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THE ECONOMIC EFFECT OF THE SEVERANCE TAX ON DECISIONS OF THE MINING FIRM

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The severance tax on mineral production is largely a development of the present century. The tax is frequently levied in preference to the conventional property tax, thereby avoiding the problems of determining the physical amount and taxable valuation of underground ore deposits. Many authorities have maintained the property tax not to be in the interest of conservation, since it encourages the firm to "mine out" from under the tax. Conversely, the severance

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The author assumes full responsibility for the contents of the article; the analyses and conclusions are his and do not necessarily reflect the views of the Bureau of the Census or the Department of Commerce.


2. Many writers have discussed this problem. See, e.g., W. A. Roberts, State Taxation of Metallic Deposits 15-26 (Harvard Univ. Press 1944), for a discussion of variations in the discount rate and interest rate under the Hoskold Formula.

To avoid the problems of appraising an underground metalliferous deposit, the assessed valuation is based on the proceeds realized from working the deposit. This is the case in seven Rocky Mountain states: Colorado (one-fourth of gross proceeds or all of net proceeds); Idaho, Montana, and Nevada (net proceeds); New Mexico (average net proceeds for five preceding years or annual net proceeds); Utah (two times the average net proceeds for three preceding years); and Wyoming (gross value of production, less development allowance). From an economic standpoint these taxes resemble a hybrid severance tax more closely than the conventional property tax.

tax has been supported on the ground that it encourages conservation of mineral resources.⁴

There is much variation among the severance taxes utilized by the states.⁵ A severance tax may be defined broadly as a levy assessed at flat or graduated rates by a government on the privilege, process, or act of commercially severing or extracting natural resources from the soil or water, and measured by the physical amount or the gross or net value of the natural resources produced or sold.

The purpose of this article is to analyze, under certain assumptions, the short-run economic effect of a state severance tax on decisions by the metal-mining firm operating a recovery plant. The probable consequences of the tax for the conservation of the mineral resource are also discussed. The effect of the tax is examined when flat and graduated rate structures are utilized. Alternative tax bases are (1) the physical output of raw ore and metal contained in the product of the recovery plant, and (2) the gross value of metal produced or sold.

I
THE OUTPUT FRAMEWORK

The mining firm makes two distinct and fundamental types of decisions in working a hard metalliferous deposit.⁶ First, the firm is faced with alternative rates of extracting the metal per time period from the deposit under production. The speed of extraction is the paramount economic factor. This decision is labeled the rate of recovery. Second, the firm must decide from among alternative total

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⁴. President’s Materials Policy Comm’n, Foundations for Growth and Security, in Resources for Freedom vol. I (1952). The Commission stated that “whenever State and local governments can substitute severance taxes, or taxes on gross or net proceeds for ad valorem taxes on mineral reserves, they will make a contribution toward improving the Nation’s minerals position.” Id. at 36.


The graduated severance tax on net profits has been discussed elsewhere. See Lockner, The Economic Effect of a Progressive Net Profits Tax on Decision-Making by the Mining Firm, 38 Land Econ. 341 (1962). In at least one state it appears feasible to utilize such a tax in conjunction with the conventional state income tax, as applied to metal-mining enterprises. See A Proposed Mineral Tax for Colorado, 15 Nat’l Tax J. 268 (1962).

⁶. For a discussion of the theory of the mining firm upon which this article is partially based, see Carlisle, The Economics of a Fund Resource with Particular Reference to Mining, 44 Am. Econ. Rev. 595 (1954). For a more recent discussion of this subject, see Tessaro, Factors Affecting the Choice of a Rate of Production in Mining, 1960 Canadian Mining & Metallurgical Bull. 575-81.
amounts of metal to be extracted from the deposit under production (alternative percentages of the total absolute, although perhaps unknown, amount of metal present in the deposit). The role of space, especially the vertical dimension affecting the accessibility of the mineral, and the grade and quality of the ore, are the strategic economic factors. This decision is designated the level of recovery.

The mineral deposit is a fund resource not replaceable by the renewable energy of solar activity. Therefore, the time required to exhaust the deposit can be shortened by increasing the rate of recovery or decreasing the level of recovery, or both. Conversely, the future date of exhaustion can be postponed by decreasing the rate of recovery or increasing the level of recovery, or both.

As far as mineral production is concerned, conservation of a metallic mineral resource involves the duration of production from the mineral deposit. More conservation occurs when the mining firm's rate of recovery is decreased or its level of recovery is increased, or both. These adjustments involve a reduction in the speed of mining, the extraction of more inaccessible ore and/or a decline in the critical grade and quality of supramarginal ore, thereby redistributing production over a longer future time period. Other things being equal, either or both of the adjustments in the rate and level of recovery conserve the resource by lengthening the economic life of the mineral deposit and postponing the date of entry into new and undeveloped deposits.

II

THE COST FRAMEWORK

The mining firm's production decisions are determined by discounting the alternative future profit streams within the price and cost structures.

In this analysis, the pre-tax costs of production include all the costs of discovering, purchasing, or otherwise acquiring the right to mine; developing and equipping the mine; extracting the valuable product; and marketing. The severance tax is added to these costs in arriving at the post-tax costs of production. No allowance is made for imputed rent and wages or the normal return on capital. An unusually large

7. In the analysis of metalliferous ore, the term "grade" refers to the per cent of metal content or the metal content per ton of rock or raw ore. The term "quality" refers to such characteristics as mineral composition, presence of deleterious impurities, grain size, grain boundary relations, hardness and larger textural features. All of these factors affect the costs of treating the ore and recovering the valuable product.
portion of the costs in mining represents capital investment and is not affected by either the rate or level of recovery in the short run. Other costs, such as those of pumping, minimum amount of management, obsolescence, and interest are "fixed charges" in the usual sense because they must be met at a more or less fixed rate per day if the mine is to operate. The total of such expenses is a direct function of the time required to exhaust the ore body. Still other costs may at times increase and at other times decrease on a per-ton basis as either the rate or level of recovery is increased. In grouping these expenses into fixed and variable costs, it is necessary to refer to costs at a total for the expected life of the deposit (i.e., unit cost times the total unit output to be obtained from the deposit) rather than total cost per time period (i.e., unit cost times the output per time period), as is ordinarily done. The justification for this approach is that both the rate and level of recovery can be changed independently over a wide range. The term fixed cost (FC), therefore, refers to costs which remain constant as a total for the life of the mine, regardless of wide variations in either the rate or level of recovery. These costs include mainly the investment of capital in acquiring the property, developing and equipping the mine, and investment in the concentrating or recovery plant. Average fixed cost per unit of output is decreased by increasing the level of recovery but not by increasing the rate of recovery. All other costs are variable. Costs which vary as a total for the life of the mine with respect to both the rate and level of recovery are termed rate-level-variable costs (VCRL). Among these expenses are most direct labor and material costs and the fixed charges discussed above. In general, a rate-level-variable cost will vary by different amounts and perhaps in opposite directions (e.g., pumping) with a given proportionate change in the rate and level of recovery. These costs include, for example, royalties on the gross product, and costs of underground surveying, sampling, and geology. Rate-variable costs (VCr) vary as a total with changes in the rate of recovery only. These costs include, for example, the addition of more workers per shift or the addition of another shift of workers. The cost classification of the severance tax is discussed later in the analysis.

Neither costs to be incurred nor gross revenues to be realized over the economic life of the deposit are discounted to present value in this analysis. Instead, the resulting alternative profit streams, both
pre-tax and post-tax, are compared in the light of the presumed time preference of the recipient mining firm. Unless otherwise stated, the mine product price, factor costs and level of technology are assumed to remain constant, not only currently, but also for the life of the mine.

III
THE EFFECT OF THE SEVERANCE TAX ON THE RATE OF RECOVERY UNDER A GUARANTEED PRICE

A. The Theoretical Setting

Assuming that the level of recovery is given, the effect of a state severance tax on the rate of recovery of a mining firm in a multi-state metal-mining industry can be analyzed with the assistance of a diagram. In Figure 1, the solid lines depict the pre-tax situation, and the

FIGURE 1
EFFECT OF SEVERANCE TAX ON THE RATE OF RECOVERY UNDER A GUARANTEED PRICE
broken lines show the post-tax situation. The tax is levied at a flat rate and is based on the physical output or the gross value of metal produced or sold.8

The sale of the metal is guaranteed at "P" price per ton; i.e., the firm's sales curve is infinitely elastic. This condition occurs when the firm is operating under perfect competition. Also, the guaranteed price exists when the firm is operating under a long-term sales contract stipulating the price of the metal.

By assuming the level of recovery to be given, the total product is fixed, and fixed costs and level-variable costs are constant as a total for the life of the deposit. Accordingly, average fixed costs (AFC) and average level-variable costs (AVCL) are fixed amounts per ton. The structure of average total unit cost (ATUC) is U-shaped, reflecting the economies and diseconomies of alternative rates of recovery. The marginal cost (MC_R) represents the additions to total cost as the rate of recovery is increased.

The maximization of total profit on the stock of ore, disregarding its distribution in time, is obtained by mining at "A" rate of recovery where average cost is at a minimum. At this rate of recovery, the average profit per unit of product recovered during the period (year) is also maximized. Operation at this rate of recovery might be expected to occur where the deposit is very small or perhaps where the volume of sales precludes continuous operation at a higher rate of recovery. The highest current rate of profit per time period (year) is obtained at "B" rate of recovery where marginal cost (MC_R) equals marginal revenue (MR). This rate of recovery is favored when rapid return of capital is desired or required, but the total profits (realizable over the life of the deposit) will have suffered by the change to a rate of recovery higher than the least average cost rate.

Profits are assumed to be discounted at a rate of interest commensurate with the time preference of the recipient mining firm. The equilibrium rate of recovery is that rate of recovery which yields the maximum present value of future profit streams. Ordinarily, this rate of recovery occurs between "A" rate of recovery at which total profit is maximized, and "B" rate of recovery at which the current

8. The physical output or gross value of metal "produced" or "sold" may actually diverge in practice, especially where stockpiling occurs. In this discussion, the mineral "produced" and the mineral "sold" are assumed to be synonymous.
rate of profit per time period is maximized. In Figure 1, the pre-tax equilibrium is shown to be at "C" rate of recovery, with "X" representing the attendant present value of future pre-tax total profits.

B. A Flat-Rate Tax on the Output or Value of Metal

The flat-rate severance tax is a cost of production and applies to physical output or the gross value of metal produced or sold. The tax constitutes a fixed unit cost and a fixed percentage of the given price. The total tax on the deposit will vary as a total for the life of the mine with changes in the level of recovery. Since the level of recovery is given, the tax is shown in Figure 1 as a fixed average level-variable cost ($AVC_L$). Also, the tax is shown as a fixed addition to average total unit cost ($ATUC$) and rate-variable marginal cost ($MC_R$).

The tax has essentially the same general effect on the firm's equilibrium rate of recovery, no matter which base is utilized. The tax does not affect the "A" rate of recovery at which total profit is maximized (minimum $ATUC$), since the amount of the tax per unit is the same for all rates of recovery. However, the tax does reduce the "B" rate of recovery at which the current rate of profit is maximized ($MC_R=MR$). As the rate of recovery moves toward the point at which the current rate of profit is maximized, there are not only increases in the rate of output and in gross revenue, but also an increase in marginal cost. The tax shifts upward the entire schedule of rate-variable marginal cost, thereby causing it to equal marginal revenue (MR) at "D" rate of recovery. Thus, the point of maximum current rate of profit retreats to a lower rate of recovery.

The equilibrium is shifted to a lower rate of recovery. The tax causes the diseconomies of speed in profitable mining to be encountered at a lower rate of recovery. Assuming the firm maintains a constant rate of discount before and after the tax, it will be encouraged to reduce the equilibrium rate of recovery in an attempt to approach the maximum present value of future profit streams achieved.

9. The equilibrium rate of recovery can be lower than the "A" rate of recovery only if the time discount is negative as might be the case, for example, if ore reserves are held in the expectation of a substantial rise in price in the future or as a hedge against unfavorable developments elsewhere. Such equilibrium will be higher for higher assumed levels of recovery. With a very high rate of discount, as when market risks are high, the equilibrium rate of recovery will move toward "B" where the maximum current rate of profit is achieved and where marginal cost equals marginal revenue ($MC_R=MR$). The rate of recovery cannot exceed this amount without shortening the economic life of the mine and reducing the current rate of profit. See Carlisle, op. cit. supra note 6, at 601 n.7.
at the pre-tax equilibrium rate of recovery. This adjustment results in the maximization of the present value of future post-tax profit streams over the life of the ore deposit. In Figure 1, the tax is shown to reduce the equilibrium to "E" rate of recovery located between "A", the point of maximum total post-tax profit and "D", the point of maximum current rate of post-tax profit. "Y" represents the attendant present value of future post-tax total profits.

The magnitude of the shift in the equilibrium rate of recovery depends primarily on the firm's cost condition, the output or gross value of metal produced or sold, and the height of the tax rate. A reduction in the firm's rate of discount would accentuate the shift in the equilibrium rate of recovery; conversely, a rise in the discount rate would modify the shift.

In a multi-state metal-mining industry, it has been assumed that the decline in the firm's equilibrium rate of recovery has no effect on industry price and, consequently, on the firm's sales curve. A rise in industry price would probably occur where the taxing state produces a significant percentage of the industry output. Under this condition, there will be an upward shift in the firm's sales curve in the short run, thereby modifying the reduction in the equilibrium rate of recovery. A renegotiation of the firm's sales contract resulting in a price increase in the short run would have the same general effect.

C. A Graduated Versus a Flat-Rate Tax on the Output or Value of Metal

If the severance tax on the output or gross value of metal produced or sold contained a graduated rate schedule so as to be effectively progressive, the amount of unit tax would increase as the rate of recovery increases. Graduated tax rates apply to the tax base arising during a given period, usually one year. As the annual tax base increases, the effective tax rate increases, causing a rise in the unit tax.

10. If the firm desires to maintain the pre-tax equilibrium rate of discount of future profits after the tax is levied, it must decrease its equilibrium rate of recovery. Although the point of the firm's zero rate of discount (also point of maximum total profit) remains unchanged, the point of the firm's highest rate of discount of future profits has shifted to a lower rate of recovery.

11. The graduated rate schedule of a tax does not typically indicate its true or effective progression. Bracket or marginal graduation produces an effective progression substantially below that indicated by the sequence of bracket rates. Only fractions or segments of the tax base are subject to the higher bracket rates. The reduction in the progressivity of the tax can be overcome by adopting lump-sum or totality graduation, whereby each successively higher rate is applicable to the firm's entire tax base.
As compared with a flat-rate tax, it can be visualized in Figure 1 that a graduated tax causes a decrease in the "A" rate of recovery at which total profit is maximized and a more pronounced decline in the "B" rate of recovery at which the current rate of profit is maximized. There is more reason to believe that such a tax, as compared to flat-rate tax, causes a decline or a more pronounced decline in the equilibrium rate of recovery than is shown by the adjustment from "C" to "E" in Figure 1. Whether or not such an adjustment will in fact occur and, if so, the magnitude of the adjustment are determined largely by the height, continuity and steepness of the rate schedule and the size of the firm's annual tax base.

D. A Tax on Output Versus a Tax on Value

The effect of the severance tax based on physical units varies with changing unit prices for the metal. For example, a given tax per ton of metal output probably causes a sharper relative decline in the rate of recovery when the metal is selling at a low price rather than at a high price. Such a tax may curtail the rate of recovery more when it is already limited and the price is falling, and less when the rate of recovery is expanding and the price is rising. Conversely, a tax on the value of mineral produced or sold absorbs approximately the same percentage of the changing price. The tax per unit increases as price increases, and decreases as price declines. The restrictive effects on the rate of recovery do not increase with falling prices and decrease with rising prices, as is the case of a physical-unit tax.

IV
THE EFFECT OF THE SEVERANCE TAX ON THE LEVEL OF RECOVERY UNDER A GUARANTEED PRICE

A. The Theoretical Setting

Assuming the rate of recovery is given, the effect of a state severance tax on the level of recovery of a mining firm in a multi-state metal-mining industry can be analyzed with the assistance of a diagram. In Figure 2 the solid and broken lines present the pre-tax and post-tax situations, respectively.

Assume an irregular ore body containing a given amount of metal is selling at "P" price per ton. The ore boundaries are gradational and a variety of grades of supramarginal and submarginal ore occur roughly in a zonal arrangement. There are numerous choices between
mining the readily accessible, high-grade and high-quality ore and nonselectively mining the entire deposit. Extraction of seventy-five to ninety per cent of the metal in the ore is assumed to be feasible. It is estimated that regardless of the total tonnage recovered a given total fixed cost is necessary for equipment and primary development. The average total unit cost first declines, then rises (U-shaped) as the level of recovery is increased, not only because of the economies of scale, but also because of higher costs incurred in extracting and processing more inaccessible, lower-grade, lower-quality ore. Since the rate of recovery is given, average fixed costs and average rate-variable costs decline as the level of recovery increases. Marginal cost (MC_L) represents additions to total cost as the level of recovery is increased.

Profits per unit of product are greatest at "A" level of recovery
where average total unit costs are at a minimum. Since the rate of recovery is assumed to be constant, this is also the level of recovery at which the current rate of profit per time period (year) is maximized. Total profits are greatest at "B" level of recovery where marginal cost (MC_L) equals marginal revenue (MR). The latter point is the optimum if time distribution of net profits can be ignored, i.e., if the rate of discount is zero, or if the difference in time required to mine alternative amounts of mineral is not great.

Assuming a discounting of profits, the equilibrium level of recovery is that level of recovery which yields the maximum present value of future profit streams. This level of recovery must lie between the "A" and "B" levels of recovery. In Figure 2, the pre-tax equilibrium is shown to be at "C" level of recovery, with "X" representing the accompanying present value of future pre-tax total profits.

B. A Flat-Rate Tax on the Output or Value of Metal

The flat-rate severance tax is a cost of production and applies to physical output or the gross value of metal produced or sold. The tax constitutes a fixed amount per unit of output and a fixed percentage of the given price. Under such circumstances, the tax is shown in Figure 2 as a fixed addition to average total unit cost (ATUC) and level-variable marginal cost (MC_L).

The tax has essentially the same general effect on the firm's equilibrium level of recovery, no matter which base is utilized. The tax does not affect the "A" level of recovery at which the current rate of profit is maximized (minimum ATUC), since the amount of the tax per unit of metal mined is the same for all levels of recovery. However, the tax reduces the "B" level of recovery at which the total profit is maximized (MC_L=MR). As the level of recovery moves toward the point at which the total profit is maximized, there are increases in metal output and gross revenue from the deposit and in marginal cost. The tax shifts upward the entire schedule of level-variable marginal cost, thereby causing it to equal marginal revenue.

12. The equilibrium will approach the "A" level of recovery with a very high discount rate, but cannot be less than this level of recovery, since both the life of the mine and the current rate of profit decline below this level. The equilibrium level of recovery can be greater than the "B" level of recovery only if the discount rate is negative, since above this level the mining firm would be sacrificing total profits for a longer life. For a particular discount rate, the equilibrium lies closer to the "B" level of recovery when the assumed rate of recovery is higher, because the extra time required to mine at a higher level and the consequent loss through time discount are less at higher rates of recovery than at lower rates.
(MR) at “D” level of recovery. Thus, the point of maximum total profit retreats to a lower level of recovery.

The equilibrium is shifted to a lower level of recovery. By raising the critical grade and quality of ore and encouraging the possible abandonment of the more inaccessible ore, mineral that was immediately above the margin before the tax becomes submarginal after the tax. The point of maximum total profit on the stock of ore (where the discount rate is zero) has shifted to a lower level of recovery. Assuming a constant rate of discount, the equilibrium level of recovery shifts to a lower level in an attempt to approach the maximum present value of future profit streams achieved at the pre-tax equilibrium level of recovery. This adjustment results in the maximization of the present value of future post-tax profit streams over the life of the deposit. In Figure 2, the tax is shown to reduce the equilibrium to “E” level of recovery located between “A,” the point of maximum current rate of post-tax profit, and “D,” the point of maximum total post-tax profit. “Y” represents the accompanying present value of future post-tax total profits.

The magnitude of the shift in the equilibrium level of recovery depends primarily on the firm’s cost condition, the output or gross value of metal produced or sold, and the height of the tax rate. An increase in the firm’s rate of discount could accentuate the shift in the equilibrium level of recovery; conversely, a decrease in the discount rate would modify the shift.

As mentioned earlier, it has been assumed that the tax had no effect on industry price, and consequently, on the firm’s sales curve. A rise in industry price would probably occur where the taxing state produces a significant percentage of the industry output. Under this condition, insofar as the tax causes a significant decline in the industry's rate of recovery and a rise in industry price, there will be an upward shift in the firm’s sales curve in the short run. This development would modify the reduction in the firm’s equilibrium level of recovery. Also, a renegotiation of the firm’s sales contract resulting in a price increase in the short run would have the same general effect.

13. If the firm desires to maintain the pre-tax equilibrium rate of discount of future profits after the tax is levied it must decrease its equilibrium level of recovery. Although the level of recovery associated with the highest rate of discount (also the point of maximum current rate of profit and minimum average total cost) remains unchanged, the level of recovery at which the discount rate is zero, i.e., where MCt = MR (also the point of maximum total profit), has shifted to a lower level of recovery.
C. A Tax on Metal Output Versus a Tax on Ore Output

The discussion of the effect on the level of recovery has been in terms of a severance tax based on the output or gross value of metal produced or sold. A severance tax is commonly levied on the physical quantity of raw ore or rock extracted or sold. Such a tax makes little or no allowance for variations in the accessibility, quality or grade of the ore, or perhaps for variations in distance from the market. These and other factors determine how close the ore is to the economic margin. Units of near-marginal ore are worth less than units far above the margin, because it takes more tons of near-marginal raw ore to provide a given amount of metal. By definition, near-marginal ore is more costly to extract and process than ore far above the margin. The marginality of the ore increases as the level of recovery increases. Under these circumstances the "raw ore" tax per unit of metal output increases as the marginality of the ore increases—that is, as there is a rise in the level of recovery. The firm must extract more taxable raw ore to produce a given amount of metal.

As compared with a tax on metal output, it can be visualized in Figure 2 that a tax on raw ore causes a decline in the "A" level of recovery at which the current rate of profit is maximized and a more pronounced decline in the "B" level of recovery at which total profit is maximized. There is more reason to believe that a tax on ore output, as compared with a tax on metal output, causes a decline or a more pronounced decline in the equilibrium level of recovery than is shown by the adjustment from "C" to "E" in Figure 2. As a result, production from the near-marginal deposit or near-marginal portions of the deposit would more likely be restricted. Whether or not such an adjustment will in fact occur and, if so, the magnitude of the adjustment are determined largely by the rate of decline in the accessibility, grade and quality of the raw ore as the level of recovery increases.

D. A Tax on Output Versus a Tax on Value

The effect of the physical-unit tax on the level of recovery also varies with changing unit prices for the metal. For example, a given tax per ton of metal output probably causes a sharper decline in level of recovery when the metal is selling at a low price rather than at a high price. Such a tax may curtail the level of recovery more when it is already limited, and less when it is expanding and the price is rising. Conversely, a tax on production or sales value absorbs approximately
the same percentage of the price. The amount of tax per unit increases as the price increases, and decreases as the price declines. The restrictive effects on the level of recovery do not increase with falling prices and decrease with rising prices, as appears to be the case with a physical-unit tax.

V
THE EFFECT OF THE SEVERANCE TAX ON A MONOPOLISTIC MINING FIRM

A. The Theoretical Setting

The assumptions of a guaranteed market price and a multi-state metal-mining industry are now removed. Some mineral deposits are located within the boundaries of one state and are worked by firms that possess monopolistic or oligopolistic characteristics.

Under general price theory, the monopolist sets industry price, incurs all industry costs, receives all industry profits and, therefore, is in a position to influence future profits by varying present prices, production and costs. Accordingly, he will presumably be influenced by the intertemporal relationships in determining his cost, production, and pricing policies from period to period. Given such intertemporal relationships, the monopolist will presumably determine these policies over a succession of time periods so as to maximize the aggregate of the present value of separate period profits through time (i.e., discounting the separate period profits by the appropriate rate of interest). This implies that the monopolist will not necessarily set price so as to maximize each successive short-period profit. Instead, he should be willing to set price at another level in any present period if it is expected to result in an addition to future-period profits which is greater than the resulting subtraction from present-period profits. Similarly, he may incur present costs which will increase profits in a future period. Therefore, the monopolist attempts to maximize profits over a series of time periods or through time rather than during one period or at a point in time.

The foregoing discussion would seem to indicate that monopoly

14. For a general discussion of monopoly decision-making upon which this paragraph is partly based, see J. S. Bain, Price Theory 233-35 (Henry Holt & Co., rev. ed. 1952). See also Carlisle, op. cit. supra note 6, at 612-14.

Oligopolists, if fully informed and if taking account of the indirect as well as the direct consequences of their pricing and production policies, will behave like monopolists. See E. H. Chamberlin, The Theory of Monopolistic Competition 46-51 (Harvard Univ. Press, 6th ed. 1948). To the extent this situation exists, the following discussion applies to oligopolists operating in the state levying the tax.
production and pricing behavior is particularly consistent with a firm having strong monopoly control over the production of a particular metal. Four possible reasons may be noted for this behavior of the mining monopolist. First, with price relatively stable over a series of time periods, one element of market risk is eliminated and operations can be planned with more certainty. Second, over long periods, by holding price below the current profit-maximizing level, the demand in future periods may be stimulated (shifting the demand curves of these periods to the right) sufficiently to increase aggregate profit from the ore deposit through time. Third, with fluctuating sales, a reduction of price in time of depressed sales may conceivably result in reduced sales at high prices (or increased elasticity of demand at high prices) in succeeding periods of prosperity. Fourth, the principal asset of the mining monopolist is the exhaustible mineral deposit which has a given, although perhaps presently unknown amount of supramarginal ore. Here the firm would tend to price in such a way so as to maximize the present value of future profit streams over the life of the ore deposit. Although the monopolistic mining firm probably makes infrequent price and output adjustments to reflect more frequent changes in costs and sales, from the foregoing discussion it is concluded that the maximization of the present value of future profit streams is the principal pricing and production goal.

B. A Flat-Rate Tax on Metal Output

When in equilibrium, the monopolist is conducting operations at or very near that rate and level of recovery which result in the maximum present value of future profit streams from the mineral deposit. If a flat-rate severance tax, based on physical output, is levied on a monopolist operating at or very near equilibrium, there will probably be a shift in production and price in order to achieve or approach a post-tax equilibrium rate and level of recovery. The adjustments will tend to be to a lower rate of recovery and to a lower level of recovery, and to a higher price. Under such an adjustment the propor-

15. There is a very slight slope to the monopolist's sales curve when the level of recovery is the independent variable. A change in the level of recovery will affect price only insofar as there is also a change in the rate at which the mineral is supplied to the market (rate of recovery). Since the rate of recovery is assumed to be given when examining the effects of the tax on the level of recovery, there is very little, if any, slope to the sales curve when the level of recovery is the independent variable. Accordingly, the effect of the tax on the level of recovery under the assumption of a guaranteed price would appear to apply generally under conditions of monopoly where costs are increasing. However, the presence of abnormal profits would make the adjustment in the equilibrium level of recovery uncertain. See Carlisle, op. cit., supra note 6, at 613 fig. 4.
tionate reduction in the annual tax and in the tax over the life of the ore deposit will probably be greater than the proportionate reduction in the annual profit and in profits over the life of the deposit, respectively. Assuming a constant rate of discount before and after the tax, such adjustments will maximize the present value of future post-tax profit streams from the ore deposit.

In addition to the aforementioned characteristics of the tax, the size of the adjustment in the equilibrium rate of recovery and price, because of the tax, is determined by two additional factors frequently associated with the monopoly case. First, given the slopes of the firm’s sales and marginal revenue curves, the adjustment depends in part upon the cost condition of the mining firm. The largest rise in price and decline in the rate of recovery occurs with decreasing costs, the next largest rise in price and decline in the rate of recovery takes place under constant costs, and the smallest rise in price and decline in the rate of recovery occurs with increasing costs. Second, the adjustment is determined by the relative inelasticity of the firm’s sales curve, caused by the absence of close substitutes for the monopolist’s product. In the probable typical case of a positively-sloped marginal cost curve, an inelastic sales curve is favorable to a large rise in price and a small reduction in the rate of recovery.

If the tax rests largely on abnormal profits of the monopolist and a stable price is expected to maintain or stimulate demand for the mineral, there may not be any adjustment to the tax. If an adjustment does occur, it will take place after a considerable lapse of time.

C. The Flat-Rate Tax on the Value of Metal

The effect of a tax based on gross value of metal produced or sold is more uncertain. Since the monopolist’s sales curve is downward sloping, the tax per unit of output, when the rate of recovery is the independent variable, decreases as the rate of recovery increases. This arrangement, while causing a decline in the rate of recovery at which the current rate of profit is maximized, would tend to cause the point of maximum total profit to shift to a higher rate of recovery. However, the magnitude of such a shift would be determined chiefly by the slope of the sales curve and the trend (increasing, constant, or decreasing) in operating costs as the rate of recovery is increased. The presence of abnormal profits, as mentioned above, may result in no adjustment in the equilibrium rate of recovery. If such an adjustment does occur, it will happen after a considerable lapse of time. These factors, in turn, would be important in deter-
mining if the tax affects the equilibrium rate of recovery and price, and, if so, the direction of the effect.

D. Graduated Tax on Output and Value of Metal

If the severance tax on metal output contained a graduated rate schedule, the amount of unit tax would increase as the rate of recovery per year increases. The same effect, although more uncertain, would be true of a graduated tax on the value of metal produced or sold over the elastic portion of the monopolist's sales curve. This tax arrangement would not only tend to cause a decline in the rate of recovery at which the current rate of profit is maximized, but would also tend to cause the point of maximum total profit to shift to a lower rate of recovery. The magnitude of these shifts would be determined by the characteristics of the tax and the cost, sales elasticity, and abnormal profit conditions. These factors also would determine whether or not the tax causes a reduction in the equilibrium rate of recovery and a rise in price.

CONCLUSION

One of the arguments advanced in favor of the severance tax is that it promotes conservation of mineral resources. Given certain definitions and assumptions, an analysis has been made of the economic effect of the severance tax on decisions of the mining firm extracting a metalliferous mineral, and the implications of the tax for the conservation of this mineral.


Conversely, a few authorities have been cognizant of the adverse implications of certain types of severance taxes on mining decisions. See, e.g., Parsons, Taxation of Mining Enterprises—Federal, State and Local, Hearings on Stockpile and Accessibility of Strategic and Critical Materials to the United States in Time of War Before the Special Subcommittee on Minerals, Materials and Fuel Economics of the Senate Committee on Interior and Insular Affairs, 83d Cong., 1st & 2d Sess., pt. 7, at 237 (1954); R. Barlowe, Land Resource Economics 547 n.17 (Prentice-Hall, Inc. 1958); Commission Appointed to Study the Taxation of Natural Resources to the Governor and General Assembly of Virginia, Report on Taxation of Natural Resources in Virginia, at 67 (1951). For one of the few public finance textbooks that discusses this matter, see M. S. Kendrick, Public Finance 278 (Houghton Mifflin Co. 1951).
The tax *tends* to reduce the speed of extraction and to decrease the total amount of metal to be extracted from the deposit. The first adjustment promotes conservation, but the second adjustment is repugnant to conservation. The occurrence and size of these adjustments depend primarily on the characteristics of the tax and the economic circumstances surrounding the production situation.

The conservation argument on behalf of severance taxation apparently results from considering a special case and giving primary, if not sole, consideration to the effect of the tax on the speed of extracting the metal.