Extractive Resources and Taxation

Proceedings of a Symposium Sponsored
by the Committee on Taxation, Resources,
and Economic Development (TRED) at the
University of Wisconsin-Milwaukee, 1964

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EDITED BY

Mason Gaffney

The University of Wisconsin Press
Madison, Milwaukee, and London
1967

Published by the University of Wisconsin Press
Madison, Milwaukee, and London
U.S.A.: Box 1379, Madison, Wisconsin 53701
U.K.: 26–28 Hallam Street, London W. 1

Printed in the United States of America
by the North Central Publishing Company
St. Paul, Minnesota

Library of Congress Catalog Card Number 67-20755

To Weld S. Carter, master of friendly persuasion, who so gently inspired the series of conferences that fostered this book; who sustained its editor through the conclusion; and who continues along his constructive way; the editor affectionately dedicates this volume, confident that every contributor will applaud the choice.

Contributors

B. Delworth Gardner
Professor of Business Economics
Director of the Center for Social Science Research on Natural Resource Problems
Utah State University, Logan, Utah

Orris C. Herfindahl
Senior Research Associate, Resources for the Future, Inc.
1755 Massachusetts Avenue, N.W., Washington, D.C.

John D. Hogan
Staff Economist, Northwestern Life Insurance Company
Lecturer in Economics, University of Wisconsin-Milwaukee
Lecturer in Managerial Statistics, Marquette University
Milwaukee, Wisconsin

David D. Martin
Professor of Economics
Graduate School of Business Economics
Indiana University, Bloomington, Indiana

Stephen L. McDonald
Professor of Economics
University of Texas, Austin, Texas

Walter J. Mead
Professor of Economics
University of California, Santa Barbara, California

Irving Morrissett
Associate Professor of Economics, Graduate School of Industrial Administration
Director of the Social Science Education Consortium, Inc.
Purdue University, Lafayette, Indiana

Giulio Pontecorvo
Professor of Business Economics and Coordinator of Doctoral Studies
Columbia University Graduate School of Business
New York, New York

Warren Roberts
Professor of Political Science
Wabash College, Crawfordsville, Indiana

Anthony T. Scott
Professor of Political Economics
University of British Columbia, Vancouver, British Columbia

James A. Seagraves
Associate Professor of Agricultural Economics
North Carolina State College, Raleigh, North Carolina

Henry Steele
Professor of Economics
University of Houston, Houston, Texas

William Vickrey
Professor and Chairman, Department of Economics
Columbia University, New York, New York

Gene Wunderlich
Chief, Resource Institutions Branch, Resource Development Economics Division, Economic Research Service
U.S. Department of Agriculture, Washington, D.C.

Acknowledgments

To consider enumerating the hundreds who have added to this work is a humbling experience for the editor under whose name it now appears. There were typists, wives, earlier writers, research assistants, teachers, editors, friends, critical colleagues, parents, foundation and academic administrators, philanthropists – the list begins to stagger one, not to mention taxpayers! It is a lesson in the technical complexity of human cooperation, but even more in the spiritual wonder of irrational mutual confidence, without which there would be nothing. Imagine: each of fourteen writers labors painstakingly over his lonely manuscript in the confidence that thirteen others, whom he hardly knows, are doing the same; that their joint product may be articulated and acceptable to a reputable publisher; that concerned intelligent readers may match their effort by responsive study, and give life to their thought by incorporating some of it among the ideas which move them; and that the acts of these concerned readers may thread their way through the perils of politics to influence legislators and administrators. What analyst, reasoning a priori from mechanistic axioms about individual optimization, would ever anticipate such group dynamics? It is too absurd even to contemplate – but here it is. That "man is a social animal" bears on ever so much more than cocktail parties. Man likes to give to exciting enterprises, and what you find in these pages are gifts of men and women who found this enterprise exciting.

In 1964 the Robert Schalkenbach Foundation financed a conference at the University of Wisconsin-Milwaukee on "Tax Treatment of Exhaustible Resources," at which the chapters of this book were originally presented as discussion papers. To the Foundation goes our appreciation, and to its amiable Executive Secretary, V. G. Peterson, with whom it is always a pleasure to work. The Conference was sponsored by the Committee on TRED, to whose Chairman and founding father, Professor Arthur P. Becker, the editor owes special thanks. Professor Becker had the rare courage to lend his name and talent to encouraging renewed study of natural resources as a tax base at a time when the

topic suffered under a peculiar historical stigma that discouraged serious consideration. His remarkable success in restoring the topic to the dignity of a respectable subject for analysis and discussion is attested to by the stature of the contributors to this and other annual conferences of the Committee on Taxation, Resources and Economic Development (TRED), and of the other members of TRED: Paul Alyea, Karl Falk, Richard Lindholm, Carl McGuire, and William Vickrey.

Mrs. Faye Levner has shepherded the editor through the valleys of style and pitfalls of footnotes and risen loyally to every crisis. Michèle Consigny has applied her genius to graphs and equations and inspired the editor as only a brilliant student can by mastering the analysis and bringing it to bear on more difficult questions before the ink was dry on this manuscript. Dennis Jesmok helped prepare the index and scanned the literature as the editor's radar. William Vickrey and Stephen McDonald have been notably generous in their help to the editor.

The Harvard University Press kindly let us reprint L. C. Gray's article, "Rent Under the Assumption of Exhaustibility," from the *Quarterly Review of Economics*, 28 (May 1914), 464–89.

Above all, the editor thanks his contributors. Each man who gave of his time and talent acted out his faith in the editor – more perhaps than he realized – a faith which led the editor to greater toils than ever he expected, but which he appreciates no less for all that. Each contributor acted out his faith in each of the others, and each was inspired to greater effort by the trust of the others. All of us owe the final debt to the wonderful social tradition of voluntary group action – a means to common ends, but a means so gratifying that, if it should be the end as well, it would be enough.

M.G.

Milwaukee, Wisconsin
March, 1967

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Editor's Introduction

MASON GAFFNEY

The Importance of Extractive Resources

Mankind signalizes the importance of extractive resources in a number of traditional ways. Nations insist on some political control of their own supplies of raw materials, believing that these are limitational inputs vital to national survival. Among oligopoly firms the same tendency prevails – most mills try to capture their own resource reserves, in spite of the inflated capital requirements, because the free market in most ores is not reliable and resource ownership is, or might become, a lever of exploitation or control. This insistence on controlling one's own supplies constitutes in the aggregate, indeed, an overrecognition of the importance of extractive resources. It often fosters premature development of excessive reserves: in mining and oil firms the asset-output ratio is higher than in any other industry.

Federal stockpiling of strategic minerals is another traditional acknowledgment of the importance of exhaustible resources. Subsidy for exploration is another. Social and legal pressures to retard withdrawal of minerals and to discourage exports are yet others. Every month or two produces its new jeremiad against rising population and living standards, with intimations of Malthusian doom.

Probably most economists would agree that those traditional feelings are, on the whole, overwrought. But there are more sober indicators of the true importance of exhaustible resources. One is the higher wage level in the United States. The perennial question "How can American firms compete with foreign firms which pay lower wage rates?" has as

part of its perennial answer that the marginal productivity of American laborers is perennially elevated by their more generous complement of raw materials.

Monopolization of strategic deposits of raw materials is one of the more common means of controlling markets; and in World War II federal priorities and rationing of raw materials were key levers in control of the economy. Exhaustible resources are especially susceptible to concentrated ownership because the workable, accessible high-quality deposits are limited. Again, the long waiting period between early exploration and ultimate liquidation of many deposits favors concentration of ownership. Only a handful of the ultra-affluent can afford to wait half a century between investment and liquidation; and if we measure the extreme range from first exploration to the last yield from a mine, more than fifty years would be a realistic life. In extractive industries, an average reserve-output ratio of twenty years would not be unusual. But that is like an inventory that turns over only five times a century. Within the industries the financial Titans tend to specialize in carrying the financial burden of holding valuable reserves, a pattern of ownership that helps set the stage for market and social control. In any complete list of giant corporations and giant personal and family fortunes, mineral holders are conspicuous near the top: oil and gas, coal and iron, and in Europe "chemicals" are paramount; followed by copper, sulfur, lead and zinc, gold and silver, molybdenum, bauxite, uranium, phosphate, potash, nickel, and so on through the list of useful elements.

In public finance, special treatment of exhaustible resources provides one of the major loopholes through which property income escapes taxation. The value of the depletion allowance is a matter of some billions of dollars each year. And in many local jurisdictions the assessor is ill-equipped to put a proper valuation on subsurface mineral possibilities for property-tax purposes.

The development of exhaustible resources is also a source of economic instability. This, like the concentration of ownership, follows from the long waiting period between early exploration and final liquidation. Natural resources might be described as a capital investment of unusual duration. The more durable a capital good, of course, the more subject it is to the acceleration principle and cobweb-type oscillations. Its value is sensitive to small changes in interest rates. Economic instability, studied both empirically and theoretically, is widely agreed to relate

closest to investment in durable assets. Added to this, natural-resource owners are prone to form cartels, with their tendency to hold a price umbrella that stimulates submarginal developments and leads, over a long swing of perhaps a generation, to the development of excess capacity and an ultimate boomerang that collapses prices and cartels.

The Conference Topic in the TRED Program

Exhaustible resources and their taxation also constitute important links in the development of economic and fiscal theory and policy. It is this that makes the subject appropriate for a symposium sponsored by the Committee on Taxation, Resources and Economic Development (TRED).[1] TRED is an association of economists sharing a common interest in the use of taxation to assert the public interest in natural resources. TRED works to foster a usable modern literature in its field to help acquaint the profession and the public with the best thinking that economists have to offer, and thereby to help guide intelligent policy. TRED's function is to bring advanced thinking to bear particularly on the moot and difficult questions that earlier writers have skirted or abandoned in confusion. TRED's philosophy is not to push policy positions as foregone conclusions, but to enlist the help of able economists to clarify the challenging unresolved issues in resource taxation, with the faith that solutions will evolve from the conflict and discussion.

The committee recognized that the traditional rationale for heavier taxation of natural resources rests heavily on the concept of fixed supply, as so unhappily expressed by Ricardo in his "original and indestructible powers of the soil." Because of this, some economists and policymakers regard the arguments for heavier taxation of land as inapplicable to exhaustible resources. At the same time, at the other extreme, there is a strong current of thought, the "natural heritage" theory, which regards natural resources as properly national property, and by "natural resources" purports exhaustible ones primarily (implicitly excluding surface extension and location). This is partly a philosophy of distributive equity, but includes a strain of skepticism of the workability of the market in resources, and perhaps, too, of the normative value of even a perfect market in matters of conservation particularly, and inter-

[1] Other symposia have treated "Land Value Taxation and Urban Economic Problems," chaired by Professor Arthur Becker; "Land Reform and Tax Reform in Less Developed Countries," chaired by Professor Carl McGuire; and "Property Taxation, U.S.A.," chaired by Dean Richard Lindholm.

temporal economizing generally. Thus we have one school that would minimize the fiscal assertion of public equity in extractive resources, and another that would control or socialize them. Here is a "moot and difficult" question worthy of our steel.

Not all economists accept the idea that even inexhaustible natural resources should be loaded with heavier taxes. Some economists maintain that the private receiver of ground rent requires it to motivate essential economic functions. These defenses are, however, relatively transparent and easily penetrated.

Among agricultural economists, for example, the idea is seriously advanced that absentee landlords serve the essential economic function of assuming the financial burden of carrying title to expensive land. This is a rather straightforward fallacy of composition. The individual absentee landlord does indeed perform this function for the tenant, but landlords collectively simply lower the capitalization rate, raising prices out of reach of tenants who lack comparable ownership of, or access to, long-term funds. Thereby, landlords collectively necessitate the very function which they individually perform. The argument fails to distinguish, a cynic might say succeeds in confusing, price-determined and price-determining factor payments. (The cynic might be wrong—the confusion could arise without malice, simply from adopting the individual farm-management viewpoint and forgetting the need for transposition from individual to social economics.)

Again, economists teach that the function of rent is to ration the land supply among competing users, even if it does not serve the double function of other factor payments which elicit the supply as well as ration it. Some economists take this as the functional rationale for private receipt of rent.

This is to ignore, however, that rent can still serve to ration the supply even if heavy taxes are imposed, just so the taxes are independent of the allocation, or if they are levied as a percentage of net rather than gross rent.[2] Resources can also be, and many are, owned by government and leased to the highest bidder, without violating free-market principles or depriving any economic function of its motivation.

However, with exhaustible resources the arguments for private collection of resource rent are not so easily demolished. Here, price has the function of regulating conservation over time, and also the func-

[2] The last method, a land-income tax, has the demerit of exempting implicit and psychic income, and therefore works a material bias against uses that yield cash.

tion of eliciting supply to replace exhausted resources. To be sure, the more enthusiastic *ex parte* arguments are overstated when the social costs of exploration are alleged to include lease payments to passive landowners. Such lease payments and "points," along with the traditional one-eighth royalty,[3] are obviously price-determined rents, and not functional in eliciting supply. But all cases get overstated by someone, without destroying the case. If we trim off the overstatement there remains a troublesome nub of substance in the claims of a need for privately collected rent income to foster conservation and replacement of exhausted resources.

And so the present symposium was organized by TRED to help advance our thinking about natural-resource taxation under conditions of exhaustibility. Given the subtleties of the topic, it is unavoidable that the symposium should also contribute to economic theory, and to a better understanding of the economic institution of property, of market structures, of concentration of wealth and power, and other central concerns of economists.

There are only a few high-quality publications dealing with this important subject. Some aspects are almost entirely untreated – such as the proper place of depletion in the national income accounts; capitalization of different kinds of taxes on exhaustible resources, and the effect of tax capitalization on output rates; the relative social efficiency of public versus private exploration, and the proper division of function between them; a correct imputation of the final product between the early prospector, the financier, and the public, whose work helps add value to mineral deposits over the years; the capacity of natural resources to yield tax revenues; the use of probability theory in appraising and assessing incompletely known underground deposits; the dynamics of expansion and collapse of cartels and their relation to business cycles; and the lessons of wartime federal control of priorities and rationing for peacetime policy.

Some areas are more marked by controversy than consensus, such as the effect of corporate income taxes on the durability of investments; the incidence of benefits from depletion allowances; and the choice of a proper discount rate.

Most topics the existing literature touches on have simply been

[3] Note that this is ⅛ of gross wellhead or mine-mouth value. It is more than ⅛ of the net rent of the resource – it may be the whole of it where production costs are high. Our concern here is with the net rent to land, not the gross-value product.

treated by too few economists to produce a meaningful consensus. The neglect of the field by the profession as a whole is betrayed by the lack of treatment in most elementary economics textbooks. Little as has been done, most of that little remains to be widely understood, even by economists. The Committee on TRED therefore believes the present volume may serve a useful role in a field marked by overall neglect, unresolved controversy, and undistributed literature.

The Articulation of the Chapters

The symposium comprises chapters on economic theory, economic institutions, and economic policy.

Few of the chapters fall entirely in one of the above classes, but overlap. The overlap makes the symposium. The papers were discussed by the participants for three days and revised. The interplay of different minds on the same topic, the constructive tension generated by differing viewpoints, and the richness of background of the several contributors, are the unique values of the symposium approach.

Each writer supplies some new insight into the common topics of the symposium, as well as expertise on his special subtopic. Comparing each writer's treatment of the common themes is like watching a landscape change with the clouds and the hour. Each brings a fresh eye for what is vital; each points up aspects that others have shadowed out. The human experience, the accumulated wisdom of several lifetimes, and the ingenuity of their several creative minds are represented here among our distinguished experts. The collective result has a depth and animated movement that displays, better than any individual author, the fullness and variety of its subject.

The editor made little effort to achieve consistency or consensus. Yet it is remarkable how much consistency (except of terminology!) and consensus emerged. The profession evidently is moving towards a generally accepted position in this still underdeveloped subdiscipline. That might suggest banality, but on the contrary the points of consensus include some shockers for anyone schooled in the conventional rhetoric either of "business" or of "conservation."

Part I THEORETICAL FOUNDATION

Introduction

Imputation

Professor James A. Seagraves took on the important preliminary task of clarifying the imputation of returns to different inputs. Part of our intellectual heritage from the Fabian Society has been that production is a joint cooperative endeavor in which the contributions of individual factors are merged and not identifiable. In this position the left wing has received support from the right, as rent-receivers resisted clear-cut imputation of returns and sought to camouflage rent elements with more functional and socially defensible elements of their income. Today, Communist critics of capitalism, as Professor Warren Roberts brings out in Chapter 9 of this book, are not eager (and probably not able) to help distinguish functional from non-functional income; that is the task of the defenders. Marginal analysis, of course, has been the tool of those seeking to clarify the analysis of income distribution.

Professor Seagraves points out that modern developments in linear programming have advanced a step beyond marginal analysis in tying specific contributions to specific inputs.

Using case studies in agriculture and petroleum, Seagraves concludes that the natural resource input, because of its relative fixity, tends to receive the primary benefit of tax favors, or other favors, to specific industries. This is a conclusion that hangs on the specificity of the resources to the industries, and would not apply to highly versatile land inputs and narrowly defined industries.

Professor Seagraves also brings to our attention some interesting political results of tenure institutions controlling mineral rights. He points out that a large share of political support for tax and other favors to mineral producers might logically be expected from landholders who have not yet signed leases. They are in a stronger position to capture the gains than those under contract already. The latter, drawing one-eighth of the gross, also tend to support higher prices. Lessees have more leverage than any other group and might reasonably spearhead the move-

ment. The three groups together are a political Troika to conjure with, indeed.

L. C. Gray's classic "Rent under the Assumption of Exhaustibility" is reprinted in the Appendix. We include the article because it is basic to our subject; our contributors refer to it often; and it is not readily accessible to many readers.

Gray faces the basic question of how much depletion charge to deduct from the cash flow of mines, after other costs, to determine what portion of the flow is properly rent income. Gray attempts to determine how much the miner should let depletion retard his rate of extraction; how he should respond to higher prices that lift his mine above the marginal level; and how the public should tax mines.

On the first question, Gray's answer surprises one: he would deduct nothing from income for depletion of the substance of the resource. Depletion, he says, is simply the present value of future rent foregone to realize present rent. He regards the entire cash flow as rent. His emphasis is more on the concept of rent as a surplus above social costs than it is on rent as an income; but he avoids the questions of discovery and replacement cost, so that the issue is never clearly posed.

On this one point, our current contributors do not all follow Gray. Henry Steele, in Chapter 10 of this book, specifically criticizes Gray for neglecting replacement of exhausted resources. It may be that Gray was implicitly assuming a resource something like the oil shale which B. Delworth Gardner treats in Chapter 8, whose discovery cost is negligible and whose replacement cost would consist entirely of capitalized rents paid to passive landowners. In such cases, Gray is telling us something important. The economic surplus, which might be socialized without impairing functional incentives, is the full surplus of gross income over non-land costs. He is rejecting the notion of rent as a surplus of income above opportunity cost, where the foregone opportunity is simply another way of realizing some rent – in this case by withdrawing a mineral in the future instead of the present.

Even with petroleum, a large share of exploration "costs" are lease acquisition and rental payments to passive landowners.[1] Yet another large share are real social costs, so it does seem that we should modify Gray's stand on this account. Gray says we might take the entire return to land in taxes and not impair functional incentives at all. Most con-

[1] In 1960, 819 million dollars out of 2,045 million dollars, or about 40 per cent of oil exploration costs were for leases. (See 3, p. 287 n.)

tributors feel we must leave *something* to motivate replacement; the interesting question is, How much?

Yet Gray sets the tone for much of our discussion. He begins to supply us with an analytical framework for appraising depletion if we do choose to net it out of rent income. Depletion is the loss of future rent caused by realizing present rent. Depletion is usually small relative to present rent because the lost future rent must be discounted over the life of the mine. Thus, even if we do define rent net of depletion, Gray reduces the depletion charge to well below the spot liquidation value of the geological fund being depleted. In this he follows Böhm-Bawerk (*1*, p. 335) and has been followed by Gaffney (*2*, pp. 555–57).

Although he would not deduct depletion from income, Gray would let it retard output by adding it to marginal costs. He emphasizes that on marginal land there is no depletion because there is no rent – and depletion is simply discounted remote future rent.[2] It might seem to follow that extraction should proceed fastest on marginal land but Gray, like all our contributors, says the opposite. There is no urgency about using marginal ores that yield nothing above cost. But it is urgent to use superior ore, because *rent today is worth more than rent that one must wait for*. Our contributors agreed that the transcendent fault of public policy today is failure to understand and follow this principle spelled out by Gray many years ago.

The higher the discount rate, and the longer the remaining life of a mine, the less will depletion retard output.

As to tax policy, Gray notes that a tax taking a fixed percentage of the rent realized in any year would achieve intertemporal neutrality by leaving undisturbed the ratios of rent-after-tax in every year. Unfortunately, he does not tell us how to handle time depreciation of durable mine improvements in defining this tax base – a matter which Professors Stephen McDonald and Henry Steele perceive as crucial, and which has a central role in the editorial conclusion.

Gray's work suffers from some other crudeness too. The use of particular arithmetic examples to demonstrate general propositions is dangerous; our contributors have remedied this. The dismissal of replacement costs is unjustifiable as well as unnecessary. The coverage is limited. And yet Gray manages in this remarkable little work to foreshadow

[2] He does not consider the dynamic case of land presently marginal but potentially rent-yielding. If he had, it would strengthen his point. Herfindahl and the editor do take this up in the present volume.

many of the issues of this conference, to build an analytical foundation consistent with the more polished ones presented at the symposium, to link current with classical thinking, and to lead us toward policy conclusions consistent with what most conferees reached by more sophisticated means.

Time in Economics

This subject is usually called "capital theory," but the ineptitude of that rubric is glaring in this symposium, where the subject is not "capital" in the usual meaning, but natural resources. Whatever we call it, it is clearly basic to any discussion of conservation, depletion, and reserve-output ratios.

Professor Anthony Scott, in Chapter 2 of this book, provides us with a systematic theoretical framework for analysis of intertemporal economizing. Some of his findings might seem heretical against the background of the existing literature in the field, as he points out. But these original contributions do not seem heretical in light of the symposium discussions, and it may be he has timely captured "what oft was thought but ne'er so well expressed."

Professor Scott concludes that it is rational for us to use our best natural opportunities first, "reducing quickly the amount of natural capital he [a miner] has tied up in illiquid form." This passage nicely epitomizes the attitude to "conservation" prevailing among the conferees. It contrasts sharply with the Pavlovian protest against depletion that not long ago dominated conservationist thought, and with many prevailing policies that force us to use marginal resources while superior ores are held in reserve.

Professor Scott finds that the optimal rate of output is a balance between time preference — as represented by interest and other carrying costs — and increasing costs that attend acceleration of the rate of production. This follows Gray's earlier reasoning, but Scott generalizes the principle far beyond Gray's vulnerable arithmetic example.

Scott's heresy, which appears unexceptionable, is that the rational mine manager will tilt his production plan in favor of the present instead of producing at a constant annual rate. He will do this because of the ever-shortening future life of the mine, even in the absence of conditions such as deterioration of ore quality, or falling prices, or rising costs. This is because of the rising value of what Professor Scott calls the user cost of mining as exhaustion shortens the future life of a mine.

Using a homely analogy, Scott's principle might be paraphrased as follows: the toothpaste which I squeeze from the tube tonight does not sacrifice tomorrow night's supply. Rather, I roll up the end of the tube (which represents the future date of exhaustion) and bring tomorrow night's supply to the orifice (which represents the present). What I sacrifice is the toothpaste supply of the year of exhaustion, and the user cost properly accounted tonight is that future value discounted back over the life of the toothpaste tube. If the life is thirty or forty years the discount factor is high and the proper user cost is correspondingly low.

The principle of rising user cost must be modified to fit the more common condition that a mine dwindles out gradually as costs rise over time. But Professor Scott's point is that such rise of costs is not the only, or even a necessary, reason for tilt of production rates. Even if quality and location of ore were constant until the hour of complete exhaustion, as with the toothpaste, user cost would rise steadily (exponentially) as future life shortened.

In addition to these primary points, Professor Scott systematically elaborates the behavior of a rational miner under a wide range of assumed conditions.

Dr. Orris Herfindahl addresses his analysis to extractive industry as a whole rather than the individual firm that Scott treats; and to the very long run – so long a run, indeed, that he takes as his unit of time the life of a mine.

Like Scott, Herfindahl gives the central role in his analysis to the net return imputable to the natural resource input, but where Scott labels this "profit," Herfindahl prefers "royalty."[3] Both authors postulate maximizing the present value of expected future net rents (or profits or royalties) as the proper rule of conduct, both individual and social.

In Scott's model, increasing cost of output is the effective constraint

[3] It should be obvious that the editor has not succeeded in imposing uniform terminology on the contributors. If he had, it would be "rent." Herfindahl's definition of "royalty" is the price of the metal in the ground. This is not to be confused with Alfred Marshall's use of the term, as criticized by Gray. Marshall's "royalty" is the same as Scott's "user cost." Scott's "profit" is gross of his "user cost" – a usage consistent with Gray's insistence that "rent" is gross of Marshall's "royalty." Herfindahl points his analysis to a longer run than Scott or Gray, and his choice of "royalty" for economic rent may intimate an implicit asumption that mine rent, in part at least, answers the description of Marshall's "royalty" (Scott's "user cost") – a depletion fund to finance replacement via prospecting. McDonald and Steele share Herfindahl's emphasis on prospecting and replacement.

on unlimited immediate withdrawals. In Herfindahl's model it is expected rising prices that serve this role, but Herfindahl does not foresee future shortages and higher prices of raw materials. On the contrary, he sees future cost reductions bringing into the market large supplies from low-grade ores now submarginal. When he postulates rising prices of the royalty they result from lower costs, not higher prices of raw materials.

That forecast presumably applies primarily to ores now submarginal and as yet undeveloped. Ores already worked with capital committed to older techniques would not share fully, if at all, in new techniques reducing costs. Output of these ores would not be limited by anticipated rising royalty values, but only by short-run increasing costs as described by Scott.[4]

With these differences of coverage, Herfindahl's findings are harmonious with Scott's. Use the best ores first: a major goal of conservation policy should be to convert illiquid surpluses to earning assets. Herfindahl elaborates this theme: the higher the royalty value, the more should output be accelerated. "If demand is greater, shouldn't use be shifted from present to future in the sense of extending the period of exploration? The answer is No. . . . urgent demands as expressed by the demand increase are urgent now as well as in the future. . . . The better deposits will be exploited first. . . . The productive services saved while using the better deposits can be put to work producing either capital or consumer goods."

This basic position of Herfindahl's harmonizes with that of Gray. In Gray's example it is a higher price of the product in both present and future that increases the rent, cost remaining fixed. As Gray puts it, the extra future rent does not fully offset the extra present rent, because the future rent must be waited for and its discounted present value is less than the undiscounted value of its present alternative. Therefore, anything raising the rent of mines by a given absolute amount in both present and future makes present withdrawal more attractive relative to future. The absolute excess of the present net rent over the present value of its future alternative rises, thus accelerating present output.

Herfindahl puts the case more generally than Gray. In effect, he tells

[4] Indeed some ores presently superior but undeveloped may be made obsolete and devalued by cost reductions. This is the present fate of hematite, due to the higher quality of pellets produced from taconite beneficiation, according to Dr. Clarence Nelson of the Federal Reserve Bank of Minneapolis.

us, the ratio of future to present royalties must always be such as to yield the going rate of interest.[5] He notes various leverage factors at work on royalty values. For example, a price rise, as in Gray's example, with costs unchanged, raises present royalties, R_0, by a larger percentage than it raises future ones, R_t, since the future ones already had to be larger to pay interest on R_0 over t years. Herfindahl points out that a given rise of prices causes a faster rise of royalties because of the leverage of fixed costs. So prices need not rise as fast as the rate of interest to make royalties rise at that rate, and warrant deferral of output.

Herfindahl, like Gray, notes the intertemporal neutrality of a tax based on the net royalty value, because it would maintain a constant ratio between royalties in different years.[6] Taxes based on gross output, or on inputs, lack this quality but apply leverage that changes intertemporal choices. Professor William Vickrey, in Chapter 14 of this book, shares that conclusion.

In the large view, Herfindahl emphasizes the similarity of mineral industries to other industries. He recognizes that depletion will overtake individual ore deposits, but he stresses that progressive cost reductions continually bring submarginal ores into economic use so that in the aggregate there is hardly any social depletion. If one takes the firm or the industry rather than a piece of land as his basic unit, ores may be regarded as a revolving inventory continually renewed by a combination of discovery and cost reduction and public works and human migration. Thus, the firm is an earthworm moving slowly through limitless resources, with an inventory of digestible resources moving through the worm. This picture of the relations of economic man to natural resources makes ore reserves an inventory – differing, however

[5] That is, where $r = \left[\frac{R_t}{R_0}\right]^{\frac{1}{t}} - 1$

[6] That is, $\left[\frac{(P_t - C_t)}{(P_0 - C_0)}\right]^{\frac{1}{t}} - 1 = \left[\frac{(P_t - C_t)(1-r)}{(P_0 - C_0)(1-r)}\right]^{\frac{1}{t}} - 1$

where P = Price of a unit of ore in the indicated year
C = Cost of removing the unit
t = Any year
r = Rate of tax

Those equations assume that the site has no reuse value. If it does, the rate of return (X) on holding ore falls to:

$$\left[\frac{(P_t - C_t) + S}{(P_0 - C_0) + S}\right]^{\frac{1}{t}} - 1$$

where S is site value. Now a neutral tax must also hit S.

from other kinds of inventories in the long period between discovery and consumption.

A General Control Model

Rounding out the theory section is an original exploration by Dr. John Hogan into the possible use of dynamic programming to optimize tax policy over time. Sympathetically reviewing the literature, Dr. Hogan notes the serious limitations of classical-type models which are forced into unrealistic simplifying assumptions, and retreat into *ceteris paribus*, because pre-computer man could not juggle many variables simultaneously. Hogan would like to introduce more realistic considerations of imperfect competition, for example, and he points to the many feedbacks ignored in classical-type models. He then sketches out for us the rudiments of a general control model along modern lines.

The potential value of Hogan's approach may be appreciated by comparing the various contributions to this symposium, which differ from one another in what each writer chooses to hold constant, or assume away.

Hogan's sophisticated and challenging contribution is especially refreshing in considerations of tax policy where policy-makers have assumed for years that guidelines should not rise too far above the level of sloganeering. Hogan would apply modern computer theory and technique to a set of issues ridden by tradition and subrational pressures. It would be interesting to see how the computer's findings might be translated for political consumption. As we go to press, Hogan and Dr. Joseph Midler (RAND Corporation) are attempting to fit real-world cost and revenue data to the control model described in this symposium, so the time for actual application may arrive sooner than we think.

References

1 Eugen von Böhm-Bawerk, *Positive Theory of Capital*, Vol. II of *Capital and Interest*, South Holland, Illinois: Libertarian Press, 1959.

2 Mason Gaffney, "Soil Depletion and Land Rent," *Natural Resources Journal*, 4 (January 1965), 537–57.

3 *Joint Association Survey, Estimated Expenditures and Receipts of U.S. Oil and Gas Producing Industry, 1960*, sponsored by the American Petroleum Institute, Independent Petroleum Association of America, and Midcontinental Oil and Gas Association, December 1962. Cited in Alfred E. Kahn, "The Depletion Allowance in the Context of Cartelization," *American Economic Review*, 54 (June 1964), 286–314.