accelerating depletion because the taxpayer may reduce the tax base by exhausting it. That effect is overstated in general, and is actually quite weak for the following five reasons:

1. Property taxes on land are capitalized into lower prices, so that the yearly carrying costs are reduced. Where the future life of deposits is very long, tax capitalization virtually eliminates any net influence of taxes on output. The higher tax burden is offset by a lower burden of interest (implicit or explicit).[17]

2. Where a prorate or production allowable system controls permissible output, as in most oil-producing regions, operators cannot accelerate output to avoid taxes in any event. In the long run, heavy property

[17] J. P. Jensen gives us an excellent treatment of tax capitalization in his *Property Taxation in the U. S.* (*24*, Chap. 3). The "carrying cost" of a mine is $V(i + t)$, where V is present value, i is interest rate, and t is property tax rate. Putting the tax rate, t, into the capitalization formula,

$$V = a \frac{1 - (1 + i + t)^{-L}}{(i + t)}$$

where a is annual net income, assumed constant over life, and L is life.

Carrying cost (CC) then is:

$$CC = a \quad [1 - (1 + i + t)^{-L}]$$

A rise of t does increase CC, but only slightly.

For an analysis of tax capitalization under credit rationing see Daniel Holland (*22*); Mason Gaffney (*16*, pp. 282–84 especially); and (*17*, pp. 30, 49, 74–82).

taxes might create pressures to eliminate the prorate system, followed by accelerated output from superior fields, but on balance that change would work a great improvement over the present constipated condition.

3. In practice, the effect on output of the property tax depends on the assessor's method and the interplay between the assessor and the taxpayer. It is likely that many assessors use a rule-of-thumb approach, always assuming the same life of wells.[18] If the assessor then takes the initial production rate as typical over this fixed hypothetical life, he would create a motive for producers to start off slowly. Even though slower production defers realization of the owner's investment, it also means lower taxes until the assessor revisits. It is only if the assessor actually estimates life and then over time progressively lowers assessments with reduced life expectancy that the property tax motivates accelerated output.

4. Much of the damage done by property taxation in fact is attributable to the levy on mine improvements, as opposed to mines themselves – that is, the *in situ* value of the resource proper. A tax on mine improvements motivates the miner to shorten the life of improvements, probably substituting capacity for longevity. That is a fault of general property taxation, but not of taxation on the capitalized net rentability of mines per se.

Even this fault is conditional. It depends on the assumption that capital can shift the tax and maintain the same rate of return after taxes as would obtain in the absence of taxes. If capital is unable to shift, however – say because the tax is too widespread to avoid by migrating – it must accept a lower rate of return after taxes, and the original rate of return *before* taxes, leaving no residual effect on longevity.

A horseback method of separating improvements from *in situ* values in present property taxation in the field is to distinguish between the property tax on lessors and lessees. The tax on the lessee's property represents improvements plus discovery values resulting from successful prospecting. A tax on *in situ* values would exempt the improvements and some of the discovery value (although that question wants further

[18] A. O. Lockner writes of several states that base property-tax assessments on production rather than on any effort at appraisal of productive capacity. To the extent that that is common practice, the property tax has become something like a severance tax, tending to retard use (*28*, p. 468, n. 2).

analysis). The *in situ* tax would bear, therefore, more on the lessor's interest; and lessors generally have little influence on rates of production.

5. The possibility is remote that property taxes on *in situ* values would lead to premature abandonment. Because the miner sinks his capital in mine improvements, their existence causes him to continue his tenure for some years after the mine has lost its rentability for immediate reuse, and has therefore stopped paying the *in situ* tax. That is, the fixed investment will cause him to work to a lower margin than it would be profitable to work on a year-to-year basis. (There is also future secondary recovery to anticipate, under improved future techniques; that, too, discourages abandonment.)

Under proper assessment of *in situ* taxes, therefore, mines in use under fixed capital would become marginal — and the taxes zero — some years before abandonment. Or, we might prefer an arrangement where taxes would approach zero as abandonment approaches. In either case, no one could avoid taxes by abandonment.

Let us add that no one who supports percentage depletion should be allowed to speak above a whisper in criticism of property taxation, because percentage depletion tends to accelerate depletion more than almost any other thinkable tax measure.

Premature abandonment is more heavily encouraged by (a) severance taxation and (b) the usual "sharecropping" arrangements between lessee and lessor, than by property taxation. Those institutions take a share of the lessee's gross and so make a mine submarginal to him before it is so in fact to society. That does not exonerate property taxation, but it does suggest that much of the received literature, which singles out the property tax for censure, is not well balanced.

The allowable or prorate system would also cause premature abandonment by inflating well costs, were it not tempered by the exemption of many older marginal wells from the prorate.

Countervailing Taxation. In spite of the above, there remains some tendency for property taxes on *in situ* values to accelerate depletion. This tendency can be offset, if desired, by a perfectly countervailing tax on depletion (on Scott's user cost). By that device any desired percentage of the rent may be socialized without excess burden either in the form of accelerated or retarded depletion. The taxes simply replace certain prices and costs in the economy of the producer. The property tax replaces interest (explicit or implicit), and the depletion tax replaces

private user cost. In either case, socialization may be partial or total, as desired. The two kinds of charges together exhaust the rent.[19]

Such a tax couplet would shift over time as life expectancy shortens, from primary emphasis on the property-tax component, the function of time, to primary emphasis on the depletion charge, a function of use. It shouldn't be a difficult trick to combine the two charges in such a way as optimally to constrain and motivate the operator of a mine. The suggested tax couplet is an alternative to the neutral annuity tax proposed above (pp. 364–67) and not a supplement. But the two approaches might be used simultaneously by different taxing authorities, provided the two together did not absorb more than the full tax base.

In fact, it is likely that the mild purgative effect of the property tax is in practice more than offset by the drop in the effective discount rate occasioned by general taxation of capital and its income in all industries and jurisdictions. The discount rate is the most powerful determinant of rates of use, and if this is artificially dropped, by a system of taxes that lowers the overall rate of return after taxes on new investments, the tax system as a whole operates to retard depletion of superior ores.

Property Taxes and Prospecting. Property taxes also draw fire for discouraging prospecting. Any tax, indeed, that cuts into the net income from minerals may tend to lower their present value before use, and thereby demotivate prospecting. We have seen the income tax may be exonerated by expensing exploration outlays. But property taxes may also be exonerated. They possess a unique virtue in this regard which has received little of the credit it probably deserves; to wit, they may be and sometimes are imposed *before* discovery as well as after.

From the fact that rents, royalties, bonuses, and "points" to passive landowners loom so large in prospecting outlays, we know that some lands have a high probability of responding favorably to exploration.

[19] For simplicity, assume a mine which yields a steady rent for L years and stops abruptly. Carrying costs (interest and property taxes) on the capitalized value of each dollar of rent are equal to:

$$(i + t)\ \frac{1 - (1 + i + t)^{-L}}{i + t} = 1 - (1 + i + t)^{-L}$$

Depletion under our assumptions is equal to:

$$(1 + i + t)^{-L}$$

The sum of carrying costs and depletion is, therefore, equal to 1. That is the entire rent (*23*, p. 170).

Adding a tax on depletion will complicate the above expression but without changing the basic principle that carrying costs plus depletion exhaust the rent income.

This probability passes frequently through the market, which evaluates it.[20] Appraisal consulting firms, such as De Golyer and MacNaughton of Dallas, specialize in valuing such probabilities. Business can be conducted on such appraisals; so can taxation. If assessors followed the rule of ad valorem uniformity, it automatically would be.

Pre-discovery property taxation motivates landowners to lease their mineral rights, or prospect themselves, to the end either of dispelling the illusion and lowering their assessment, or confirming it and starting production. There is even a danger of overmotivating prospecting by injudicious application of the principle. Here we need not lay out the precise requirements of striking an optimal balance. Suffice it that taxation may accelerate as well as retard exploration, and we need not leave mineral rents in private hands on the illusion that there is no other way to motivate exploration. Comparing property taxes and percentage depletion the latter encourages exploration by giving away tax revenues; the former by raising them.

We return to this matter in the discussion of taxation to motivate exploration.

Transit to Higher Taxes. A transition to higher taxes on mines may not be as difficult as at first glance it appears. It is possible without over-accelerating depletion, by adopting a transitional policy of countervailing taxation which will retard depletion by the same amount that the anticipation of higher future taxes accelerates depletion.

In many jurisdictions we already have a set of tax and prorate and cartel policies which retard depletion, so such countervailing institutions already exist and the anticipation of higher future taxes would move us toward optimality when it accelerated depletion above present rates. Severance taxes and excises are heavily retarding. Even a tax on net income acts like a gross-receipts tax after the date of heavy capital investments.[21] So, in the absence of precision-planned countervailing taxes, we may still feel some assurance that accelerating depletion would improve the general welfare in jurisdictions with such taxes.

Percentage depletion, on the other hand, tends to accelerate depletion

[20] Lessees generally obtain oil leases *after* geological and geophysical evaluation. In Alberta they are even allowed some core and exploratory drilling before bidding for leases. Market values are not established entirely in the dark.

[21] Landlord-lessee relationships may also retard recovery. Much of the landlord's rent comes in the form of a royalty fixed at a share of gross, customarily 1/8 but often more. It affects the lessee's motives somewhat as a 12½ per cent or more severance tax would.

heavily and would do so even more if its withdrawal were imminent. But its production effects are already held in check by the allowable system. It would be a matter of timing to repeal the allowance first, and then lift the prorates. The worst that could happen, however, is not a wholesale waste of resources as some may envision. Accelerating production, should that occur, would quickly bring spot prices down very low, motivating most resource owners to hold out for a rise.[22] Rather than suffer such a redistribution of income, industry leaders and state agencies would probably prefer to cooperate in effecting an orderly transition to higher taxes and freer markets. They of all people have nothing to gain by suddenly flooding the market. Only we should beware the strategy that would release chaos to induce trauma and so win support for a return to their leadership and control.

Taxation to Motivate Exploration. If it is possible to frame tax laws that will capture mine rent without jeopardizing economical conservation of the known stock, is it also possible to capture the rent without demotivating replacement by exploration? As taxes drain the value from resources, do people lose an adequate profit motive to hunt for more? How much profit motive is adequate?

I suggested above how the property tax may be modified so as to encourage exploration. I briefly suggested as well a method of taking a percentage of rent net of discovery costs, a method that could be substantially neutral if administratively feasible. The brief abstract analysis (pp. 364–67) raises as many questions as it answers. Here let us bring it down to earth with reference to going institutions and in confrontation with other ideas.

It is possible to tax mineral rents without diluting the motive to explore. The following devices would work, some better than others.

1. Under the property tax, we may assess and tax the *pre-discovery* value of unexplored land with good mineral prospects. These values are

[22] The force of this point is evident in the Persian Gulf, where foreign firms hold concessions of limited life. Aramco concessions in Saudi Arabia, for example, terminate in 1999 and 2005. Why does the company not loot the reserves while it can? A primary concern with price effects would seem to be the answer — exploiting consumers is more lucrative than exploiting resources. See Wayne Leeman (27, pp. 168, 225, Chaps. 2, 6, *et passim*).

There remains a remote danger of chaotic collapse of dimensions that would cause lenders and credit to shrink from the industry, encouraging widespread liquidation. With most reserves being held by some of the strongest financial powers in the world, that seems an improbable outcome.

measurable in the market for leases giving exploration rights. Such taxation of leasability value not only permits exploration, it forces it, and in some anti-commercial cultures might be the best way to open lands for prospecting. As to public lands, we may lease them to explorers, with much of the payment being an annual fixed charge until such time as the lessees begin producing and paying royalties. This would have the same effect as annual ad valorem taxation of privately held lands. In either case, the landowner would accelerate exploration, either to find minerals or to lower taxes by establishing the absence of minerals.

"Discovery" is not usually a single dramatic revelation, but a slow accretion of evidence. Most reserves are chronically in a half-discovered condition. Nothing could accelerate further probing quite so much as a fixed steady charge on the market value of the title to these shadowy treasures.

Then, after discovery, of course, we could continue to tax rent without the tax's having risen as the result of discovery. Thus we would not discourage exploration. The trick would be to collect about the same amount from all lands after exploration as before, only after exploration the taxes would be concentrated on the rich lands and removed from those proven poor. A simple ad valorem approach tends to bring that result.

2. Under the income tax, we may allow expensing of exploration outlays (other than lease acquisition). Indeed, we already do so in large part. This practice in effect exempts from the tax that part of gross income imputable to the expensed outlays for exploration. Its rationale is similar to that of the annuity tax on rents. The higher the tax rate on mineral rents, under this system, the higher the public contribution to exploration.

The neutrality of expensing capital investments in mineral development of course presupposes similar treatment of capital investments in other stages of production (which means in other industries, also). In the absence of general expensing for all taxpayers, it would be more neutral to let mineral investments be capitalized and depreciated over life, like other investments. However, such general income taxation imposes severe intertemporal biases, the topic that Professor McDonald has opened. The virtue of general expensing is that it comes close to converting the corporate income tax into a tax on pure economic rent, thus assuring its neutrality and stimulating productive investments by exempting their income from taxation.

3. Under the income tax, we may allow a depletion write-off from taxable income, but nothing like the present system.

Depletion is the decline in value of a resource due to extracting part of it. It is usually much less than the spot liquidation value of the unit extracted, because depletion is a loss of remote future value. To define depletion as the spot value, and then deduct it from taxable income, is virtually to exempt the rent of mines from income taxes. To define depletion in terms of *wellhead* value as today we do, is to exempt more than the rent of mines (a subsidy which inures to mineowners because it is given only to outlays used in connection with mining). Mining and oil company publicity releases often urge just that; but depletion, properly defined, does not approach spot liquidation value until ultimate exhaustion is imminent, and never approaches wellhead value unless production costs approach zero.

But an economic allowance based as Hotelling recommends on the actual drop in value caused by use (Scott's user cost) would supply enough to replace the used mineral, including lease costs, which are price-determined rents. We might choose to leave such an amount in private hands.

The motive to reinvest this amount in minerals exploration would be weakened by taxing rent (net of user cost), which would take a bite of the interest on the investment in discovery value. To be sure, the actual exploration outlay for superior resources is less than their discovery value. This fact is expressed in lease prices charged to explorers by passive landowners, which absorb the difference. Expectation of taxes on post-discovery rents lowers lease prices, preserving part of the net income of the actual explorer. But on marginal land there is no cushion of surplus to absorb the loss.

This approach fails to pass the test of zero taxation on marginal land. Defining marginal land as that on which discovery values equal discovery costs (and use begins on date of discovery), the taxpayer would eventually recover his discovery costs tax free, but would pay a tax on the income they generated.[23] Such a tax is "neutral" only on the unreal assumption that because taxation is general capital cannot shift part of the tax. But it does, by emigrating, lowering its rate of

[23] Davidson interpreted the provision for percentage depletion, which lets a miner recover *more* than the original cost of discovery, development, and lease purchase, as simply adding to rents. But in fact it would also lower taxes on marginal land and expand exploration, as his critics brought out. See also note 15, above.

turnover,[24] and moving into durable consumer goods. Thus the tax makes marginal land become submarginal.

At the same time that the depletion approach taxes the income of productive investment on marginal land (and all land), it lets some economic rent escape from superior land. For the miner recovers not just his productive exploratory outlays, but also his lease acquisition costs, without discrimination. In a simple case, if I discover at a cost of $100 a one-year mine netting me $1000, I get immediate depletion of $1000, the decline of value, ten times my discovery cost. In a more general case, if I discover at a cost of $100 a mine whose discovery value is also $100, but which grows to be worth $1000 before I begin to use it, the accrued income is tax free because I can then deduct $1000 (or more!) in depletion. And even the taxes which I do pay are deferred until long after the appreciation of the investment value of my mine.

Indeed, the present federal income-tax law seems to regard depletion primarily as a recovery of leasehold costs. Other discovery costs are recovered separately, either by expensing or by capitalizing and then depreciating them. Percentage depletion is an option, the alternative to which is to depreciate capitalized leasehold costs. (See McDonald in Chap. 11 of this book.)

By the same token, depletion also lets landowners collect economic rent from exhaustible resources of zero discovery cost, such as virgin timber, shale oil, and now ground water and next, perhaps, topsoil. It lets landowners recover the value of deposits discovered at their neighbor's expense, which deposits extend under their land, even though they never pay a tax on the windfall income.

Thus, if our motive be to reward discovery effort, the use of depletion allowances costs the Treasury more than it rewards the explorer. Professor Paul Davidson may have overstated his attack but he was and is basically right about this (*8*, *9*). He might have strengthened his case by emphasizing that present law even extends percentage depletion to landowners, to lower their tax liability not only on royalty income, which has some relation to real depletion, but on bonus income, which

[24] Brown establishes the intertemporal non-neutrality of taxes on net business income in his "Business-Income Taxation and Investment Incentives" (*2*). Actually I think he got it backwards when he concluded that the bias is towards shorter lives; it is the opposite, a point that Michèle Consigny and I have established and will soon publish. But the present point is that income taxes are unneutral intertemporally, as Brown and McDonald say. The popular notion that taxes can be neutral by virtue of broad coverage has to be abandoned as soon as we test for intertemporal bias.

has none (*26*, p. 287, n. 2) and in neither case rewards exploration. The frictional loss is so great that this must be classed as a primitive inefficient social instrument for its alleged purpose. We have also seen (pp. 362–63) that the problems of measuring depletion, while conceptually soluble, are intricate enough to tempt tax agents to slide over the basic concept in favor of spot values.

The danger with any income-tax proposal is more likely to be overstimulation of discovery than the reverse. The taxation of realized cash income puts a premium on acquiring assets that appreciate over time before incurring tax liability; and unripe mineral deposits suit that description nicely. The bias is even stronger if the appreciated value may be written off as capital recovery, even though the appreciation was never taxed as income.

4. Taxes from mine rents could be used to finance, and better yet, to motivate public exploratory outlays.

It is questionable if prospecting is properly an exclusively or primarily private function. State and federal agencies should explore underground resources more actively than now, just as they conquered, explored, and surveyed public lands in the nineteenth century.

Public exploration permits pooling and disclosure of information obtained. It avoids costly duplication. The social value of the information gained by private prospecting is greatly diminished by secrecy. Public disclosure of the findings of public exploration would enhance their value, especially in finely subdivided areas, offsetting the possible lesser efficiency of a government operation.

Public prospecting would permit a more sober and rational use of information than presently. Now, advance information secured by early prospectors is a fugacious asset which must be exploited before the next prospector duplicates it. That sometimes injects an element of frenzy into lease hounding which does not conduce to rational behavior, as noted in Gospel: ". . . a treasure hid in a field; the which when a man hath found he hideth, and . . . selleth all that he hath, and buyeth that field."

Public prospecting and disclosure would do much to dispel the aura of mystique which now surrounds exploration, as it does any private monopoly of arcane lore. The mystique is worth dispelling because it lends itself so nicely, as any plunge into the unknown, to exaggeration and exploitation to claim special privileges.

Private prospecting is partly a gamble and as such tends toward ex-

treme inequality of income and wealth,[25] which is socially disruptive and politically anti-democratic. It favors giant firms which can pool their risks internally, and large surface landowners [26] who control more of the underground than anyone else. It would do much for middle- and lower-class Americans to remove such an influence from the distribution of wealth.

The most and perhaps the only persuasive reason for advance prospecting is the spillover value of the scouting function. Others can modify their plans on the basis of geological information. Planning public roads and common carrier pipelines would benefit. Other explorers can slack off if they learn that ample supplies are already pinpointed. But when prospectors treat their knowledge as secret private property, they do not perform this important scouting function for anyone else.

Textbooks tell us that perfect competition presupposes perfect knowledge. When the object of our activity is to acquire knowledge, to sequester it, to use it to acquire property, and even perhaps to surprise and embarrass competitors or threaten off new entrants, it hardly meets the standard. Public exploration is therefore an alternative seriously to be considered.

There are private consortia in some areas that pool their findings. (They might be sticky about widening membership, however.) A com-

[25] It might be thought that wins and losses from gambling would even out in the long run. But in fact those who win in the first round have an advantage in the second, because a gambler with a deeper purse has more options than his less pecunious rival. So early advantages tend to snowball.

[26] The King Ranch, the Kern County Land Co. and the Northern Pacific Railroad are obvious examples. A 1952 pamphlet, *Railroads Discover Oil*, by Merrill Lynch *et al.* (*33*), lists the following acreages owned in fee plus mineral rights:

	millions of acres
Atchison, Topeka & Santa Fe	1.8
Atlantic Coast Line	.2
Canadian Pacific	11.3
Chicago, Milw., St. Paul & Pacific	.3
Northern Pacific	9.0
St. Louis–San Francisco	1.4
Southern Pacific	4.7
Union Pacific	7.5
	36.2

All but the Canadian Pacific lands are in the U.S. The total is more than the area of Illinois. Union Pacific makes about as much from oil as from railroad operations. Northern Pacific stock tripled in 1951–52 with oil publicity from Williston. Stock held in the large corporations is highly concentrated, as many studies have shown. ESSO means Rockefeller; Gulf means Mellon; and so on.

promise may be possible with government helping to finance exploration in return for wider disclosure and, of course, higher taxes on post-discovery rents.

The Alberta system also has attractive possibilities. Lessees are simply required as lessees to disclose a great deal of information to the province, which then publishes it. They must take core drillings and furnish them to province geologists, keep logs, etc. (*29*, p. 201). Kansas,

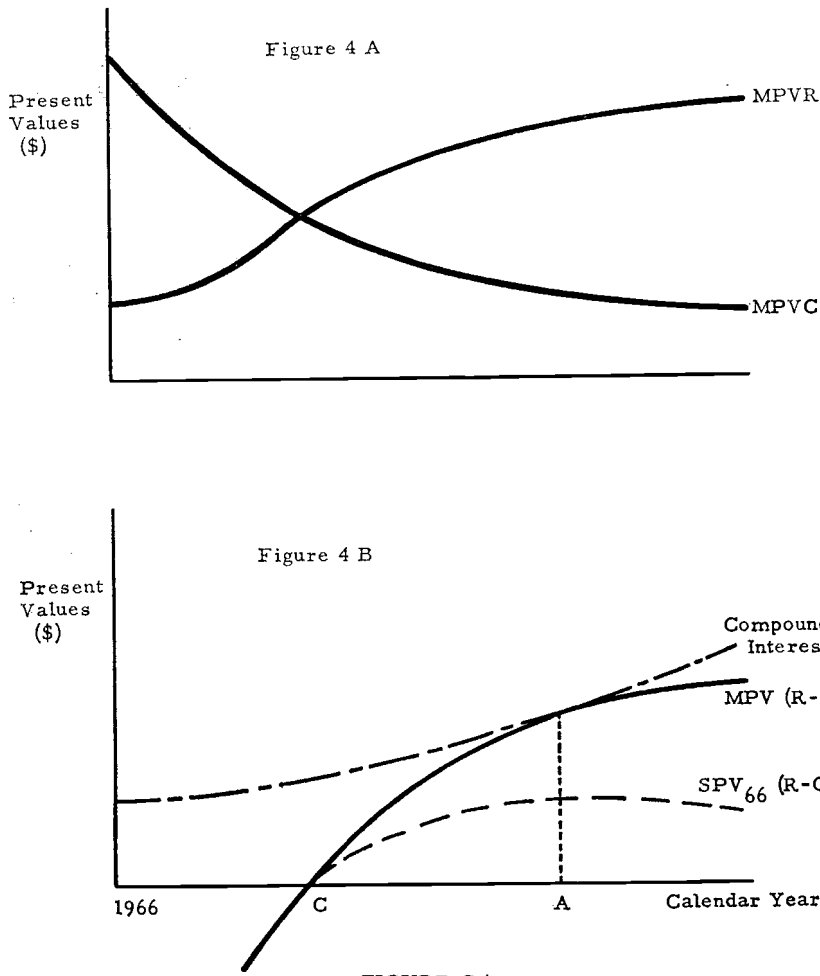

FIGURE C.4

Moving Present Values (MPV) of Revenues and Costs of Mineral Discovery and Development; and Stationary Present Value (SPV) of Revenues Minus Costs (R-C) Referred to a Base Year, 1966

which lacks Alberta's leverage as landlord, achieves something of the same result by law.

Comparing public exploration with the proposal to expense exploration outlays, one notices a likeness. In both cases exploration is financed with public funds. In the former case it is publicly administered, in the latter privately. In either case taxation of mineral rents is possible without discouraging prospecting.

When to Explore (and Three Misleading Analogies). There are then four possible ways to tax mineral rents and still motivate exploration. Now we come to the interesting quantitative question: How much exploration is just enough, but not too much? When is soon enough, but not too soon?

I have been writing as though the motive to explore were an unqualified good. Yet it is entirely possible to motivate too much, and too soon, and it may well be that we are doing so. If that sounds like desecrating church, mother, and flag, beware! It only betrays one's long exposure to the pro-exploration bias that suffuses our traditions so thoroughly we are scarcely aware of it. Men who on most issues seek an optimal moderate target as a norm will find that they can conceive of having too little mineral reserve but hardly of having too much. It is as though one could be too thin but never too fat.

But it is possible to explore too much and — equally wasteful — too soon. I have discussed selecting a year of discovery when the present value (PV) of a mine net of discovery costs stopped growing faster than the rate of interest. Figure C.4 shows the relevant quantities.

The "Moving Present Values" (MPV) are present values computed as in Figure C.3 (p. 349). Each is the maximum PV (R-C) that could be achieved by beginning production in the current year. By waiting, this value rises if costs are falling or prices rising, as shown. This is what makes lease values rise, and makes owners hold them for the rise, for lease values represent the net value of a resource after all non-land costs.[27]

Since this is a net value after all costs, including interest costs on

[27] In a perfect market, however, lease values will not rise as fast as MPV (R-C). Rather, they would grow exactly at the rate of interest, along the compound interest curve in Figure C.4B. The expectation of future value assumes a present value some years before the optimal date to begin liquidation, as shown. The conditions under which leases are written, however, probably do not allow full expression of those foreshadowed values in the market for leases. Rather, they show up in inflated prices for ranch land, reservations of mineral rights, etc.

non-land outlays, it is socially desirable to conserve the resource so long as its appreciation outpaces the relevant market interest rate. The time to begin discovery and development is when the lease appreciation slows down to the interest rate or less.

That is the year in which the *non*-moving PV of the lease is a maximum (*A*). On Figure C.4 this stationary PV is based on the origin, 1966, but any other year would do as well.

It would not make sense to hold the lease until its MPV was a maximum. That might be never; and in any case it would deprive us of interest on the net value of the resource *in situ*.

It would not make sense to develop the lease as soon as it assumed any spot liquidation value (*C*), for it is then of negligible current net value, but appreciating much faster than money in the bank.

It would make even less sense to develop the lease at the time *D* (not shown in Fig. C.4) when it first developed a perceptible market value. *D* would come before *C*. *D* would be the year in which the remote future possibility of rent-yielding mineral development was first faintly suspected. For a future net value, once foreseen, always has some present value, however small.

A tax that takes a fixed percentage of the rent will lower the absolute but not the percentage growth of MPV (*R–C*) and so leave unchanged the date of *A*, the time to begin exploration and development.

But before discussing tax policy in detail, let us elaborate on my allegation that *A* is indeed the normative time to begin exploration and development. Many readers will not find the mathematical-graphical approach persuasive. Many economists and others have tended to reason the issue through on the basis of analogies to other resources. And this kind of analysis must be met, for it effectively blocks perception by many people of the principles in Figure C.4. It particularly blocks the realization that discovery should not ordinarily much precede development.

Analogies are always tempting. They let us analyze a new situation just as we did an old familiar one, using thoughts that fit us as comfortably as an old shoe. But they may not fit our subject that well. Reasoning by analogy is, indeed, one of the classic fallacies of logic and exposition.

Analogy has been widely used in analysis of exhaustible resources. So deeply rooted in our subject are several misleading analogies that it is well to analyze them explicitly before moving to final conclusions. I

will discuss three: that prospecting is analogous to other production, the discovery being the product; that the margin of mining is like the margin of cultivation (or of other permanent land use); and that mineral reserves are like other inventories. While the analogies are half true, that only makes them the more dangerous by masking their fallacies behind a face of plausibility. We will see that minerals are in some ways unique, *sui generis*, and require custom-tailored analysis and policy.

Prospecting is not entirely analogous to other production. Many economists regard discovery as similar to planting a new forest. Discovery produces discovery value just as planting produces saplings. The investment slowly ripens over time, until the ripe investment is harvested, returning to the investor principal plus accumulated interest. Discovery is the cause, and appreciation of mineral values is the effect. That is the analogy on which they base their thinking.

But there are differences between finding what exists and creating what didn't. There is important economic truth in the literal truth that Nature, not man, actually produced mineral deposits.[28] Discovery has elements of sheer acquisition, as well as addition to value. Where tenure is perfect, leases sell for high prices and "discovery" by the lease buyer is partly outright purchase: the purchase of a high probability of finding minerals is only a step away from buying the minerals themselves.

The acquisitive element manifests itself in another way where no one has perfect tenure of undiscovered minerals, and discovery establishes ownership through some rule of capture, or adverse possession or prescriptive or prior appropriation principle. Under such institutions unbridled outlay by prospectors should dissipate rent entirely, as with Pontecorvo's fisheries or other open-access resources. As Gardner mentions in Chapter 8 of this book, prior appropriation is a commonly applied working principle in mining law. It was from the custom of miners, indeed, that the principle found its way into water law.

In case of minerals other than the fugacious this principle has a special acquisitive twist, since discovery closes the open access. (Discovery of oil pools does not close access if others may still tap in. Here, rent is dissipated after discovery.) What I find today, you cannot profit by finding tomorrow. Dissipation of rent, therefore, must occur before discovery, during the period of open access. It takes the particular form

[28] Professor Davidson deserves credit for emphasizing this point (*8*).

of premature acquisitive searching in a race to establish tenure. Rent is swallowed up by interest on premature advance exploration outlays, outlays whose timing is advanced by the imperative to outrace others who are likewise motivated.

Mineowners may then think that the rents they get are necessary to cover interest cost on exploration outlays long past, or on their huge inventories of reserves. From their individual viewpoint, under present policies, they may be thinking reasonably. But the social economist must see beneath the veil of familiar institutions and the fallacy of composition and ask deeper questions. Is there any aggregate social benefit from advancing prospecting costs so many years before use?

The analogy between finding minerals and planting trees misleads us because undiscovered minerals, unlike unplanted trees, appreciate.

If minerals exist, they are almost certain to be found one day. They appreciate before being found as well as after. Several factors conspire to that end: demand grows; older deposits dwindle; science and technique advance, lowering costs of producing as well as of finding; population spreads out, bringing demand nearer to remote deposits; transportation lines reach out; United States military bases and political influence establish a firmer Pax Americana over insecure areas; etc.[29] Compared to such powerful and expensive factors, an act of discovery appears a small part of the complex of conditions that permit mineral extraction.

In some cases, and in some measure, discovery is prerequisite to and helps guide the other activities, and therein lies the most likely rationale for early scouting of the underground. But even under assumptions most favorable to the argument, the scouting function is only one of many outlays necessary to make minerals appreciate.

There are those who will hasten to tell us that minerals have no value unless they are discovered. The allegation is neither correct nor relevant.

It is incorrect because prospectors in fact pay landowners lease bonuses and rents, and agree to give one-eighth or more of any gross for the right to explore for minerals under lands whose location relative to market,

[29] If we assume U.S. military outlays are indeed guided by mineral acquisition, then (a) we have a serious indictment of U.S. policy, and (b) the minerals should repay in taxes the cost of the military outlays. On the other hand, if military outlays are made independently of mineral acquisition, then exploration serves no "scouting" function for the military and cannot be so rationalized.

collection lines, established fields, and propitious geological formations indicates a high probability of uncovering minerals whose present worth is more than finding costs.

It is irrelevant because no single economic input has much value until combined with others, and we can never impute the whole product to one input on the grounds that the input is indispensable. Several inputs are indispensable, above all the mineral deposit itself. Fortunately, generations of economists have already explored the fallacy, and developed marginal production analysis and linear programming to handle the problems of imputation and distribution. Unfortunately, capital theory, needed to help us cut the pie when production extends over many years, remains underdeveloped. But the doctrine of discounted marginal productivity has set out the essentials. No one who has mastered marginal analysis can doubt that a mature capital theory will limit the prospector to a cut of the pie based on his marginal contribution. Our analysis above (pp. 340–67) takes a step in this direction.

Now, if finding costs are not to exhaust the entire value of their "product" – i.e., the discovery value of minerals – it is necessary that we defer exploration until social discovery value has risen to exceed discovery cost, preferably by a wide margin. Otherwise, the entire prospecting activity yields no social surplus, but consumes as much value as it returns.

Under perfect tenure and competition, the rational and enterprising landowner defers discovery and therefore development until the net lease value stops appreciating faster than money at compound interest – the point I am here supporting. A neutral tax preserves this timing unimpaired. A better-than-neutral tax would sharpen competition and apply leverage to make sleeping absentee owners more enterprising; but it would not force an advance of exploration and development before the perfect market timing. It would simply make markets more nearly perfect.

In the absence of good tenure the market fails, and premature investment in discovery is the rule. No one then waits for leases to rise to a maximum present value before exploration. As soon as discovery value covers discovery costs, exploration begins. Monopolists do not even wait that long, nor would interlopers who might hope to blackmail a monopolist.

In this condition, taxation of post-discovery rents is desirable pre-

cisely because it would defer exploration and close the gap of years between investment in discovery and actual use. The appreciation of minerals that now occurs after discovery, at a rate about fast enough to return interest on discovery investments, would then occur free, before discovery—a good bargain for society, turning base metal into gold. Thus, mine rents would be created by the very act of socializing them—an interesting reversal of the more usual case where taxes impose an excess burden.

Note that these taxes would *defer* exploration, and not necessarily *reduce* the aggregate effort in the long run. If we begin from a condition of redundant discovered reserves inherited from previous institutions, there would be less exploration during a transition while we worked down the surplus, and recovered for more productive uses a great fund of real social capital now frozen in the reserves. (In the present acute shortage of capital that would be a very useful thing, supplying needed capital to the rest of the economy.) After that the need to maintain level stocks and replace depleted reserves would prescribe as much exploration as before. The difference would be in a leaner industry, carrying less reserves.

The margin of mining is not analogous to the margin of "cultivation" (or other production) of a flow resource. The idea of deferring discovery, and therefore use, until minerals have risen well above zero net value may seem to run counter to the general principle that we should use resources as soon as they become supramarginal. It might seem that discovery has beneficial timing effects by advancing the date of use of any supramarginal mineral deposit. But that principle applies strictly only to inexhaustible perpetuities, or flow resources.

Fund resources may be ready to yield a surplus above discovery, development, and mining costs, and yet remain unripe for harvest. Their net liquidation value may be appreciating faster than the interest rate,[30] making them submarginal for use in all years until their net liquidation value stops growing so fast.

Everyone recognizes that mineral extraction is non-repeating, so that timing is the essential economizing choice. We often forget, however, that discovery is equally non-repeating and the timing is equally critical.

[30] That does not mean their exchange value in place would rise faster than the interest rate. The emplaced value is the discounted value of liquidation in the most favorable set of years, and in a perfect market grows exactly at the rate of interest. This is shown on Figure C.4B as the compound interest curve.

The opportunity to discover is, as Vickrey has said, a species of exhaustible economic opportunity. The optimal time to discover may very well be only a short period before liquidation begins, even though that entails letting resources rise above the marginal condition before they are explored.

When resources are marginal it means the present value of costs just equals the present value of revenues, so that any decision lowering costs or raising value of revenues by a small percentage has great leverage on net rent and raises this by a large percentage, as Herfindahl brings out in Chapter 3 of this book. The *net* present value of undiscovered marginal or slightly supramarginal minerals may therefore easily be rising faster than the interest rate, due to a much slower percentage rise of demand or drop of costs, warranting deferral of discovery and use. Discovery is not timely until that *net* present value, net of both development and discovery costs too, stops rising faster than the interest rate.

The fact, therefore, that oil companies hold millions of acres around the world which they hope to explore sometime in the future does not necessarily betray monopoly designs. It might or it might not. Under perfect competition and neutral taxation it still is good social economics to hold minerals so long as their value in place grows faster than money at compound interest. Only those who hold them longer than that, or who reckon unreasonably low rates of interest, are behaving like monopolists.

The discussion so far assumes that prospectors can distinguish in advance the better from the worse opportunities. But what if they cannot? Certainly they cannot always, and the oftenest repeated argument for favorable tax treatment of those who strike it rich is the need to cover the costs of dry holes and less productive wells or mines. So let us entertain the assumption of homogenized expectations of success by prospectors, and see where it leads.

If each prospector is faced with the average expectation of success and we let the lucky winners keep the full mine rent, we would overmotivate prospecting. It is as though we took all the economic rent of land in New York City and spread it around equally among all the city's landowners, and let any landowner join the city. The meanest marginal location would net as much ground rent as Broadway and 42nd Street. So, naturally, every peripheral farm owner would turn his

land to urban use to share in the rent, until the city covered half the state and the rent was dissipated.

In the case of prospecting, if we let the aggregate discovery value of findings be the motive to prospect, we will call forth an aggregate exploratory effort roughly equal to the prize,[31] thus eating up the entire value of the prize. Such a procedure flies in the face of all marginal economic analysis. It is motivating the prospector's marginal effort with his *average* product rather than his marginal product — a remarkably Marxian argument to be the bulwark of private rent collection. The rent of good land will be used to subsidize exploration of bad land, not just marginal but submarginal.

So the dry-hole argument turns out to be a variation of Marx's theory that labor creates all value, and is no more worthy of serious consideration. Even if prospectors' expectations were entirely homogeneous it would be desirable to charge some mine rents to defer the premature exploratory outlays.

In a perfect market with perfect tenure, as before, lease prices would serve to siphon off the surplus motivating rent. On the public domain, however, or on other open-access lands, letting discovery win a full equity in the findings will badly overmotivate prospectors.

The dry-hole argument has, to be sure, its proper applications. A gusher on private land whose cash flow is 95 per cent quasi-rent is the prize that has caused others to pay for leases a sum roughly equaling the net present value of the gusher less exploration costs. The real costs need to be recovered in one of the ways listed earlier. But the quest of gushers on open lands will pull in too much investment in exploration if we let discoverers keep their full value.

Mineral reserves are not analogous to inventories. It is common to regard advance untapped reserves of minerals as a kind of company or national stockpile.[32] Much of the conservation literature, the alarmist

[31] And possibly a good deal more valuable than the prize, if the spirit of Las Vegas prevails. Marshall observes ". . . if an occupation offers a few extremely high prizes, its attractiveness is increased out of all proportion to their aggregate value." Folklore has it that the sum of prospecting outlays exceeds the discovery value of minerals. If true that is no defense of present institutions, as often alleged, but the roundest condemnation. It means we have organized mining so cleverly that the net social value of our country's great mineral resources is negative.

[32] "This exhaustion or depletion resulting from production is likened to the using up of raw materials in manufacturing," Prentice-Hall, *Federal Taxes* (37). The terms "fund" and "stock" resource, applied to mineral reserves, reflect the same kind of thinking. They are semantic booby-traps.

kind, suggests a high degree of uncertainty about future discoveries, implying or stating that much longer advance reserves would be optimal; and that means widening the time span between discovery and use, either by advancing discovery or retarding use, or preferably both. The notion advanced here of deferring discovery until just before use would be scouted as an irresponsible hand-to-mouth philosophy courting imminent danger of exhaustion.

But mineral reserves are not discovered in one-year bundles. Mineral deposits share some of the traits of an economic fund, but some of the traits of land. Like other land, they are "indivisible in time": that is, when we discover a mineral supply for next year it includes a supply for the next 5 to 100 years, willy-nilly.

Future reserves thus occur as by-products of current supplies. So we need not defer the use of discovered minerals in order to have future reserves. Presently producing mines include future reserves, except in their twilight years. All mines might go into use as soon as they are discovered and an industry still have from 15 to 50 years' reserves or more.

That may well be more than they would carry if mineral reserves could be stockpiled in divisible increments of one year. Indeed, it is likely much more than they would then carry. What other stage of industry carries a 15 to 50 year reserve of raw materials? When *Fortune* ranks the 500 largest United States industrial corporations by "assets per employee," the ten highest are all oil and/or gas companies. Ranked by "sales per dollar of invested capital," four of the five lowest are oil or mining companies (*13*, p. 251). When we measure "bigness" by assets instead of sales, Standard Oil of New Jersey outranks General Motors (*13*, p. 226), the legend of whose unrivalled stature rests on high turnover and gross sales as much as owned assets. At 6 per cent a unit of ore to be sold for $100 in 50 years has a present value of $5.43. One would hardly bother to discover it today unless as an indivisible by-product associated with a larger discovery to be used on the whole much sooner than that.[33]

[33] President Haider of Standard Oil of New Jersey in 1963 estimated proven world oil reserves at "over 300 billion barrels, equivalent to about *35* years of production at the present rate of consumption, and this is no doubt very conservative" (*20*). Thomas Crocker, who is currently completing a study of the phosphate industry of Florida, estimates a life index there of 80 to 120 years. (Computed by Thomas Crocker from Plate 5, United States Geological Survey Bulletin No. 934, *Phosphate Resources of Florida*, 1942, and a map prepared by Bureau of Sanitary Engineering, Florida

Even the "twilight years" of a mine arrive not because the miner has exhausted the geological deposit. He has, rather, taken as much as he economically can with his tired old fixed plant and the obsolete methods it embodies. His short-run marginal costs have risen towards their marginal value product. But many a deposit is renewable by new capital, like an urban site with a new building. It is the capital improvements that are in the twilight years. The deposit still holds mineral reserves.

Over the life of the original mine improvements, several things have happened: (a) they have surely depreciated and lost effectiveness; (b) new techniques have evolved (secondary recovery, like steam injection in old oil fields; refining advances such as taconite beneficiation, giving value to previously submarginal grades of ore; new uses for by-products and associated minerals — natural gas, helium, etc.); (*c*) new knowledge of the field has added to proven reserves (every year much more oil and gas, for example, are added to reserves by "revision" of old discoveries than by new discoveries); (d) the location of the field has (probably) improved by spreading of population and extension of transport lines; and (e) the location of existing shafts or holes in the field itself has worsened in relation to the unrecovered minerals, which naturally are the ones to which they give poorest access. Contemplating the aggregate meaning of the above factors, it seems that even mines near retirement contain reserves. But that is a secondary point here.

The primary point is that most mines are far from retirement, and contain long reserves. Advance exploration years before use begins, and idle deposits in cold storage, are not necessary to provide reserves therefore. An industry keeps reserves by using slowly what it has. Newly found mines may often go right into use and an industry still have ample reserves. If and when we are to defer the use of any deposit, it makes more sense to choose one nearly exhausted so the conserved mineral may benefit us in the near future; or else one not yet discovered, to spare us interest on discovery cost.

Conceivably most mines might approach retirement simultaneously, threatening a reserve shortage. But in fact most firms or industries tend to stagger their mines in order to maintain a going concern: to smooth the yearly need for discovery and the yearly flow of output. They have

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State Board of Health. *Lands Owned by the Various Phosphate Industries in Polk, Hillsborough, Manatee, and Hardee Counties, Florida* [Jacksonville, 1965]).

some mines nearly exhausted, some fresh and new, and most in the spectrum in between.

All we need discover in a given year, therefore, is enough to replace the mines retired that year plus a few more for expansion, or less a few if some retiring ones are replaced by secondary recovery from the same deposits. As we have shown earlier, the number of years of future reserves is determined by how fast it proves economical to remove known deposits. It is an index to the economical speed of amortization of mine capital rather than to the nation's chances for survival. Reserves for amortization double as shock absorbers; they should also be anxiety relievers.

Returning to Figure C.4 now, there is no need to question the optimality of discovery at time *A*. Ample reserves for the near future lie behind existing shafts. Ample assurance for the further future lies in the high price of leases to explore propitious untapped land. The reason we carry reserves as long as we do now is for amortization, not security, and those reserves provide more than the security we need.

So much then for the three false analogies that block perception that landowners should defer discovery and development of minerals so long as title to the undiscovered minerals appreciates faster than money in the bank.

How We Overmotivate Exploration. Next let us see if prevailing institutions seem likely to encourage individuals to time exploration that optimal way. I submit that we tend to overmotivate exploration for nine reasons which I will now treat. They entail the following: open access to undiscovered minerals; preclusive acquisition to enhance market power; duplication by vertically integrated firms; artificially high prices; the need to replace the flexibility destroyed by prorationing; the leverage of private over public investment; the publicity – promotional value of discovery; management self-aggrandizement; and tax favors.

Mineral law is the Ur of the Chaldees of the appropriative principle that discovery establishes ownership. Staking a claim on public land is a time-honored process. Most National Forest land, for example, unless reserved, is open to twenty-acre mining claims, which blanket some areas of the West.

It is widely understood that the rule of capture motivates premature use of fugacious petroleum. It is not so widely understood, but more forcefully true, that open access for prospectors followed by closed access after discovery overmotivates prospecting by a larger factor. The oil

pumper only gets what he pumps up; the discoverer gets the whole resource. The entire discovery value of resources becomes the motive to explore. It calls forth outlays roughly equal to itself, dissipating the entire rent by interest costs on early investments.

Like all pure concepts, cases of completely open tenure of undiscovered minerals today may be hard to find; but so are cases of completely closed, or perfect, tenure.[34] There is commonly some element of imperfection in the tenure of undiscovered resources: it is hard to see how tenure of the unknown could be truly perfect. Exploration is a game of Bingo in which superior minerals, the motivating prizes, are subject to capture. Prospecting on closed land differs from prospecting on open land in that one must buy a ticket of admission first – i.e., pay for a lease – and that does indeed cut down the excessive effort and retard the premature effort. The rational landowner tends to hold back his lease until its market value stops growing faster than money at compound interest, at which time its present value (referred to any fixed base year) is a maximum. And that is the economical date to begin discovery, as established above. But there are biases in the market which tend to advance exploration.

Unequal access to information is one. A few giants, with teams of high-powered geologists, operating among and dealing with local landowners who live on a different cultural and financial level, constitute an imperfect market. The Houma Indians of Terrebonne Parish, Louisiana, for example, bargained at a great disadvantage with Humble Oil Company, according to a current lawsuit, and signed in their ignorance very disadvantageous leases in 1937. When a giant gains advance information on the underground his lead is a fugacious resource. He tries to capitalize on it before the nearest rivals[35] duplicate it, and before

[34] In a dynamic world, social institutions chronically tend to lag behind individual enterprise. The legal right to do something often develops as a delayed response to the fact that people have been doing it for years. Thus the Geneva Convention of 1958, not yet ratified, seeks to formalize national jurisdiction over offshore waters. Meantime drilling goes on apace, if anything stimulated by the near certainty that the ancient customs of mankind plus the force of their governments will let use establish tenure.

[35] At least the nearest minor rivals. The more "gentlemanly" majors tend to follow "the time-honored practice of staying clear of the other fellow's territory," according to Howard Kegley, oil editor of the San Francisco *Chronicle*, "to avoid running up the price of leases." Thus there is for the first major in a field a precarious grace period during which to snap up leases at bargain prices. The bias toward early exploration is manifest.

local landowners get wind of it and raise their demands. Where the contrast is very great between the information held by a prospector and the local surface landowners, he is almost in the position of one working on open public land. His urgency is in some ways even greater because the overt approach of a rival may raise lease prices and so devalue his information, even if the rival never finds the prize.

Another market imperfection tending towards premature exploration is the contrast in financial strength between giant corporations on one hand, and on the other local landowners with poorer access to credit and correspondingly higher internal or insular individual rates (i.i.r.) of time discount. Ancient possessors with higher i.i.r. will sell a lease to buyers of lower i.i.r. earlier than if both had the same i.i.r., because the expectation of future income has higher PV to the buyer of lower i.i.r. Then, terms of the lease sale [36] will often require early exploratory outlays to protect the seller who wants to begin receiving his 1/8 royalty soon. Landlord-tenant relations here, as elsewhere, often distort economic decisions.

The primarily acquisitive nature of much advance exploration is suggested by the fact that each year's addition to known reserves consists less in new discoveries than in revaluation of old ones (*29*, pp. 17–19, *et passim*). That is, prospectors are busy staking claims to new resources sometime before they have carefully appraised what they already own. The lag between discovery and development is a long one.[37]

Preclusion to strengthen market power is a second factor tending to overmotivate exploration. Wherever there is imperfect competition there is a bias to prefer exploration over development of controlled reserves. Exploration invests a company's funds without adding to current output, thus deferring for many years any price impact from increased output. Exploration aids in preclusive preemption of the industry resource base from potential interlopers. Discovery has high

[36] Leases are often of limited life unless production begins, forcing the lessee to explore and begin producing. Yearly lease rentals which cease when production begins also force action. The lessee may rationally produce initially only the minimum necessary to retain the lease or stop the rentals. The 12½ per cent royalty is a retarding factor when a field is marginal by virtue of prematurity. So lease terms permit retarded production, but force early exploration.

[37] About 19 per cent of the area of the U.S. was under lease for oil in 1960, and 1 per cent of the U.S. was currently producing (Duncan Campbell [7, p. 116, n. 5]). Leasing often follows geological-geophysical outlays. Many landowners, in addition, must explore their own land without any lease — not all oil is produced by sharecroppers.

publicity value, adding to a firm's credit base and security sales message. Investment in advance acquisition of reserves puts the assets of a large company into cold storage, where they may earn a market rate of return with minimum turnover and therefore minimum demands on an overpressed management of an oversized firm. It defers liquidation and associated tax liability, and of course opens up broad avenues for tax avoidance.[38]

Firms whose market power hangs on resource control will naturally put a higher value on discovery and acquisition than if markets were purely competitive. Other firms seeking to work out from under this control do the same. A kind of law of comparative *dis*advantage prevails. It is much more important to a firm to get in on resources that might be handy for others than to concentrate on resources already firmly under its wing.

Absence of any tenure opens access to all comers and destroys competitive rent, which is bad. Absence of monopoly tenure opens access to competitors and destroys monopoly rent, which is good. But the quest to establish monopoly control, a sort of "super tenure," works the same as the quest to establish proper tenure; that is, it advances discovery effort wherever sellers are competitive in order to bring them into the "higher" form of tenure.

In the duplication necessitated by universal vertical integration, each firm carries enough reserves for its own survival and there is no pooling, so some firms must explore even though others hold idle reserves. This is a third factor overmotivating exploration.

The duplication might be less marked if the exact quantity of reserves were a more definite and known figure. But the return to given exploratory outlays is probabalistic or stochastic. Since under vertical integration each company must assure itself independently of a firm supply of raw material feedstock, the exploratory effort of each must be enough to assure that the *minimum*, rather than the *mean* probable discoveries suffice to fill its needs (its maximum needs, incidentally). The vital economic principle of pooling risks, which affords such important economies in insurance, banking, warehousing and other familiar businesses, is denied.

[38] "Though there is an almost universal oversupply of crude, Jersey continues energetic exploration for it. 'It's a matter of strategy, not shortage,' [Jersey President] Haider says" *Business Week* (6, p. 57). He is not quoted further on the point, but one may suspect that "strategy" comprises some of the biases mentioned above.

The greater is the dispersion of the *ex post* productivity of exploratory outlays around the mean expectation, the greater margin of safety is required.

It might seem that the surplus of discoveries that in the aggregate must result from this peculiar incentive pattern would glut the demand shortly and slow down future exploration. But it seems equally likely that the surplus aggregate reserves, once found, would before long prompt the finders to expand their output and then go on to repeat the cycle as their exploration for replacement needs led in the aggregate to more expansion. Thus the condition is chronic and repetitive.

Utility regulation works also toward vertical integration and duplication. Each gas pipeline company must put supplies under contract to qualify for its FPC certificate, as security for bondholders, and to protect its share of the market. No nonsense here about relying on an open-market supply of raw gas! Market imperfection is assumed and institutionalized.

International rivalries work the same way. Each major bloc must control its own reserves and not count on surpluses of the other. Each minor power center in the Western bloc tries to control its own reserves. No one wants to rely entirely on reserves in politically marginal and unsure nations (Iran, Saudi Arabia).

Secrecy also forces different firms and neighboring landowners to duplicate some exploratory effort, when they have not worked out pooling.

Mercantilist ideas about raw materials often cause primary producing nations to tax or forbid export of unprocessed ores in an effort to force processors to locate and pay taxes in the mercantilist jurisdiction. That often forces importers to find marginal supplies while rich ones lie idle.

High price umbrellas supported by cartel control of output from superior wells overmotivate marginal exploration, especially in jurisdictions that enforce no prorate or which, like Alberta and Texas and Louisiana, allow more production from higher-cost wells, or like Texas exempt discovery wells from prorate for eighteen months.

A fifth overmotivating factor is that the need for reserves for flexibility is magnified by the inflexibility of allowable output from controlled wells – prorationing.

A sixth is the leverage of private over public investment. The flag follows discovery into many areas. The private explorer who wins a strike can usually rely on a shower of complementary public funds to

protect him, if need be, from national enemies[39] (and even friends!); to subsidize harbor and inland transportation works, perhaps through World Bank; to extend pipelines to new areas inside the United States, or at least Texas, even though the new areas' population does not carry the incremental cost; to extend state-subsidized highways to new communities that may grow up around mining employment; etc. Such institutions tend to subsidize and vitalize otherwise submarginal land developments of all kinds. In less-developed foreign countries, as Roberts brings out in Chapter 9 of this book, it is the miners who are the chief outriders of the central economic system. They would not ride nearly so far if they paid their own way in full.

An important aspect of this lies in the economics of regulation of utilities such as gas transmission lines. Permissible profits are figured on original cost less depreciation. So the companies are under pressure to expand constantly to keep up the rate base. They expand their collection and feeder lines into submarginal territory, raising their rate base and hence the rates they can charge in rich territory. Economic rent is spread thin and partly dissipated in the process. But submarginal lands are made supramarginal for exploration and gas production.

Two of the facts of life assumed away by the pure theorist's assumptions are imperfect knowledge and imperfect allocation of credit reflect-

[39] See Wayne Leeman (27, pp. 183–84, 236–37) for a very muted statement of the case. Britain has been much more specific than we in protecting private mineral concessions with the public armed forces. The British government, indeed, has itself been a major owner since 1914. But who, one might ask, protects Britain, and why did Britain accept the open-door policy in the Persian Gulf, which let U.S. majors in?

As the U.S. becomes more and more an importer of primary materials there is little doubt that it will move in the mercantilist direction of protecting its sources with the sword. The U.S. clearly presided over the replacement of Mohammed Mossadegh, the nationalizer of Abadan, by Fahedi, supplying dollars and trained police. The close ties of oil policy and foreign policy came to the surface very clearly when on January 11, 1953, the National Security Council, acting upon the urging of the State and Defense Departments, ordered the Justice Department to withdraw its criminal indictment of the five U.S. based majors whose conspiracy in restraint of trade had been documented the previous year by an FTC report, the release of which had required months of agitation. The rationale was that the revelations of the report might weaken the majors in dealing with foreign governments. If State and Defense run interference for the majors against domestic enemies, it seems a fair inference they are doing the same against foreign ones. And not for the benefit of American consumers, for whom the FTC spoke, but for the majors themselves. More recently James E. Akins, an operations officer in the U.S. Department of State, has stated openly and publicly that United States foreign policy in the Middle East is predicated on the "enormous" American investment in oil there.

ing that ignorance. A central problem of business enterprise is always to promote itself in the capital markets, to borrow and to sell shares. Remote armchair investors are clearly biased toward the dramatic, newsworthy, and glamorous.

Given a choice between prosaic quiet development of owned reserves, therefore, and new strikes in Timbuktu or Xanadu, the ambitious corporate manager may often prefer the latter for its publicity value in the credit markets.

On owned lands, landowners who should wait a few years for exploration may often advance the date to get their land appraised, to the end that it may better serve as collateral for credit, or stock promotion. The information which exploration generates is not used for present production, that is, but to reallocate the economy's pool of loanable funds to the advantage of the landowner. Since that is purely redistributive, and does not create net new wealth, it does not constitute any net social payoff to compensate and vindicate the interest cost of the early exploration. Note, too, that a rise in asset values is real income whose tax liability is deferred until realization by sale, but whose benefits are immediately enjoyable by borrowing on the collateral that has appreciated, and to boot deducting interest payments from taxable income.

Separation of corporate management from ownership has been widely recognized as the source of serious conflicts of interest. Public corporations essentially dominated by managers are a fact of modern life. The managers' interest is usually to plow back undistributed profits into the business, magnifying his own role.

Thus any business with a rich rent-yielding core is liable to overexpand its fringe and promotional activities, of which exploration is a perfect type. We have seen and will see further that mineral industries are extraordinarily rent-yielding. And how universally do we hear corporation public-relations people justifying (for the benefit of those who oppose high profits) high returns in some areas of their business by the losses they suffer in others, as though the latter were necessary to the former (27, p. 81). In explaining this to stockholders, too, it is always important to dwell on future prospects. They are much harder to evaluate or refute than the bleak facts of today. "The future is the refuge of those with no plan for the present."

Thus some public corporations tend to become agencies for diverting the surplus of rich lands to explore marginal ones ahead of their time.

For many years now prospecting, especially for oil and gas, has been

overstimulated by a number of tax favors so well summarized by Professor Kahn:[40] percentage depletion, capital gains, and expensing of "intangibles." Expensing of major exploration costs particularly acts to advance these outlays. Expensable are: dry-hole costs; lease rentals; geological cost not resulting in lease acquisition; intangible costs of drilling and equipping productive wells; and cost of abandoned leases. Expensing might be neutral if universal, but it is reserved for minerals' exploration and drilling. As to tax liability, that waits upon realization of cash income by liquidation. There is a long period when discovered but untapped minerals rise in value yearly and in each subsequent year rise enough more to earn interest on the previous rise, thus yielding their owners a real income, but without being taxed. Michèle Consigny's forthcoming work on this topic indicates this may be the royal road to virtual tax exemption. The package of special favors is at any rate material.[41] Oil prospecting has become a fashionable tax shelter for the affluent, pulling in great investments and extending the margin of prospecting.[42]

In addition to those special provisions, any corporation with a rent-yielding core can help its stockholders by plowing back earnings into expansion, whereby their tax liability is deferred and, if taken as capital gains, cut by half or more. Again, recall that mineral industries are extraordinarily rent-yielding at the core.

Undertaxation in the past would not justify overtaxation in the future (unless from a viewpoint of compensatory equity) if past policies had left no heritage of oversupply. But in fact the excess of premature findings now on hand is such as to let us temporarily regard discovered,

[40] Professor Kahn points out that double (or more) recovery of capital may make it pay to invest in oil even when outlays exceed receipts (*26*).

[41] The habit of integrated companies of transferring crude to their refining divisions at fictitiously high "posted" prices, in order to transfer profits to the crude production division and enjoy the ensuing tax benefits suggests there are still net tax benefits accorded to that stage. Kahn (*26*) and Leeman (*27*) document this practice.

[42] Anything making *in situ* oil more valuable encourages exploration. One minor provision warrants more specific mention in this context. That is the 50–per–cent–of–net limit on percentage depletion. A firm may strike the limit if forced to tie exploration capital costs to higher cost wells. It may escape it by segregating dry-hole costs and geological-geophysical costs from revenues of the producing wells that ensue. This encourages advancing the exploration to ensure the desired segregation. The limit only applies to the unit of property. It is not reached by deducting costs from simultaneous income of other properties.

undeveloped minerals as being more akin to gifts of nature than would otherwise have been proper. At least for a while, it would not hurt to undermotivate prospecting.

There, then, are nine reasons why our institutions tend to overmotivate or advance prospecting. On the other side, prospecting tends to be undermotivated in subdivided areas by the inability of finders to collect the full value of their findings, much of which underlie the lands of neighbors.[43] However, this argument may defeat itself, for the element of secrecy often forces neighbors to prospect also, and subdivision may overmotivate prospecting by enforced duplication of effort in subdivided areas. On balance, overmotivation seems the predominant condition. It would be surprising if it were not, since a bias towards capturing underdeveloped territory, even at high cost to central developed territory, is manifest in most of our social institutions for resource development.

A crude test of the question is, "By how much does advance discovery precede development?" Here, the recent work by Lovejoy and Homan (*29*), is quite suggestive. They find that each year's increment to "proven" reserves consists more in development and revaluation of previously discovered deposits than in "new discoveries." The implication is clear that discovery precedes intensive development by many years.

The upshot is that the motive to explore is not a fragile, precious flower, but rather a lusty weed that wants some constraint.

How to Tax Mineral Rents. It is a curious commentary on our times that the former notion of taxing earned (wage) income at lower rates than unearned (property) income we have not only abandoned but reversed. It is the style to pooh-pooh the quaint notion that high income-tax rates might dilute the incentive to work. On this topic the modern policy-maker produces a backward-bending supply curve of labor and explains that "income effects" of lower after-tax labor income more than offset "substitution effects" so labor may very well work longer for less money. But when it comes to oil royalties, that's different![44] Here the incentive argument comes back to life and we hear that what we thought was a gift of Nature is the work of men – men who will stop work unless they receive large financial rewards! In the modern idiom,

[43] The high bonuses for federal offshore leases reflect in part the automatic pool unitization that follows discovery (Kahn [*26*, p. 291]). The finder acquires more than a license to race with his neighbors for a pool to which many have access.

[44] Professor Kahn has earlier noted this irony (*26*, p. 297).

labor income has become mostly rent, and land income is a necessary incentive to call forth supply.

In truth, the older idea had merit. If indeed our institutions overmotivate prospecting it makes sense to tax mineral rents not just as highly as other land income, but higher. And if it makes sense to tax economic rent, then some mineral income can be completely socialized without any excess burden whatever.

The question that remains is simply how to do it. A modified income tax, a modified property tax, and government ownership are the major instruments for the purpose. Let us sum up our conclusions about each:

Given perfect tenure, perfect competition, perfect knowledge, international amity, and neutral public-works investment policies — i.e., given the absence of the nine biases toward premature prospecting — a business income tax could tap the rent of mineral land and exempt the income of productive investments in exploring and developing it by a fairly simple, straightforward device: let the taxpayer deduct his investment costs fully in the year expensed, except lease purchase, royalties, and other payments for land.

On the whole, I conclude that an income tax so modified, while a great improvement over present practice, is less desirable than a modified property tax. Income taxation with expensing poses a number of problems.

1. Given the nine biases for prospecting, an income tax fails to offset the overmotivation because all prospecting is expensable, even on public land. Conceivably the law might allow expensing on private land but not on public. However, the matter is too subtle and many-sided to be handled by any such simple formula, and in practice it is hard to see how an income tax can discriminate among degrees of tenure (a property tax does so discriminate, and very precisely).

2. Expensing is hard to administer equitably, because there are many new, small, marginal firms with no outside income from which to deduct their capital outlays. How to treat such firms? None of the options is wholly satisfactory: If we deny them any tax credit, then only giant diversified firms can benefit. If the Treasury advances them cash, it must lend without security and to almost anyone as a matter of legal right, a dubious prospect. If we let them carry forward their deductions until they have other income, we are denying them interest on their investment, which is the essence of the expensing feature. If we let them

carry forward deductions with interest, the rate would be the same for all taxpayers, an advantage to the stronger firms whose insular individual rates (i.i.r.) are lower. Worse, we would be guaranteeing a fixed tax-free return on all investments, however ill-advised, however filled with graft for the taxpayer.

3. At high tax rates a serious incentive problem arises after the taxpayer has recovered his capital tax-free, with or without interest, because all income above that base would pay a high rate. The overage is supposed to represent economic rent, but when we tax even economic rent on a realized-cash basis we motivate taxpayers to convert cash income to psychic income. The critical value, the maximum economic rent, is much less sharply defined when the taxpayer keeps only a small fraction of it.

A bumbling manager on superior land would show little net income over costs, including his and his nephew's inflated salaries and overpriced supplies from his brother-in-law. Thus land rent, which we set out to tax, would be diverted to private pockets or dissipated by incompetence; while the high tax rate, aimed at rent, would instead capture the fruits of superior management. The leverage is applied backwards. If a tax is to motivate men it must let them, and not the Treasury, retain most of the marginal cash flow above a fixed basic charge.

The proposal would in effect amount to an original lump-sum grant, to encourage prospecting and developing, followed by a stiff tax on gross income (net of operating costs, usually minor compared with capital costs). Following initial investment, the taxpayer would suffer under all the defects of a severance tax, or Ricardo's "tithes." Only the rate would have to be much higher than a tithe: even higher than the present 50 per cent, to compensate for the loss of revenue by permitting expensing.

To avoid demotivation, the annuity approach outlined earlier might contain the germ of an answer. In effect, it could put the income tax partly on a putative basis and give it some of the quality of the property tax, based on expert and free-market appraisal of resource capacity.

4. The personal income tax hits labor and management income, of course, as well as property income, and it would require much more than expensing of capital costs to convert it into a tax on land rent.

The corporate income tax hits only property income, since management is salaried and deductible. But it fails to tax unincorporated

owners, however wealthy, and it also exempts the income of corporate bondholders.

5. If payments for land are not deductible, and productive investments are expensable, taxpayers will seek to disguise the former as the latter. To overcome that, Treasury agents would have to show more insight than they do today in the analogous case of preventing urban real estate owners from assigning most of the value to depreciable buildings when it is really non-depreciable land value.

6. Changing the income-tax basis for going mines would pose a formidable transition problem because of all the old records of capital outlay that would be required to establish the investment history.

The major advantage of the income tax over the property tax is jurisdictional, thanks to the Sixteenth Amendment. The federal government can also tax property, and actually has done so at least five times in American history, but the levy must be apportioned among the states by population, a weakening limitation. The income tax may also capture some income from foreign holdings of United States nationals and corporations, but the deductibility of foreign taxes limits that, perhaps completely, perhaps more than completely. It may even be that United States firms lower their United States taxes by deducting overseas costs destined to generate foreign taxes — a pregnant topic for future research.[45]

A modified property tax has a better chance of being administered so as to be neutral or better. The modification from present practice is to exempt capital improvements, leaving the pure *in situ* resource value as the base. Based on resource capacity rather than the performance of individual men, this tax avoids demotivating post-discovery production as an income tax, however well-intended, will. The present question is, will it demotivate discovery itself?

Under conditions where discovery creates tenure by closing previously open access, discovery creates taxable property where there was none — from primordial chaos, so to speak. A property tax is then a tax on discovery. But that is a virtue because under conditions of open access discovery is otherwise overmotivated, as we have seen. The prop-

[45] President Kennedy's budget message of January 1963 urged blocking "the deduction of foreign development costs . . . to reduce the U.S. tax on their domestic income." Foreign taxes are credited in full against U.S. taxes — i.e., not simply deducted from taxable income but from the taxes themselves. See Philip Stern (*40*, p. 30).

erty tax discriminates among forms of tenure exactly in the manner that is needed, and does it inherently because the tenure instrument itself is the tax base. Thus it solves a problem which baffled us under the income tax.

Given perfect pre-discovery tenure, on the other hand, the property tax may be made substantially neutral in most circumstances by imposing it on pre-discovery "leasability" values, previously discussed. Perhaps "pre-" and "post-" discovery are oversimplified concepts. "During" discovery is more meaningful, for discovery is usually a gradual process. The tax assessor, by following the simple rule of keeping up with market values, administers a tax that rises gently with the prospects of a field during a protracted period of study and revelation of its detailed anatomy.

As experience brings ever sharper detail of a field into ken, the property tax on the barren properties drops and on the fertile ones rises, keeping the total about the same. That kind of administration of assessment would make the property tax virtually neutral towards prospecting. No doubt it will fail to be perfectly neutral, but no tax should be compared to perfection for that is not a real alternative. Other taxes are the alternative, and none other is so likely to approach neutrality.

The sum of experience in a field, the production and prospecting of many independent people, may raise or lower the earlier opinion of its capabilities and so raise or lower the value of the tax base. The effect is so diffused and remote from the activity of any one person, however, that it would not normally deter exploration. To the extent that it would, in special circumstances, it merely introduces into the property tax a small element of fiscal risk- and profit-sharing to temper its high leverage effects. Some people seem to prefer that in any event.

It may no doubt occur that random prospectors on land of no known mineral content will strike rich minerals. Should these finds then pay a property tax? There is no easy answer nor is any perfect solution likely. But as a general rule, the biases toward excess exploration work strongest on fringe or marginal lands, so taxing such strikes may do less harm than good.

So the *in rem* property approach to resource taxation has a basic soundness lacking in the realized cash income approach, and warrants heavier reliance. In addition to its basic merit it offers several advantages.

First, it applies leverage prompting landowners to behave more economically, somewhat as would the interest on a heavy mortgage.[46] Unlike the tax on realized cash income which blurs critical values at high tax rates, the property tax accentuates and sharpens their definition to the taxpayer. Let us note some of the ensuing benefits:

1. Leverage on surface landowners, where mineral rights go with the surface, overcomes the resistance that backward-looking traditionalists sometimes offer to any change of land use. Under an equally high tax rate on cash income, landowners might frequently prefer the psychic security of their older ways. In less-developed countries, and anywhere where much of the land is closely held by absentees too affluent or dissipated or military to be enterprising, this factor can be crucial.

2. Applying leverage will result in more compact fields and lower collection costs. Lease values have a strong location element.[47] Forcing development in existing fields served by existing lines, and near markets cheaply reachable by new lines, will save large line costs.[48]

To the extent that mineral location determines community location such savings are multiplied in all community costs of overcoming space. The isolation that curses many mining camps and towns will be considerably relieved.

3. Marginal resources will pay little tax — only the amount necessary to offset and neutralize post-discovery taxes — and feel no leverage, which is desirable.[49] That lets their owners wait while the resources ripen. The leverage to produce bears on owners of superior re-

[46] Unlike a mortgage, the tax involves no repayment of principle. It corresponds to the interest on a perpetual loan.

[47] "One hundred years ago, land at the heart of the Comstock Lode sold for $10,000 a foot, but dropped off sharply. 'The remarkable descent in value of mining land was attributed to the fact that the Gold Hill miners recognized that the bonanza ore body's chances for extension into adjoining ground became increasingly less likely with greater distance from the center'" (*Milwaukee Journal*, November 15, 1964, citing the *Appraisal Journal* [*34*].)

[48] In difficult territory like Holland a gas feeder line averages $250,000 per mile (*5*, p. 97). In the Louisiana swamps it is $350,000 per mile (*4*). The Gulf of Mexico and the North Sea are also difficult territory. In the aggregate, line and other hauling costs are comparable to exploration costs. An important social cost of pipelines in settled areas is their propensity to leak and explode. The FPC attributes 64 deaths and 222 injuries to this cause from 1950 to 1965. As higher safety standards are enforced the monetary cost per mile will no doubt tend to rise.

[49] The precise detail of how to administer this policy is not supplied here, and needs to be worked out. From Figure C.4B it is evident that some of the detail could be interesting, because resources assume a value even when still submarginal for present use.

sources, prompting fructification of stagnant reserves whose value has stopped rising by a large annual percentage.

Were it not for the leverage effect, the margin of resource use would probably be extended by the exemption from taxes of improvements on marginal land. That is, present tax policies hit marginal land and thereby make submarginal some lands that will be marginal or better under a neutral tax like the one here proposed. But the leverage of the tax on superior resources might well be such as to supply the market so well that presently marginal resources become submarginal, regardless. If present markets were perfect the leverage effect would be nil and the net effect would be some extension of the margin, due to untaxing of improvements on and cash flow from marginal land. In my judgment present markets are so far from perfect that the leverage effect will on balance predominate, raising the margin.

Second, *in rem* property taxation of the value of mineral deposits tends to promote competition. To the extent that it succeeds it opens the door to great savings not just to consumers but to the industry. For a free market in ores releases each firm and other unit of interest from the need to protect its individual resource base through vertical integration, and spares all the waste and duplication that entails. It opens the way to free-and-easy interfirm cooperation and specialization of the kinds that man, the social animal, works out in an environment where survival and security are the fruits of constructive cooperation rather than avaricious or defensive acquisition.

The modified property tax promotes competition in these ways:

1. It falls heavily on the firm which seeks to control a market by cornering the ore deposits. As these are monopolized their market value rises and the speed of intended use falls. If the tax rises with the value it becomes a tax on monopoly, in effect.

One may object, the property tax has not worked that way in the past. In fact it probably has, in many jurisdictions and industries, to the extent that it has fallen on *in situ* values. But remember that we are now analyzing a property tax modified to exempt mine improvements. Today's property tax falls heavily on improvements and so hits the competitor who fructifies reserves more than the monopolist who sterilizes them. The modified tax would do the reverse, and so force the monopolist to sell to competitors, not just to get rid of direct tax liabilities but to lower the taxes on property it retains by reducing the value given it by the monopolist's artificial scarcity.

2. Small, new, marginal firms with weak credit would benefit. The tax would bring down the market price of leases to explore superior land, lessening the financial burden of entry, opening the door to large numbers of small firms.

The income tax tends to do the same, but is less effective. The immediate impact of the property tax is on landowners, holdouts who have not yet signed leases. Lease prices fall thanks to increased supply more than reduced demand. The income tax, on the other hand, lowers lease prices by lowering what buyers will pay, a less stimulating process. With expensing of exploration costs, it might take some time for the depressing effect of higher anticipated post-discovery taxes to work its way through to lease prices. Some of the gain intended for prospectors might leak away to landowners.

Either tax, however, ranks high in this respect and is preferable to no tax at all, even if the taxes be not needed for public spending – if inflation, for example, be the alternative mode of public finance.

3. Large mineral owners would lose much of the differential value of their holdings as a credit base. It is through the mechanism of credit rationing that the land giants gain much of their market power. Focusing taxes on superior lands tends to equalize credit ratings. Owners who create real capital to speed the rate of recovery would enjoy better credit with taxes removed from real capital.

4. Giant landowners would lose much of their power to engage in extinction pricing. A tax on rent tends to remove the cushions of surplus income and assets from supramarginal firms and lessen the differences of reserve power among firms. Thus the giants lose their power to discipline competitive firms by losing some of their superior power to absorb losses. The giants also lose much of the high rental income which they plow back into expansion, something which modern income taxation prompts them to do as a primary method of tax deferment.

5. The tax hits old and new firms impartially, in contrast to the income tax, which is hard on new firms which lack outside income from which to deduct early losses.

A third advantage of the property-tax approach is greater ease of transition. There is no need to reconstruct histories of past outlay. The tax is based simply on present value capitalized from anticipated income. The evidence is always at hand.

The problem of hyper-accelerated liquidation during a period when voters are debating tax increases should not be severe under the modified

property-tax approach. On marginal land, where acceleration would be most uneconomical, no tax is to be levied so there should be no effect. On superior land, acceleration over a few years would very likely boomerang on the owner by giving the assessor an inflated idea of a mine's capacity. Remember, too, that acceleration would entail heavy irreversible investments in mine improvements, which improvements and their cash flow would themselves be taxable in the event the present proposal to limit the tax base to *in situ* values be rejected. Remember, finally, that acceleration would lower spot prices and brake itself. All told, it is neither a likely nor a disastrous outcome.

A difficulty in property taxation is assessment. The details of that art warrant another volume and cannot be elaborated here, but to observe that most of the art is simply to follow the market, which sets values in the course of business.

A great disadvantage of the property tax is jurisdictional because, as mentioned, federal use of the tax is constitutionally unwieldly. It is available to states wishing to accelerate their economic development, but on the whole in recent years state governments have proven cartel minded. In oil and gas it is especially obvious that state governments are active and essential partners in the cartel. Their property-tax policy of focusing on improvements what little tax there is appears as simply another arm of a set of policies to restrict output.

A solution to that is at the federal level, however, and analytically quite simple. The cartel of mineral-producing states of the Union needs to be relieved of its privileged control of the American market by free import of foreign minerals – crude oil, tungsten-molybdenum, silver, or what have you. In the revival of competition that would result, state governments would find economic development more to their advantage than cartel deportment and would break ranks, to the benefit of consumers, workers, investors, and the overall health of the economy. If the suggestion seems too large-minded for American politics, recall that mercantilism, surely a small-minded philosophy, traditionally welcomes the import of crude raw materials. It is their export which stamps one a colonial.

On the principle that rank-breaking is cumulative, all policies helping to promote competition might be enlisted. Citing oil as one example, another obvious federal move is to repeal the Connally "Hot Oil" Act whereby federal power undergirds state restrictions on free oil in interstate commerce – one cannot but recall the Fugitive Slave Law and the

Dred Scott Case—and in its place to subject state governments and their agencies to the antitrust laws. The 1943 Supreme Court declined to interfere with state prorates,[50] but dropped a broad hint: ". . . Congress could, in the exercise of its commerce power, prohibit a state from maintaining a stabilization program like the present[51] because of its effect on interstate commerce" (*36* at 350). The 1943 Court was perhaps passing the buck. Injunction of illegal acts is a judicial function. The modern Court has acted more decisively in several fields when the public was ready.

The pace at which state and federal lands (primarily offshore) are released to commerce should also be subject to the scrutiny of the FTC and the Antitrust Division. Without extensive evidence it seems a reasonable inference that states which limit private production to market demand (at the seller's price) must also hold back state lands;[52] and a Congress which restricts imports and supports the Hot Oil Law and excessive stockpiling would hold back federal lands and stifle Bureau of Mines research. In fact it is Interior Department policy, based merely on the Secretary's discretion, to abide by state-decreed allowables for production from offshore oil lands! A voter-supported demand for investigation and reconsideration of our disposal policy could illuminate the matter brilliantly, and get results.

By this time it is obvious that I conclude on the whole that outright government ownership is less desirable than property taxation. Governments own so much that they almost always administer their holdings monopolistically, however enlightened they may be in other ways. Alberta is the supreme achievement and the supreme disappointment of government ownership of minerals. It is just another member of the world cartel, limiting production to market demand at its price. The Dutch Government, which also owns mineral rights, is equally or more disposed to restrict output. The Organization of Petroleum Exporting Countries (OPEC) is currently trying to prevent private oil companies

[50] See Parker *v.* Brown 317 U.S. 341, 63 S. Ct. 307 (1943) (*36*). I am indebted to Stanley Hack, Attorney, for calling this to my attention.

[51] The program at bar was the California Agricultural Prorate Act, originally of 1933.

[52] California's East Wilmington field off Long Beach was held back until 1965, by which time it had become "the richest known untapped field in the world, and by all odds the most handily situated . . ." (*Business Week* [*5*, p. 36]). There were special reasons—but aren't there always? In Alberta, which owns most of its own mineral rights, land-disposal policy and production limitations are completely integrated into one system.

from cutting prices. The historical record of governments as landowners is such as to lead us to expect no better future performance, unless some revolution in economic education fundamentally improves the behavior of administrators and legislators.

Where public lands are mixed with private, owners of the latter bring pressure to underutilize the former and maintain artificial scarcity.

Another common weakness is that of setting rents below the market for the benefit of politically influential lessees, as on the federal domain.

A third weakness is that of falling under the spell of irrational ideologies and slogans related to conservation, with overbalanced emphasis on one aspect. Thomist-Marxist-Keynesian anti-usury bias often takes sway. It dovetails nicely with the needs of monopolists, and makes the slowest, least enterprising policy seem the height of "efficiency" while an economical sense of urgency appears the most unseemly myopia and greedy fast-buck profiteering.

Minerals in the earth have some unique economic traits. Unlike other land they disappear with use into the sink of time. And they originate in the limbo of future time, unknown and unowned.

Each trait poses tax problems and has solutions. Countervailing taxes on property value and on severance assure an economical timing of extraction; countervailing pre- and post-discovery taxes on *in situ* property values assure a correct timing of discovery. Even the political problem will be soluble when economists arrive at a working consensus among themselves and offer the world consistent counsel.

The Share of Rent. In spite of the tendency of many policies to dissipate economic rent, a large share of the cash flow in mineral industries represents rent.

One indicator of that is the very high rate of business "profit" per sale typically reported by minerals firms. In *Fortune's* annual ranking of its "500" by this criterion, mineral firms cluster at the top (*11*). Combining some accounting practice and economic theory, that means that minerals firms have low explicit costs per dollar of sales. Business "profit" stems from the implicit input of owned resources, in this case largely rich minerals. The fact is more striking when we consider that these firms may understate their profits by writing off capital investments twice or more by expensing and percentage depletion.

Explicit mineral rent generally takes three forms: lease acquisition "bonus," paid usually before major exploration; annual lease "rental," paid until production begins; and "royalties," a share, usually one-

eighth, of wellhead value. Professor Alfred Kahn has estimated that from 32 per cent to 38 per cent of the value added by the oil industry represented rent, in 1959–60 (*26*, p. 290). Professor Paul Davidson puts it even higher, as "the major costs in oil exploration and development . . . ." (*8*, p. 103). Kahn criticizes Davidson for simply adding together royalties and bonuses, overlooking their different time-distributions (*26*, p. 291, n. 12). It is true that royalty dollars tomorrow weigh less than exploration dollars today, which is Kahn's point. But on Davidson's side, the lease bonus is paid well before the cash flows back in, as well as before exploratory drilling. Those are heavy dollars. Not only is the lessor paid first in time, but he is paid hard cash, leaving risk to the lessee. Lease rentals, again, are paid annually during the years before production begins. If, therefore, one reckons bonuses and rentals as a share of cash flow, the different time-distribution magnifies the former relative to the latter. It is not clear from Kahn's note just how he treated this, but it gives the impression he was more concerned to adjust his estimate of rent downwards for the lateness of royalties than upwards for the earliness of bonuses and rentals.

So if Davidson's treatment of time-distribution overstated the rent share it is also possible that Kahn overcorrected him, and further refining would raise the estimate. But in any event the rent share is a very high one. And mark that "rent" here means pure land surplus net of discovery costs.

Davidson also raises the vital question of implicit rents that are not reported as rents. He points out that royalty shares are subject to some bargaining in the original lease contract when the *ex post* richness of the deposit is still not exactly ascertained. Lucky lessees whose leasehounds secure rich deposits for low royalties collect some implicit rent. Their opposite numbers who overbid, on the other hand, do not pay more than the *ex post* rent as a royalty, for they are simply blocked from producing at all until the royalty is renegotiated downwards.[53]

More generally, there is no reason to assume that all or even most mineral rent is explicit. Many firms and individuals simply develop their own land. If Kahn's estimate omits, as it seems to, implicit rent, the true rent share is much higher even than the high figure he gives.

[53] Davidson's "Reply to Campbell and Steele" (*9*, p. 128). The point is curiously at odds with his reaffirmation on the same page that a negative royalty (percentage depletion) will not encourage production. But later on (p. 130) he seems, more consistently, to modify this position.

Again, some rent is now publicly collected by property, income, and severance taxes — Louisiana, for example, takes 1/6 — which makes it no less rent.

In rich fields the bonuses paid are legendary. Hanson cites over $20,000 per acre as a high in Alberta (*21*, p. 192) with a 1956 (a high year) average of $1200 per acre in proven areas.[54] Kahn cites average bonuses of $233 to $2267 per acre in auctions for offshore Gulf lands in 1959–62, with a royalty of 1/6 (*26*, p. 291). Considering that 19 per cent of the United States is under lease (*7*), the sum of payments is substantial.

Another indicator of mineral rents is the wealth and success of those governments which have seriously sought to socialize mineral rents. Alberta, Kuwait, Saudi Arabia, Venezuela, and even California (from offshore lands) absorb high shares and enormous sums from oil producers without seeming to repel them. One half of net has become a sort of international rule of thumb, generally regarded as too favorable to the major producers, who have made it a defensive line that is under constant pressure. Competitive bidding in California shot the East Wilmington lease up to 94 per cent of net — probably an all-time high, but much would depend on the detailed definition of "net."

It is probably significant that so many economists who write about oil give much more play to the concept of rent than it gets in most other current literature. Davidson, Kahn, and Wayne Leeman are conspicuous. Leeman did not even set out to include the production end of the business, but was finally drawn to it regardless. (This statement is based on discussion with Mr. Leeman. Also, see his *The Price of Middle East Oil* [*27*].) Rent simply looms so large in oil and other minerals that an economist cannot overlook it.

Comparing mineral rents and urban rents, the latter are also high, as reflected in unit values. But the urban rents are a much lower share of gross. A new building outvalues its site by 3 to 10 times, and the turnover in commerce is so high that rental of building space may run at 2 per cent or 3 per cent of gross. Only in old slums does land rent take the lion's share of gross. But even a new oil well pays the lessor at least 12½ per cent, plus prior bonus and rentals, and the oil lessee supplies the capital improvements including exploration costs, dry holes, and bonuses and rentals on leases that prove unproductive.

Agricultural share leases run higher than one-eighth. The standard

[54] At Mt. Gilead, Ohio, $30,000 an acre has been reported for one-acre leases.

is 50 per cent in a few prime counties; one-third is a floor rarely breached. But there are no prior bonuses, and the landlord supplies buildings and some other capital. Farm tenants are very credit-needy compared to oil lessees. The dilution of tenant incentive is offset by leasing more land to better tenants. And there is nothing universal about the 50 per cent rule. On less than prime land the landlord's share is lower. (For a good basic source see F. J. Reiss [*38*].) On mediocre and marginal land, sharecropping simply is not practiced, because too much of the small surplus would be eaten up by the costs of the landlord-tenant relationship. It is questionable if the mineral landowner's share is greater than the farm landowner's in Champaign County, Illinois; but there is no question that it is a much larger share than society now recoups by taxation.

Yet another indicator of high mineral rents is the ineffectiveness of the 50-per-cent-of-net limitation on percentage depletion. What other industry could take full advantage of a tax provision letting firms deduct 27½ per cent of gross where that does not exceed 50 per cent of net income? McDonald cites a Treasury sample study of large oil firms showing they succeeded in deducting 26 per cent of gross under this provision (see p. 270, n. 6). Evidently their net is high relative to gross — a point, indeed, which is McDonald's major theme, and which he has convincingly demonstrated in several prior works that he cites.

What is true of the oil and gas industry may be even more true of other mineral-extracting industries whose discovery costs are less. Recall Henry Steele's figure on how much more money is spent searching for oil than for all other minerals. With low discovery costs, the land income is almost pure rent or surplus.

It is inevitable in a progressive society that land should claim a high share of cash flow in mining. If mines are currently marginal in the sense that non-land costs would absorb all the gross, those mines are normally idle. For the net present value *in situ* being zero, any remote possibility of a better future would warrant deferring removal, the percentage growth in net value being very high. The customary acceptance of a one-eighth royalty charge suggests that many landowners do not consider putting minerals to use until they yield a nice surplus (although sliding scales which put lower royalties on poorer mines are sometimes encountered). Whether this surplus should be regarded as a form of income, and therefore "rent," or be given some new name (perhaps "hent?") is an interesting moot question. Personally, I regard

it as income, because it has appreciated from zero value, but that is not vital here. It is a surplus that can be taxed without burden, and it is a large amount.

An Overview. The most general fault of conservation policies and related tax policies today is their failure to implement the unanimous recommendation of the conferees that society should use its best exhaustible resources first.[55] Superior resources gravitate to strong financial hands whose strength consists in access to money at interest rates lower than those paid or imputed by most citizens; intertemporal allocation of resources in strong hands is made at interest rates lower than prevail elsewhere. The political strength of the strong hands often succeeds in keeping property-tax assessments on the *in situ* value of reserves quite low, minimizing carrying costs and the economic pressure to recover superior resources.

The owners of superior resources also take the lead in schemes of market control, restricting the output from superior mines in the classic and heavily documented cartel syndrome: the owners of superior resources hold a price umbrella, stimulating premature, excessive, and geographically dispersed submarginal developments. Public policy and the conservation ethic are harnessed to the service of cartels, and the details of policy repeatedly betray the public's malignant ignorance of the economics of rent. Private capital is wasted in developing submarginal resources while superior or rent-bearing resources lie in cold storage. Public capital is wasted as the political mechanism extends submarginal transportation lines as a concession to the weaker resource owners, who have numerous votes; and the regulatory mechanism prompts pipeline companies to extend service to inflate their rate bases.

Comparing states, for example, Texas leads in restrictive policies so that it had in 1963 47 per cent of United States reserves, from which it produced 35 per cent of United States crude (*25*, p. 272), whereas Wyoming and Florida, marginal producing states, have no prorate at all. Comparing nations, we restrict imports from superior Persian Gulf resources compared to which most United States oil is marginal or worse. The "Life Index" of Middle East reserves is about 100 years at present rates, compared to our 12½ years (*26*, p. 310, n. 47). Restrictive

[55] This seems to be a general pattern of resource development. "Urban sprawl" is closely analogous. So is "Cornbelt sprawl" and our whole agricultural pattern. Water development follows the same course. We consistently underutilize superior resources and prematurely invade the submarginal. See Mason Gaffney (*19*, *14*, *15*).

arrangements among the international majors dominant there also deserve part credit for the slow use of these reserves (*27 passim*).

Some marginal minerals also gravitate to strong hands — minerals that are presently submarginal but are expected to become superior. Advance survey and preemption of resources presently submarginal but potentially superior require what strong hands possess, waiting ability. Political influence is also useful. Obstacles to survey in superior regions, like subdivided ownership of mineral rights derived from surface rights, and unreasonable holdout prices demanded by well-placed lessors, help divert exploration to Ultima Thule, and the oceans, where primitive tenure conditions bring the appropriative principle and *lex fortioris* into powerful play — recall our nine reasons for premature exploration — overmotivating prospecting. Overseas, prospecting becomes involved in international rivalries and enjoys national support for political and military reasons. The lives of American conscripts, in part or in whole, become part of the public investment.

One may wonder why I stress the underuse of superior resources more than the complete non-use of marginal land, and marginal opportunities on all land. Taxes on gross products, or on improvements, tend to make marginal land submarginal, and lessen the intensity of use on all land. Prorates inflate well costs and take out marginal land and prohibit deep lifts. The reason for not stressing these effects is that they tend to be compensated by lower wage rates and lower rates of return on investment, public works that bring in submarginal land, and exemption of marginal wells from prorate. The residual waste is complex and many-sided, but has as a most conspicuous aspect the underuse of superior resources. To an extent, that means the underuse of marginal qualities of superior land, notably deep deposits, and that is indeed part of the pattern.[56] The more serious net waste is the underuse of the superior aspects of superior lands, notably highly rentable deposits whose rapid fructification is blocked.

All that adds up to a syndrome marked by wide diffusion of titillating possibilities, and restricted use of known certainties.[57] The syndrome

[56] Sterilization of marginal deposits is often avoided by sliding-scale royalty and severance-tax arrangements which put much lower user-charges on marginal deposits. Alberta, for example, sets its royalties from 1/6 on the largest wells down to 1/20 on the smallest (*21*, p. 196). That saves the marginal wells — it may even foster premature use — but the marginal units from superior wells are subject to the higher rates and are therefore used too slowly if at all.

[57] Any such formulary summary of a complex set of uncoordinated policies requires

betrays a social illness, to cure which we need attend to both efficiency and equity. Both these are served by levying heavier taxes on the superior resources, provided the taxes are designed not to retard output. Here, heavy reliance is desirable either on the neutral tax on the net income of mines, or for a more positive effect, on the ad valorem property tax based on *in situ* value.

A concern for conservation is out of place if directed against such acceleration, because it is the slow use of superior resources that maintains prices, and so hastens the high-cost looting of marginal resources.

A concern for efficiency is misconceived if directed against taxing superior firms. It is misleading to equate supramarginal firms with efficient ones. Supramarginality results from possession of great assets,

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some interpretation. There is a specious contradiction between our summary and Kahn's, but it is no more than specious. Kahn (referring to oil) emphasizes excess *capacity* (not production) in known domestic fields (not foreign), and declining domestic exploration (*26*, p. 306). These are twin children of low allowables per well and unrestricted drilling in known fields. But the capacity is not used, hence it is harmonious with our formula; and exploration outside the prorate states is not discouraged.

Inside Texas, regulation gives a favor to old, tired wells. "Strippers," which require heavy pumping and secondary recovery wells may produce continuously. The "good" public reason is "conservation" — waste not a drop of oil. The jaded observer of economic institutions will not overlook, however, the evident preference to old-timers (although this is tempered by exempting discovery wells for a maximum of 18 months). This fits our syndrome in that marginal production is favored over supramarginal, although in this case there is no "diffusion of titillating possibilities." Prolonged worrying of exhausted submarginal deposits is certainly not interpretable as "intensive" resource use. It is *persistent* use, but intensity refers more to the *speed* of removing crude when it is supramarginal.

The general effect of a low monthly allowable is to increase the industry's well costs. If 7½ days are allowed, it takes four wells to do the job of one. That, in turn, discourages particularly the search for and development of deep oil, where well costs are a high share of total. Remote, shallow oil on the other hand is encouraged (by the price umbrella, etc.). The bias is against intensity in the third and fourth dimensions. Horizontal hauling is not penalized — we have seen it is often subsidized. Vertical lifting and prompt recovery are penalized. Here again is the "diffusion of titillating possibilities." Intensive deep development and intensive fast use are estopped; extensive shallow lateral wandering is encouraged in their place.

Alberta, Texas, and some other jurisdictions give higher allowables to deeper wells, tending to compensate for this bias (*21*, p. 204). Percentage depletion, a federal institution, is based on the well*head* values, and thus helps deeper wells. Louisiana allows more to offshore wells but that is probably a concession to high collection costs as much as well costs. Given the rigidities of public regulation I doubt if the device can compensate accurately. Where pushed too far it leads to another absurdity, lifting deep oil up past idle shallow pools. And basically, of course, even if perfect, it presupposes the more general absurdity of prorationing itself.

usually superior natural resources. Supramarginality, far from connoting efficiency, lets a degree of inefficiency go undetected or uncorrected. Firms which are truly marginal must be 100 per cent efficient or expire.

Taxation focused on ownership of superior resources, therefore, is not the taxation of efficiency. On the contrary, it makes supramarginal firms more marginal and forces them to higher efficiency. As Professor Kahn writes, we can have an "allocational optimum accompanied by heavy taxes on the rents" (*26*, p. 297).

By the same token, taxation of extractive industries is not necessarily taxation of natural resources as such. The resource value of marginal mines is zero – taxes that hit them are taxes on labor and capital. To collect more taxes from natural resources, therefore, does not mean moving tax burdens to extractive industries. It means moving tax burdens from marginal lands to superior lands in all industries – a radically different notion.

As to equity towards owners of marginal resources, that is met by supporting government from the rents of superior resources, and met more efficiently than by subsidizing the uneconomic development of submarginal resources as we do today.[58] It achieves equity in a much broader sense than present policy, because it is equitable not only towards the owners of submarginal resources, but also towards the other 99 per cent of the population, who are frequently not considered in discussions of distributive equity among different resource owners. *In situ* taxation also promotes equity and efficiency by lowering capital barriers to entry into resource-based industry, and helping the competitive economy work better.

Envoi

Some of these policy suggestions may have early political possibilities. Many of them do not, but that should not affect their appraisal by economists. No idea that is truly new will be politically acceptable for a number of years. Society does not – or should not – support an estab-

[58] Wayne Leeman discusses at some length the international aspects of this proposal in the Middle East (*27*, pp. 253–57), where the Pan-Arabian socialization of Kuwait, for example, by the U.A.R. under Nasser, is a very real possibility. The international majors rationalize their high returns in the Middle East by citing losses elsewhere, but he doubts if they possess the "moral authority" to act like a world government. One also doubts if a world government should choose the method of waste as the vehicle for redistributing economic rents.

lishment of economists to advise the crowd to do what it is about to do anyway; and economists do not – or should not – accept a role as either hired guns or consensus-takers. Economists who think the profession should try to assert some social leadership will, I hope, find the above ideas worth entertaining.

Anything worth doing is, of course, "politically difficult" or "impossible." Only banal, myopic, timorous, corrupting proposals seem to earn high marks from the seers of political expediency. I suspect they do the American people an injustice, difficult though that may be. Academic need not remain synonymous with irrelevant. Intelligent policies, patiently detailed, realistically developed, and imaginatively expounded are surprisingly, remarkably viable. They stir the imagination of dedicated men and enlist unsolicited support from the most unexpected and influential quarters. It is not always necessary to indulge the primitive, to cater to peasant avarice and anxiety, or cavalier prejudice and passion. People have been known to respond to appeals to their public spirit and enlightened self-interest, and to appreciate the implied compliment. People have been known to lose patience with the plaintive demands of sheltered interests, especially when there was something better available. In that spirit it is not unrealistic to speak seriously of policies calculated to enhance the general welfare.

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Appendix

Rent Under the Assumption of Exhaustibility

LEWIS C. GRAY

IN the infancy of economic science rent was distinguished from other forms of income as the periodic return from the use of land. And because land itself was regarded as one of the great agents in production, the existence of a peculiar type of income attributable to it appeared particularly suitable.

This complete correlation between rent as an income and land as its source was not destined to continue. In the England of the classical school rent was usually a form of income which seemed to leave the basis of income unimpaired. Year after year the landowner might receive a substantial return without decreasing the capital value of his investment. It is not strange that the imperishability of the basis of rent came to be considered an essential characteristic of rent as a form of income. It became necessary, therefore, to define anew the basis of rent so that it might conform to this preconceived essential characteristic of rent itself. Accordingly Ricardo modified the economic concept of land as the source of a rent payment, and introduced the

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assumption that rent is a payment for " the original and indestructible qualities of the soil." Later writers have interpreted Ricardo's criterion of land more rigorously than did Ricardo; and after passing through a process of gradual refinement, the Ricardian assumption has been reduced to its extreme form in Professor Commons' conclusion that the property of extension is the essential quality which distinguishes land from other kinds of goods and constitutes the basis of rent.[1] Thus the concept of land as the basis of rent has been gradually reduced to an abstraction.

A practical man might well ask why it is necessary to develop an elaborate and peculiar doctrine to explain the value of the services of natural agents when by very assumption a large part of natural agents are excluded from the scope of the explanation. Why must rent be a payment for an original and indestructible property in order to be rent ? The question is a part of the long continued dispute as to the desirability of distinguishing land from capital, and rent from other forms of income. It is not necessary, however, in this connection, to wander so far afield. This question may be disregarded if it can be shown that indestructibility is not a characteristic which separates rent from other forms of income. The ground will then be clear for a reconsideration of the rent theory under the assumption of exhaustibility.

In one sense there is no basis of rent which is imperishable. For there is no conceivable basis which might not lose its utility, and therefore, its ability to yield a rent. A change in social demand may cause even the property of extension to lose the ability to yield a rent. However, it may be alleged with justice that the word *indestructible* has been employed by

[1] Professor Marshall seems inclined to a similar view, altho he has not come out unreservedly in its favor. Principles of Economics, 5th ed., bk. iv, chap. ii, sec. i.

Ricardo and his followers in quite another sense: in the sense that the use for which rent is paid does not cause the impairment of the basis of rent. In this sense the basis of rent may be indestructible. The clearest illustration is urban land. In the case of agricultural land also it is frequently possible to isolate the income attributable to the indestructible properties. When the elements which are exhausted are economically replaceable, the expense of replacement determines the value of the exhausted elements; and the remainder of the total surplus may be considered the rent of the inexhaustible properties. In many cases, however, it is not possible to isolate the returns assignable to the indestructible properties. In the case of mines, for intance, it is impossible to separate the value of the exhausted properties from the value of the inexhaustible properties. It is easy to determine how much the capital value of a coal mine is reduced by the process of use. But this capital value is nothing more than the present value of the surplus income from the mine during a period of time, — that is, the present value of the total rent which it will yield, — and this rent consists of two indistinguishable elements: the return for the coal used up and the return for the site value of that coal. A similar impossibility exists in the use of agricultural land when it is more profitable to exploit the soil than to conserve it: for instance, under frontier conditions.

It seems clear, then, that under the Ricardian assumption rent may be referred to a small part only of the total category of natural objects. Moreover it is frequently impossible to distinguish rent from the income of the destructible elements. These facts appear to justify an attempt to alter the Ricardian statement of rent in such a way as to avoid the necessity of assum-

ing that rent is paid only for the " indestructible qualities of the soil."

Exhaustion consists either in a change of place or in a change of form. Coal may be removed from a mine and continue undestroyed. In this case the exhaustion is merely relative to a given locality. So far as the theory of rent is concerned, it is the exhaustion with reference to a particular locality that is of primary importance whether the valuable elements are absolutely consumed or merely removed to another location.

This exhaustion with reference to location may be prevented by restoring other elements of the same kind in place of those removed in the process of utilization. Whether or not this is true depends to a large extent upon economic conditions. For instance, it is physically possible to restore a forest, but such a restoration may not pay. It is even physically possible to restore mineral that has been removed from a mine, but it is hardly conceivable that it would ever be economical. Even in the case of agriculture, the experience of the world has abundantly proven that restoration is frequently unprofitable. In this sense exhaustion may be characteristic, under certain conditions, of nearly all natural objects.

The relation of the assumption of exhaustion to the theory of rent largely depends upon the possibility of preventing exhaustion so far as a given locality is concerned. It is necessary, therefore, to consider several cases which may be presented schematically as follows:

1. Prevention of exhaustion is economical.
   (*a*) May be effected without additional expense.
   (*b*) Requires additional expense.
2. Prevention of exhaustion is not economical.

When prevention requires no extra expense, the Ricardian theory is not invalidated by the assumption of

exhaustion. The entire return attributable to land is a surplus which accrues so long as the conditions of demand and supply remain unchanged. Exhaustion occurs; but the process of restoration is merely incidental to the process of most profitable utilization. Likewise, the assumption that exhaustion is preventable, provided it is profitable to incur an extra expense for that purpose, does not seriously impair the Ricardian theory of rent. The extra expense either may be considered a part of the expense incident to the process of production or may be charged against the land and deducted from its net return. In both cases the rent, after all deductions are made, will be the same. The difference is merely one of accounting.

In those cases where the prevention of exhaustion is either impossible or unprofitable, a considerable readjustment of the rent doctrine is necessary if the assumption of inexhaustibility is to be avoided.

Under the assumption of inexhaustibility land resembles labor in the sense that it perishes through non-use rather than through use. If it is capable of furnishing a valuable service year after year, the failure to utilize it in any year is the source of loss, just as labor suffers loss from unemployment. When, however, it is assumed that the benefits that may be derived from the natural object are exhaustible and non-replaceable, the point of view is altered. The owner of a valuable coal deposit, for instance, desires to derive the maximum benefit from the limited supply which he owns. If for any reason less benefit can be derived by immediate removal and sale of the coal than by waiting until some future time, it may be profitable to postpone utilization.

The simplest condition that might produce this result is an expected alteration in the price of coal. If the price is rising and the prospect is that the rise will

continue, the owner of the mine will find it to his interest to take out but little coal in the present. This is true because the resources at his disposal are limited. Obviously this motive would not exist if the basis of income were perpetual. Likewise a lowering of the prices of those factors which enter into the expenses of production will make profitable a postponement of removal. On the other hand, a decrease of prices of the product or an increase of the prices of the factors of expense, in so far as such changes are continuous or anticipated, will create motives for rapid utilization.

Outside of mere price change, however, the owner of the mine will be moved by still more fundamental considerations. One of these considerations is *diminishing productivity*.[1] According to the Ricardian theory of rent the landowner will find it to his interest to add units of labor and capital to a given surface of land up to the point where the last unit applied just equals the product which might be derived from its employment on marginal land. In familiar phraseology, labor and capital are added up to the intensive margin of cultivation. According to the theory, such a ratio between the factors of production will yield the maximum rental to the landowner, under the given conditions. The exhaustibility of the natural resource, however, dictates a different course. The owner of the mine may well hesitate to proceed beyond the point of maximum average returns per unit of expense.[2] At this rate of removal the average net return per ton of coal is a maximum, since the average expense of removal per ton is a mini-

[1] This phrase is used to designate the decrease in product which results from the increase in the expenditure for the other factors of production applied to a given surface of land.

[2] In a strict productivity theory of distribution it would be necessary to continue the comparison of the units of labor and capital instead of substituting units of expense, since the latter assume the determination of the value of labor and capital. In the consideration of the policy of a single entrepreneur, however, it need not be seriously inaccurate to employ the more convenient and more easily illustrated idea of expense.

mum. The attempt to appropriate the coal more rapidly results in a diminishing product per unit of expense and, therefore, a diminishing average net return per ton of coal. Were the mine owner influenced by no other consideration, his interest would demand that no more coal be removed at any time than can be removed at a minimum average expense per ton. If he is willing to wait for the return from his coal, he can postpone for future removal all coal over and above that amount which can be removed at a minimum average expense per ton.

The point may be illustrated by the accompanying table, which shows the results of removing various quantities of coal from a mine during a definite period of time — one year. It is assumed for convenience that each ton of coal is worth $1.00; so that the same figures represent both the quantity and the value of the product.

TABLE I

Variations in the Net Return in the Removal of Varying Quantities of Coal in a Given Period of Time

Quantity of coal removed (tons)	Value of coal removed (dollars)	Expense of removal per 100 tons	Total net return	Average net returns per 100 tons	Increase in expense due to the removal of each add'l 100 tons	Net return of each additional 100 tons after the point of maximum net returns per 100 tons
100	100	$120	−$20	−$20	...	...
200	200	100	00	00	...	...
300	300	80	60	20	...	...
400	400	50	200	50	...	...
500	500	52	240	...	$60	$40
600	600	55	270	...	70	30
700	700	59	287	...	83	17
800	800	64	288	...	99	1
900	900	68	288	...	100	0
1000	1000	73	270	...	...	...
1100	1100	79	231	...	...	...

The figures in the table show that the minimum average expense per ton is achieved by taking out 400 tons of coal during the year. If more than this amount is removed, each ton will yield a smaller net return than if its removal is postponed until it may be effected at the minimum expense. Were the mine an inexhaustible basis of income, there would be no necessity for solicitude on account of the fact that each ton yields less than a possible maximum. The interest of the owner would dictate the extraction of eight hundred tons of coal. At this point the value of an additional one hundred tons just equals the expense of its removal.

It is necessary to turn aside for a moment to consider certain confusions which are involved in the concepts of diminishing productivity and diminishing returns as applied to mines.

Some writers have denied that a mine is subject to the law of diminishing productivity. Altho admitting that the extension of mining to other fields as well as to lower depths may be subject to diminishing return, Professor Marshall appears to deny the diminishing productivity which results from an attempt to accelerate the process of extraction by an increased application of the other factors of production to a given surface. He compares a mine to a reservoir. "The more nearly a reservoir is exhausted," he says, "the greater is the labor of pumping from it: but if one man could pump it out in ten days, ten men could pump it out in one day, and when empty, it would yield no more."[1] It is not denied that the physical possibility suggested by Marshall may occur in some cases. The probability, however, of an indefinite acceleration of the rate of removal without incurring an increased expense

[1] Principles of Economics, bk. iv, chap. iii, section 7. J. S. Mill expressed a similar opinion, but more guardedly, with respect to collieries and other such surface deposits, but not with respect to ordinary mines. Principles, bk. iii, chap. v, section 3.

per unit of result appears to be very unlikely in ordinary circumstances. Even in the case of surface deposits, such as those of the Mesabi Range, the attempt to remove the entire surface supply in a very short period would entail a much larger investment in fixed capital than would be necessary over a longer period. In the case of mines where the sinking of shafts is necessary, an increase of the rate of utilization must often mean the sinking of an increased number of shafts and the provision of a more elaborate equipment than would be required for a lengthier period of extraction. It appears fairly safe to assume that, as a general rule to which there may be certain exceptions, the law of diminishing productivity is applicable to mining as well as to agriculture.

It must be clearly understood that the term *diminishing productivity* as employed above has been used in the sense in which Ricardo used it; that is, with regard to successive applications of labor and capital to a given surface of land. The conclusion that the owner of a mine may stop short of the point where the last unit of expenditure just equals its product constitutes an exception to the modern productivity theory only when the quantity of land is measured by surface. After the quantity of coal to be removed has been determined, the ordinary statement of the productivity theory is applicable. In the removal of that coal expenditures will be profitable so long as an additional outlay facilitates the process of removal to a sufficient extent to justify the expenditure.

The influence of the rate of interest has thus far been disregarded. It is obvious, however, that the tendency for the owner of the mine to postpone for future removal all coal which would otherwise have to be removed at an increased average expense per ton is

counteracted by the fact that the present value of the return from future removal is lessened by the discount on the future. The net return from each ton removed in the present, even at an increased expense, may be greater than the present value of the same coal removed at minimum expense in the future. The basis of comparison, of course, beyond the point of maximum average net returns must be the net return from the removal of an additional quantity of coal (columns six and seven of table one), not the average net return.

TABLE II

Present Values of the Net Returns Derived from the Removal of Various Quantities of Coal at Different Future Periods with Interest at Ten Per Cent

Present Value of	No. Tons	1st Yr.	2d Year	3d Year	4th Year	5th Year	6th Year	7th Year	8th Year
The maximum average net return per 100 tons	400	$50	$45.45	$41.66 +	$38.46 +	$35.71 +	$33.33 +	$31.25 +	$29.41 +
Net return of each additional 100 tons	500	40	36.36 +	33.33 +	30.76 +	28.57 +	26.66 +	25.00	23.52 +
	600	30	27.27 +	25.00	23.07 +	21.42 +	20.00	18.75	17.64 +
	700	17	15.45 +	14.16 +	13.07 +	12.14 +	11.33 +	10.62 +	10.00
	800	1	.90 +	.83 +	.76 +	.71 +	.66 +	.62 +	.58 +
	900	0	0	0	0	0	0	0	0

Table II illustrates the theoretical method of determining the rate of utilization as a resultant of the two antagonistic factors: diminishing productivity and the discount on the returns from future removal (assumed to be ten per cent). If the total quantity of coal to be removed under the assumed conditions is only twelve hundred tons, there is no reason for the mine owner to remove more than four hundred tons a year; for the present value of the net return of the last four hundred tons removed in the third year is $41.66, whereas the removal of an additional one hundred tons in the first year will yield a net return of only forty dollars. If

the entire quantity of coal is 3,700 tons, the owner of the mine will find it desirable to remove six hundred tons in the present; for the sixth hundred tons could not be removed at any time in the future so as to yield a greater net return than thirty dollars. If postponed until the eighth year, the present value of the net return is only $29.41.

In the theory thus far presented, certain conditions have been left out of account for the sake of simplicity. In the first place, it is assumed, with Ricardo, that the landlord has the option of leasing the land to others or of using it himself. This assumes, of course, that the landlord will so adjust the contract in case of a lease that the mine will yield the maximum rent which might be derived from his own utilization. The limitations of this assumption need not be further considered here.

In the second place, the ideal rate of utilization illustrated above implies operation on a large scale in the first year, with a decline in the magnitude of operation in successive years. It will be necessary to employ a larger amount of fixed capital in the first year than in successive years. A part of this fixed capital provided for the larger scale of operation in the first year will be wasted. It will, therefore, pay for the entrepreneur to adjust his rate of removal so that the rate of utilization will be more nearly uniform. This rate will be somewhere between the two extremes represented by the maximum rate of utilization in the first year and the minimum utilization of the last year. A third modification is made necessary by the fact that in the above consideration of the economic rate of utilization substantially constant returns were assumed. No allowance was made for the possibility that the removal of coal in the first year may change entirely the condi-

tions of removal in the second year. The removal of the 400 tons may have exposed coal which is not only of a better quality but also capable of being removed at less expense per ton than the coal removed during the first year. On the other hand, the deposit made accessible by the removal of the 400 tons may be of an inferior quality and so situated that the average expense of removal per ton will be greater than for removal in the first year. This may be true because of greater depth or special difficulties encountered, such as water or gas or the thinness of the vein of coal. In short, mining is subject either to the law of increasing returns or to the law of diminishing returns or to both tendencies alternately according to conditions.[1]

The assumption of decreasing returns would not affect the above conclusions. The owner of the mine would have no motive to accelerate the rate of removal of his coal simply to get access to the less profitable coal at lower depths. Under the assumption of increasing returns, however, a more rapid removal in the present might be justified by the fact that the larger net returns from the mine are in the future and are subject to the discount. With this modification the principles of utilization as above outlined will continue applicable.

The influence of differences in the price of the product has thus far been disregarded. In an earlier part of this paper the effect of changing prices was discussed. The influence of higher or lower price levels must now be considered.

It should be noted that, were there no discount on the future, a higher price level would not necessarily change the economic rate of utilization. It might still

[1] Ricardo believed the law of diminishing return is normally characteristic of mining. Principles of Political Economy, chap. iii. On the possibility of increasing returns, cf. Taussig, Principles of Economics, vol. ii, p. 95.

be economical to extract the coal at the point of maximum average net returns per unit of coal, as determined by the physical conditions of appropriation and the expense of the other factors.

TABLE III

Variations in the Net Return of Varying Quantities of Coal in a Given Period of Time (Price of Coal $2.00 Per Ton)

Quantity of coal removed (tons)	Value of coal removed	Average expense of removal per 100 tons	Total net return	Average net returns per 100 tons	Increase in expense due to removal of each add'l 100 tons beyond the point of maximum av. net returns	Net return of each additional 100 tons beyond the point of maximum av. net returns
100	$200	$120	$80	$80	...	...
200	400	100	200	100	...	...
300	600	80	360	120	...	...
400	800	50	600	150	...	...
500	1000	52	740	148	60	140
600	1200	55	870	145	71	130
700	1400	59	987	141	83	117
800	1600	64	1088	136	99	101
900	1800	68	1188	132	100	100
1000	2000	73	1270	127	118	82
1100	2200	79	1331	121	139	61
1200	2400	87	1356	113	175	25
1300	2600	96	1352	104	204	−4
1400	2800	106	1316	94	236	−36

This point is illustrated in Table III, which is similar to Table I, except that the price of coal is doubled. The difference between the average net returns per hundred tons remains the same. The effect of the rise of price is merely to add one hundred dollars to the net return per hundred tons in every case no matter what the quantity removed. The point of maximum net returns is not changed.

Altho a higher level of prices does not necessarily compel a change in the rate of utilization when there is no discount on the future, such a discount will affect the relative merits of present and future removal, and, therefore, the rate of utilization. For under the higher prices the magnitude of the net return per hundred tons, both in present and in future, is increased by the same amount. Because of the increase in the amount of the net return the discount of the net return for a future use will result in a larger deduction in arriving at present value than before the rise of price. Consequently the future use will be relatively less desirable than its competing present use.

TABLE IV

Present Values of the Net Returns derived from the Removal of Various Quantities of Coal at Different Periods with Interest at Ten Per Cent (Price of Coal $2.00 Per Ton)

Present Value of	No. Tons	1st Yr.	2d Year	3d Year	4th Year	5th Year	6th Year	7th Year	8th Year
The maximum average net returns per 100 tons	400	$150	$136.36 +	$125.00	$115.38 +	$107.14 +	$100.00	$93.75	$88.23 +
Present value of the net return from each additional 100 tons..	500	140	127.27 +	116.66 +	107.69 +	100.00	93.33 +	87.50	82.35 +
	600	130	118.18 +	108.33 +	100.00	92.85 +	86.66 +	81.25	76.46 +
	700	117	106.36 +	97.50 +	90.00	83.57 +	78.00	73.12 +	68.82 +
	800	101	91.81 +	84.16 +	77.69 +	72.14 +	67.33 +	63.12 +	59.41 +
	900	100	90.90 +	83.33 +	76.92 +	71.42 +	66.66 +	62.50	58.82 +
	1000	82	74.54 +	68.33 +	63.07 +	58.57 +	54.66 +	51.25	48.23 +
	1100	61	55.45 +	50.83 +	46.92 +	43.52 +	40.66 +	38.12 +	35.88 +
	1200	25	22.72 +	20.83 +	19.23 +	17.85 +	16.66 +	15.62 +	14.70 +

This point is illustrated in Table IV, in which all the conditions are the same as in Table II except that the price of the product is doubled. At the original price of one dollar per ton the difference in the net return of the fifth one hundred tons in the present, as compared with the present value of the net return per hundred tons when four hundred tons is removed one year from the present, amounts to $5.45 in favor of the latter.

When the price of coal is doubled, this difference disappears and the balance is in favor of the fifth hundred tons removed in the present. For the net return in the latter case amounts to $140, while the present value of the net return per hundred tons derived from the removal of four hundred tons in the second year is only $136.36. If the mine owner has 3,700 tons of coal subject to the assumed conditions of Table IV, he will derive maximum returns from the entire quantity by adjusting his margin of utilization as indicated by the dotted line in Table IV, which shows a more rapid rate of removal than under the lower price. (See Table II.)

Altho the influence of an increase of price is in the same direction as under the Ricardian theory, the intensive margin cannot fall so far that the product and expense on the margin just coincide, as under the Ricardian theory. For, however long the period of utilization may be and however large the discount on the future may become, the net return from the removal of coal at the point of time most remote in the future can never be reduced to zero. Hence, in theory, the competition of this surplus over expense which is marginal in time must always be great enough to prevent the coincidence of product and expense on the intensive margin of present utilization.

If we turn from the consideration of the conditions which determine the intensive margin of utilization to those which determine the extensive margin, the alteration in assumption with regard to exhaustibility does not greatly change the Ricardian formula. It is likely that an extension of the margin will occur whenever such an extension is sufficient to repay the expense of removal. Altho there will be a surplus on the intensive margin, there will be no surplus on the extensive

margin. It has been suggested that while the extensive margin yields no rent, it may yield a royalty: that is, a return to cover the value of the mineral extracted.[1] It will be apparent from the above analysis that this cannot be true theoretically. The value of the coal is due to the fact that it yields a net return above the expense of extracting it: that is, the value is a result of the rent. In order that the coal *in situ* may have a value, the conditions of utilization must be such that the coal may be extracted and sold in the present at an expense sufficiently low to yield a surplus. For, except when the mine is subject to increasing returns as lower depths are reached, or unless prices are expected to change, it is impossible that future uses may yield a surplus unless conditions are such as to yield a surplus in the present. Hence the coal in the mine on the margin which yields no rent, except in the cases above-noted, has no value which could be made the basis of a charge for depreciation. In the case of exhaustible natural objects above the margin of utilization the Ricardian doctrine of rent is characterized by much confusion. Ricardo first sought to rule out all payments for minerals and timber from the category of rent. In the chapter "On Rent" he criticizes Adam Smith very severely for the assertion that the demand for timber and its consequent high price in the more southern countries of Europe, caused a rent to be paid for forests in Norway, which could before afford no

[1] Notably, Professor Sorley in an article on mine royalties, published in the Journal of the Royal Statistical Society for March, 1889; Marshall, A., Principles of Economics, 5th ed., p. 439, note; and Flux, A. W., Economic Principles, pp. 108-109. In his recently published Principles of Economics, Professor Taussig questions the assumption that marginal mines would bear a royalty charge even tho yielding no rent surplus. Professor Taussig does not attempt to prove his point. Professor Sorley bases his position upon the argument that a landowner of a mineral deposit which is marginal must have some inducement to compensate for the necessity of incurring the bad repute of his neighbors on account of the fact that a mine is an unpopular institution. This is a question of fact which need not be discussed here.

rent. "Is it not, however, evident," says Ricardo, "that the person who paid what he thus calls rent, paid it in consideration of the valuable commodity which was then standing on the land, and that he actually repaid himself with a profit, by the sale of the timber? . . . in the case stated by Adam Smith, the compensation was paid for the liberty of removing and selling the timber, and not for the liberty of growing it. He speaks also of the rent of coal mines, and of stone quarries, to which the same observation applies — that the compensation given for the mine or quarry is paid for the value of the coal or stone which can be removed from them, and has no connection with the original and indestructible powers of the land." [1]

Strangely enough, in the next chapter Ricardo develops a new doctrine. He appears to disregard entirely his previous positive denial that the return to mines or forests is to be classed as rent. His treatment of the subject is a mere extension of his previous discussion of agricultural rent without modification. "Mines," he says, "as well as land, generally pay a rent to their owner, and this rent, as well as the rent of land, is the effect, and never the cause of the high value of their produce. . . . The metal produced from the poorest mine that is worked must at least have an exchangeable value, not only sufficient to procure all the clothes, food, and other necessaries consumed by those employed in working it, and bringing the produce to market, but also to afford the common and ordinary profits to him who advances the stock necessary to carry on the undertaking. The return for capital paying no rent would regulate the rent of all the other more productive mines. This mine is supposed to yield the usual profits of stock. All that

[1] Principles, chap. ii, section 24.

the other mines produce more than this will necessarily be paid to the owners for rent." [1] Nowhere in his book does Ricardo make an attempt to explain the apparent contradiction. In fact, the law of mine rent as stated in chapter three is several times reasserted and illustrated, especially the point that the entire net return from a mine is rent.[2]

Later writers have tried to harmonize the two antagonistic principles developed by Ricardo, by combining them. It has become customary to recognize that the return imputed to a mineral deposit consists of two parts: a rent and a royalty. This plausible doctrine has been maintained by so many writers that it is desirable to devote considerable attention to it.

The essential fallacy of this explanation of mine rent lies in the fact that the so-called royalty is nothing more than a depreciation charge which results from capitalizing a terminable series of incomes. A little attention to Böhm-Bawerk's illustration of the nature of the income from durable goods would have shown clearly that the current distinction between rent and royalty is not sound. Böhm-Bawerk has shown that when the succession of incomes is regarded as interminable, the present value of the most remote in time is nothing. The income in the present is all regarded as interest. When, however, the successive prospective incomes are terminable, the present income is divided into two parts: that is, from the entire net income in the present is subtracted the present value of that portion of the income whose accrual is most remote in time. The remainder is interest; the subtrahend is a depreciation fund, or charge.[3] It is this depreciation fund

[1] Principles, chap. iii, section 32.

[2] Notably in the discussion of the rent of woodland, chap. xii; in the chapter entitled "Taxes on Gold"; and in chap. xxiv.

[3] The Positive Theory of Capital (Smart Translation), bk. vi, chaps. vii and viii.

which has been called a royalty. In short, the royalty is the product of the process of capitalization. The business man, unconcerned with socially valid distinctions between rent and interest but desirous of keeping intact his fund of capital, charges to depreciation the amount by which the total value of the mine or farm has been reduced by utilization.[1]

To consider that the amount which is left in the present after the subtraction of the amount of depreciation is determined by the law of rent is to confuse the process of capitalization of a rent surplus with the conditions which determine rent itself. This amount which is regarded as the economic rent of the mine, as distinguished from the so-called royalty, is obviously a quantity which varies with every change in the rate of interest and with the degree of remoteness of exhaustibility. The true rent, indeed, in the present is not simply this amount; rather it is the whole surplus as determined by the difference between the gross product in the present and the expenses of production.[2] It may be said that there can be no objection to calling this depreciation fund a royalty. This is true. The objection lies in applying the term *rent* to the *residuum* after the subtraction of the so-called royalty from the total net return. For the actual amount of this so-called rent is not determined in amount by the conditions which give rise to a surplus over the expense of utilizing natural agents. It is determined mainly by

[1] Mr. J. A. Finlay, a New York mining expert employed by the State of Michigan to appraise the mines of the state for purposes of taxation, has recently used this method of capitalization in the valuation of Michigan mines. An account of the appraisal is published by Mr. Finlay in the Engineering and Mining Journal for September 9, 1911, p. 488.

[2] In the article on mine royalties already referred to, Professor Sorley recognizes the identity of rent and royalty so far as mines above the margin are concerned. As already pointed out, he attempts to show the existence of the royalty in the case of marginal mines. Professor Sorley does not attempt to explain the nature of this royalty.

the process of capitalizing such a surplus. Only indirectly is the surplus responsible for the size of this pseudo-rent, as the whole may limit the size of its parts. Inasmuch as the removal of all coal in the present, beyond the point of maximum net returns per unit of coal, is subject to the competition of future uses; it might be considered that the value of all coal extracted beyond this point is subject to an opportunity cost measured by the present value of the net return which would be derived from the coal if extraction were postponed until the future. Even this opportunity cost does not represent a value of coal in addition to the rent surplus; for the entire surplus in the present is none the less a real surplus merely because a smaller return in the future could be derived from the same coal by postponement of utilization.

The relation of mine rents to price has naturally been the subject of much confusion. Generally speaking, modern writers who have given attention to this subject have taken the position that royalties " enter into price " although the so-called rent of the mine does not. This position is maintained on the ground that the royalty is a capital fund which must be remunerated in order to induce the owner of the mine to employ it productively.

It is now generally recognized that the old idea that rent does not " enter into price " does not imply that rent may not be a determinant of relative prices. The question, then, of the relation of royalties and of rents amounts to this: are they forms of income which are disposable ? If they were partly or entirely taken by taxation, would the supply of land be decreased ?

In this sense a royalty may " enter into price " under certain conditions, and under other conditions it may not enter into price; but in no case is its relation to

price attributable to the fact that the royalty is capital which must be replaced. The entire pseudo-rent and nearly all the royalty might be taken without causing the mine to fall below the margin of utilization. For, since the royalty itself is a part of the total surplus, the owner would be foolish to abandon his mine so long as any surplus is obtainable. What will happen is that the *residuum* of the old royalty will be recapitalized and divided into a new royalty, and a new rent. The actual amount of each will be determined by the conditions of capitalization.

It does not follow, however, that a tax on the mine will in no way affect the supply of the product placed on the market in the present. Such a tax may disturb the relation between present and future. It has been shown that the tendency is for the rate of utilization to be so adjusted that the present value of the marginal uses in present and in future are just in balance. Much, therefore, will depend on the manner in which the tax is applied.

An annual tax on the value of the mine, provided the tax is expected to be permanent, will increase the tendency for the mine owner to remove the coal in the present rather than in the future. For, since the mine must pay the tax as long as it is operated, the tax may be evaded by increasing the rapidity of exhaustion. This will be true even if all of the so-called rent and a part of the royalty is taken by the tax. Far from preventing the mine from being utilized, it will actually increase the amount of coal placed on the market; and if demand is constant, will probably lower price.

On the other hand a tax upon the annual surplus from the operation of the mine, even if it is so heavy as to take more than the pseudo-rent, will not create an inducement for the mine owner to alter the adjust-

ment of utilization between present and future. If the rate of extraction is already adjusted upon the most profitable basis, nothing will be gained by postponing until the future, coal that will yield a greater net return in the present. For the tax can be avoided only to the extent that the surplus return is reduced, and the loss in surplus must always be greater than the saving in the tax. The effect of such a tax is to take a certain share of each dollar of surplus whenever it appears, whether in the present or future. The tax can only be evaded by losing that part of the dollar which remains. This is true on the assumption that the tax is regarded as permanent. Of course, in any case, if the tax is regarded as merely temporary, the tendency will be to transfer as much as possible of the process of production to the future.

In the case of a tonnage tax consisting of a fixed amount per ton, the balance of motive between present and future will probably be affected in such a way as to encourage a slower rate of utilization, and the postponement of a greater amount of coal for future extraction. If, previous to the levying of the tax, the marginal net return from coal to be extracted in the present is in equal balance with the present value of the marginal net return from future uses, the tax will reduce the net return of a given quantity of coal which is on the margin of utilization in the future less than it will reduce the net return in the present. This is true simply because the future tax is discounted. For instance, suppose that the marginal present use yields a net return per ton of one dollar while a competitive future use twenty years from the present will yield a net return of two dollars per ton, the present worth of which is one dollar (assuming a discount at five per cent). A tax of ten cents per ton will leave the net

returns of present and future ninety cents and one dollar ninety cents respectively. The present value of the future coal, however, is ninety-five cents instead of ninety cents, indicating the probability that a lower rate of utilization will be adopted.

The consideration of the incidence of taxes on mines makes clear the fact that the royalty is not a necessary part of supply price. The entire rent and part of the royalty may be taken without affecting supply provided it is done in such a manner that the relation between the net returns from present and future production are not disturbed.

It will now be apparent that of the two solutions which Ricardo applied to the problem, the idea that the rent of a mine or forest comprises the entire surplus above the expenses of production is the more nearly correct explanation. At the same time, Ricardo was not justified in extending his theory of rent to exhaustible natural agents without modification, especially when the rent-bearer is exhaustible and non-restorable. For the location of the internal margin of utilization is determined by the competition of present and future uses rather than by the coincidence between product and expense. Consequently the rate of interest exercises an important influence in determining the location of the internal margin. On the other hand, the price level of the product has substantially the same influence upon the rate of utilization as under the Ricardian assumptions. Moreover, there is no alteration in the method of determining the extensive margin; altho, when the comparison is between surfaces, the intensive margin does not coincide with the extensive margin.

These modifications do not necessarily nullify the conventional statement that rent is the difference between the product of a given amount of labor and

capital applied to good land in the most profitable way and the product of an equal amount of labor and capital applied to marginal land. It is only necessary to give a special interpretation, as above, to the phrase "*in the most profitable way.*" However, the traditional division of the net return from exhaustible natural resources into a rent and a royalty is justified only as a method of capitalization. The real economic rent of such resources comprises the entire net return from the rent-bearer, including the so-called royalty.

Index

Extractive Resources and Taxation
edited by Mason Gaffney
(The University of Wisconsin Press, 1967)

Correction to page 99, second line from bottom of text:
for rameter(s) that optimize the criterion (preference) function. If the
read rameter for a succeeding period) can be determined by analytical

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On page xii, the name of Lewis C. Gray should be associated with the Appendix which follows it, not with the Editor's Conclusion.