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Property Rights and Taxation in the Australian Minerals Sector

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Property Rights and Taxation in the Australian Minerals Sector[*]

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To own mineral rights is to participate in a lottery. Normally, the economic return from a potential mineral deposit will not be known until after a great deal has been spent on exploration and development. Efficient exploitation of mineral deposits typically involves a large initial outlay on the "mine" and associated infrastructure, including transport facilities. Actual extraction from the "mine" is then spread out over a period of many years. This delay between investment and return causes further uncertainty, since the prices of the mine's outputs or inputs may change drastically over the course of its economic life.

The uncertainty surrounding returns to mining is not qualitatively different from that in other economic endeavours. Just as the uncertain prospects associated with ownership of an item of plant or equipment have a definite market value, so there is some price that will just clear the market for a mineral lease. If state governments were to "give away" mineral rights to properties which offer an attractive lottery, then there would often be multiple contenders for these leases. Scarce resources can be allocated by a number of methods. They could be allocated by queueing on some "first-come-first-served" basis. They could be given as rewards for services rendered in the past or for services promised in the future. Or they could be sold to the bidder willing to pay the highest money price for them.

The amount of money or "works" that a company is willing to pay in order to obtain mineral rights depends critically on how mining operations will be taxed by state and federal governments. Likewise, the amount of revenue that a government will collect from taxation may depend in an important way on the method by which mineral rights are

allocated. A central principle of public finance is that the effect of any tax on government revenue cannot adequately be understood without determining the indirect effects of the tax on revenue gathered from other taxes by the same and other units of government. These interdependencies are especially important in Australian minerals taxation. Therefore we take some care to examine the interaction between various taxes and the method of allocating minerals rights. A truism in the study of public finance is that there are no perfect taxes. Any workable tax scheme will have some perverse incentive effects and some administrative imperfections. Accordingly, the objective of this discussion is not to seek an ideal "neutral" tax, but rather to look at the advantages and disadvantages of some alternative systems and to illustrate the application of some general economic principles that may be helpful in choosing among imperfect instruments.

Australia's Current System

Mineral deposits in Australia are generally owned by the states and developed by private enterprise.[1] Exploration licences and mining leases are granted by the states to firms which intend to develop them. Although there are differences in details from state to state, the systems are broadly similar. Mining concessions are typically not sold for money but rather are awarded according to a system of "work program bidding". If a firm wishes to explore an area of land on which no exploration licence or mining lease is outstanding, it must apply to the state government for an exploration licence. In order to obtain such a licence, it must agree to undertake a certain amount of exploratory expenditure within a specified period of time. Typically, these licences need to be renewed after a period of about five years and the holders of licences are required to relinquish exploration rights to a substantial percentage (25% is common) of the land under licence at the time of renewal. If a firm discovers a commercially viable deposit and wishes to profit from its discovery, it must apply for a production lease. Typically the firm which has made the discovery is given preferential treatment, but in order to obtain the lease, it must promise to spend at least some specified amount of resources within a certain period on developing the property.

State revenue from mining activities is obtained primarily through a

1. Important exceptions include offshore oil deposits and mineral deposits in the Northern Territory, which are owned by the federal government.

system of "royalties" which are proportional to output.[2] The federal government also taxes mining operations, but except in the case of offshore oil, does not charge significant royalties. Its principal instrument for gathering revenue from mining is the "company tax", which is a tax on returns to land and capital net of interest costs. The federal government is also constitutionally empowered to charge an "export levy" on minerals shipped abroad, as it does in the case of coal.

In general, a system of royalties for extraction is inefficient because it will induce mining companies to discontinue operations on mines before it is economically appropriate to do so and will inhibit the development of marginally efficient mines. Where there are royalties, any increase in production from more intensive mining will result in extra tax costs as well as extra resource costs. Therefore, royalties lead mining firms to pursue their operations with less than efficient intensity on every margin.[3] An efficiency loss of this type is known in the economic literature as the "dead-weight burden" of a tax.

Since the state government's revenue comes from royalties and not from the sale of mineral rights, a state government can increase its revenues from minerals by imposing conditions on licences and leases that lead to rapid and intensive exploitation of potential mining sites. To a certain extent, work program bidding may mitigate the dead-weight burden of royalties. In order to obtain an exploration licence or a mining lease, a firm must commit itself to at least a minimal level of expenditure on development and exploration. If the government had full knowledge of the technological choices available to a mining company at every date in the future, it would be possible in principle to award exploration licences and minerals leases only on condition that the recipient develops the property in the most efficient way. But given that thousands of marginal decisions must be made during the life of a mine, most of which must be based on detailed technical information that is not publicly available, it should be clear that, at best, work program bidding could only be an extremely blunt instrument for rectifying the inefficiencies of the royalty system.

A second potentially important source of inefficiency in the current

2. In some cases these royalties are proportional to the value of output and in some cases proportional to the volume of output. For our purposes, this distinction is unimportant. Queensland also extracts the equivalent of a royalty on coal exports by charging "excess rail freight" for coal shipped on the Queensland Railways, which monopolize shipping from Queensland mines. New South Wales has a profits tax on silver-lead-and-zinc mines and on copper, but charges royalties on all other minerals.

3. This point was made rather more succinctly by Senator Peter Walsh, the Australian Minister for Energy and Resources, in *The Bulletin* (3 May, 1983): "... it does not pay to tax marginally profitable production."

Australian system of allocation is the absence of clearly established and fully marketable property rights to mineral exploration and to development of specific sites. Some aspects of the current system can be viewed as efforts to emulate the allocative effects of markets without establishing property rights. In a system where mineral rights can be bought and sold, if a firm sees better prospects for exploring and developing a site than the current owner does, it will be willing to pay enough to buy these rights and can then proceed with its plans. If private sale of mineral rights is not possible, current leaseholders have nothing to gain by surrendering their minerals rights and some possibility for gain from holding them. Works requirements and relinquishment rules reduce the amount of costless speculation of this kind. Even if it is scrupulously and competently administered, however, a system of *ad hoc* rules is not likely to realize all of the subtle possibilities for improved efficiency by means of mutually beneficial trade that are present when property rights can be bought and sold.

It is widely believed that an advantage of the current Australian system of issuing exploration licenses and mining leases only to firms proposing sufficiently ambitious work programs is that it discourages unproductive "speculation" in minerals rights. Economic analysis of the intertemporal allocation of exhaustible resources suggests that this view is misguided. So long as minerals rights can be bought and sold, an individual will hold mineral rights without exploring or developing a property only so long as he believes that the market value of the random stream of income which would arise from postponement exceeds the market value he could obtain from immediate exploration or development. Efficient allocation of resources requires that the schedule for exploration and mining activities on a land parcel or for mining from a known mineral deposit be that schedule which maximizes the market value of the resulting random stream of costs and returns. This means that where mineral rights can be privately bought and sold, competitive firms will have appropriate incentives to time their activities in a socially efficient way. In fact it is precisely through the "speculative" activities of investors who believe that they will gain by waiting to exploit mineral potential that the anticipated demands of future generations are able to influence the rate at which earlier generations exhaust these resources. Perhaps those who believe that speculation is antisocial would do well to reflect on whether they would regard the same activities as socially meritorious if they were renamed "conservation".

If exploration licences are granted only on the condition that the licensee spends a specified amount on exploration, then some areas will
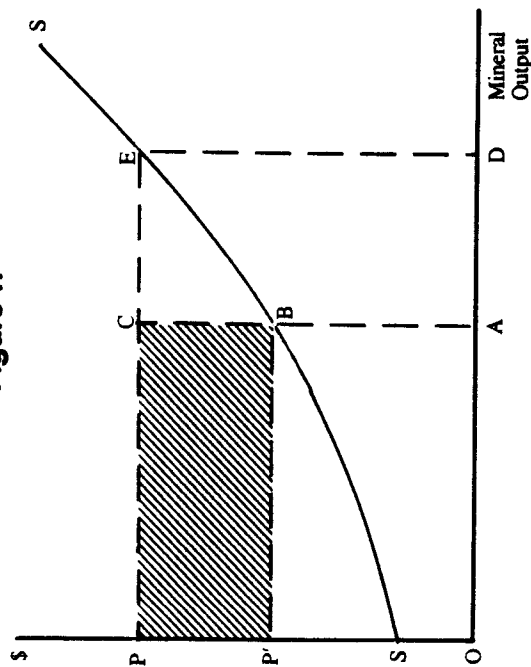
be explored too intensively and others not intensively enough. For many potential mineral sites, the costs of exploration and the probabilities of discovery will be such that the efficient way to explore the site involves a less rapid expenditure of resources than is required by the state as a condition for obtaining an exploration licence. For a site of this kind, some firm may be willing to explore the site in an inefficiently intensive way in order to obtain a licence. Alternatively it may be that although the efficient program of exploration for a site involves positive but small expenditures, no firm will find it worthwhile to meet the work program requirements for a licence and the site remains unexplored. In both cases, the work program requirements induce inefficiency.

The theory of "rent-seeking behaviour" as presented by Krueger (1974) and Buchanan and others (1980) and applied to Australian minerals by Nellor and Clarke (1982) makes an interesting case that Australia's system of work program bidding might lead to substantial over-investment in exploration and related activities. These authors argue that if there is free entry in the bidding process, the equilibrium rate of return on investment (allowing for risk) to those who compete for minerals leases will be no higher than rates of return in other sectors of the economy. Therefore it can be expected that most of the rents to super-marginal properties will be dissipated in economically wasteful "rent-seeking" activities. Marginal deposits will return zero rents after royalties are paid, which implies that those deposits that are better than marginal must return positive rents after royalties if they are to be efficiently developed. Mineral rights to these super marginal sites are valuable property which cannot be bought and sold for money but can only be competed for by offering expensive work program plans. But if work program bidding proceeds to the point where the winning bidder's rate of return after engaging in the work program is no higher than can be found elsewhere, then the works program must result in a waste of resources whose value equals the amount of rent that would have resulted from efficient development. Although some of the rents from super-marginal deposits are undoubtedly dissipated on inefficient work programs, it is likely that some will also be dissipated on lobbying activities and other methods of political ingratiation. Even if some of these rents are not wasted, awarding them at less than their market value constitutes an implicit income distribution which most taxpayers would probably find unpalatable.

The analysis of rent-seeking behaviour in the minerals sector can be illustrated with a diagram. In Figure 1, quantities of mineral output are represented on the horizontal axis and dollars on the vertical axis. For

any price on the vertical axis, the curve SS represents the amount of output that would be forthcoming if suppliers received that price per unit after royalties are paid. The curve SS slopes upward because at higher prices, it becomes profitable to exploit less rich deposits and to exploit the richer deposits more intensively. The horizontal line at P represents the before-tax price of mineral output. The horizontal line at P' is after-tax revenue per unit of output when the royalty rate is T. At royalty rate T, the government's revenue will be the shaded rectangle PCBP'. The total value of the leases which the government has surrendered, however, will be the area PCBS, leaving an untaxed rent of P'BS to those who obtain the leases. Whether this rent is dissipated in nonproductive ''rent-seeking'' activities or appropriated by fortunate domestic or foreign investors and their political friends, it does not accrue to the Australian taxpayer as would be the case if these property rights were sold for their market value. If no royalties were charged, minerals output would be OD rather than OA while the value of the rents associated with mineral rights would be the area SEP. The loss to taxpayers from not being able to appropriate this entire area is therefore the area P'BS + BCE. The area BCE represents the ''deadweight burden'' which is lost to everyone. The area P'BS represents the rents from super-marginal mining activities which are either dissipated in ''rent-seeking activities'' or distributed in arbitrary ways.

Figure 1.

Sale of Unassigned Minerals Rights by Auction

An alternative method of allocating rights to exploratory and mining activities would be to establish a system of marketable property rights to the exploitation of mineral deposits. For that land where no exploration licences or mining leases are currently in force, the government could offer to sell minerals rights to the highest bidder. The purchaser of mineral rights could then choose to explore and develop his property at the rate that seems most profitable given his information. If the government does not charge royalties, then this is the correct system of incentives. If all bidders agreed about the probability distribution of profits to be made from exploring and developing a plot of land, then the winning bid for minerals rights to that plot of land would be approximately equal to the expected value of the lottery associated with ownership of these rights.[4] Where different bidders have different notions of the value of mineral rights, the winning bid will be somewhere ''in the middle'' of the various bidders' expected values. Rational bidders, realizing that if they win the bidding, they will probably have received atypically favorable signals about the site's prospects, will tend to bid less than their own observations alone would suggest. However, the winning bid will be the highest of these valuations. Therefore if no royalties are charged, the government will recover close to the full expected value of the mineral rights that it owns, simply by auctioning them off.

Of course there will be some properties that turn out to yield much more than was paid for them. There will also be properties that return less than what was paid. If the probabilities of profitable discovery at different sites are roughly independent, then on average the gains and losses will approximately balance and the total present value of returns to minerals developers after they have paid for other inputs will be approximately equal to the total amount that was paid to the government for minerals rights. However, some kinds of risks are not independent among sites. For example, an unexpected change in the world price of a mineral will simultaneously affect the value of all deposits. Because of such non-independent risks, it is possible that the government might recover either substantially more or less than the ex post present value of the mineral rights that it sells. In either case, however, it does recover approximately the expected value at the time it sells. ''Windfall'' gains and losses in this environment are not really

4. More precisely, the market value of a random flow of income and expenses will be higher or lower than its expected present value depending on whether this flow is believed to be positively or negatively correlated with random fluctuations in the market portfolio.

windfalls. They are simply the outcomes of gambles voluntarily taken and fully paid for at market value. To confiscate the returns of fortunate risk takers would diminish the amount of risky activity undertaken.

We have argued that if no royalties are to be imposed on output, then the government will recover nearly the full expected present value of mineral rights simply by auctioning them. Furthermore, since there is no taxation on marginal production, there will be no interference with the incentives for efficient exploitation. If the government were committed to a policy of collecting a royalty at some known positive rate but sold the minerals rights at auction, the total revenue of the government from royalties and sale of mineral rights would be lower than if the government charged no royalties and auctioned the rights. The reason is simple. Potential developers of mineral rights will take into account the amount of royalties they have to pay when deciding how much they are willing to pay for rights to any site. They will be willing to bid approximately their expectation of the present value of rents net of royalties. Since, as we have argued, royalties bring an inefficiency into the development of sites, introducing a royalty will reduce the receipts from auctioning mineral rights by more than the amount of revenue collected from the royalty.[5]

If there were no more to the story, it would be hard to understand how governments could be so foolish as to use the royalties system instead of auctioning rights. There are, however, some reasons to expect that an auction system would perform less well than the previous discussion suggests. One reason that has been suggested is that royalties are a method of allowing risk averse firms to share risk with the government, while an auction places the entire risk on the purchaser of minerals rights. For a modern economy, this argument is merely specious. Risk sharing is possible in the private sector through the simple mechanism of portfolio diversification. Investors who do not wish to bear the risk inherent in betting on a particular mine can buy a diversified portfolio (or a share in a mutual fund). That part of the risk which, like the effects of changes in minerals prices, constitutes a social risk, cannot be eliminated even by being borne by the government. In fact, forcing social risks into the government portfolio simply allocates these risks to taxpayers in a way that is less efficient than what could be achieved by a stockmarket, where those people who are relatively more willing to assume social risks bid to do so.

A second reason why auctions might not be an appropriate mechanism for allocating minerals rights is that bidders might collude

5. This is a dramatic illustration of the principle that one cannot adequately analyze the effects of a tax without looking at its effects on revenue from other taxes or sales.

to cheat the government out of the full present value of these rights. It is possible to imagine auction schemes in which participation was so restricted that collusion would be significant. If, however, the bidding is made open to all comers, domestic and foreign, the number of potential participants for most kinds of minerals lease is very large. It is possible to devise closed bidding schemes which would make enforcement of collusive agreements very difficult. Though possibly of some importance in certain special circumstances, the problem of collusion in bidding is likely to be minor.

We now consider two difficulties with an auction system which seem, on reflection, to be more significant. Both of these have to do with the nature of governments. The first difficulty is that a government can not easily make credible commitments about its future behaviour. We have argued that if the government can persuade the investors that it will never charge royalties, then it will recoup a greater present value from sale of mineral rights than the present value it would collect from royalties and the sale of mineral rights. A revenue maximizing government would therefore like to convince investors that it would never in the future impose royalties. The difficulty is that government promises are not always kept. This is particularly true of promises made by a previous administration when it is in the interest of the current administration to break them. One possible device for adding credibility to government promises is to embed them in the constitution through "equal protection" clauses. Of course even constitutional promises can be broken by constitutional amendment or court interpretations.

Perhaps a stronger restraining force on any government is the fact that capricious introduction of taxes on existing investments will discourage future investments. If a government holds a large amount of minerals rights and sells them gradually, the private sector has some "hostages". If the government should introduce new taxes on mines which have been developed, this will reduce the selling prices of the mineral rights it still holds. This restraining influence will diminish if the value of unassigned mineral rights diminishes relative to potential revenue from a royalty on existing mines. These considerations suggest that there may be some advantage to the government in selling off minerals rights gradually rather than all at once. But since a deposit is of positive market value only if there is some probability that it will eventually be exploited, all valuable rights must eventually be sold off. Eventually, then, government promises can not be sustained on this basis alone.[6]

6. In fact, an argument can be made that in certain circumstances unsold mineral rights can not work as credible hostages to make the government keep promises about not

If, however, the government makes promises about minerals taxation and then proceeds to violate them, then anyone who is considering investments in durable plant and equipment in any industry will have reason to suspect that once the investment is in place, new taxes will be introduced on its quasi-rents. (This effect would probably be enhanced if mineral rights were more clearly defined as private property purchased in open markets since there would then be less rationalization for special tax treatment.) If a broken promise to the mining companies reduces the credibility of the government to all investors, then the government will have a substantial incentive to keep its promises. To break them will deter investment and may ultimately reduce the government's revenue. The devices we have suggested should lend some credibility to government promises, but they are unlikely to be entirely convincing. For this reason, the government is unlikely to recoup the full value of minerals rights by auctioning them.

Another difficulty with instituting a scheme of auctioning mineral rights lies in the nature of the Australian federal system. Mineral rights to onland deposits are owned by the state governments, but the Commonwealth also has the power to collect royalties on minerals once they are extracted. Even if a state government could convince potential buyers of mineral leases that it will not later impose royalties, the federal government might seize the opportunity to impose a tax of its own. Such a federal royalty would reduce the revenue of states from sale of mineral rights by more than the amount of revenue that it collects. It would of course be in the joint interest of the state and federal government to co-operate in devising a tax system which maximised joint yield from sale of mineral rights and taxes. It is not at all certain however, that the federal and state governments could strike a bargain on this distribution issue without introducing additional inefficiencies.

It might reasonably be asked whether there is much at stake in the issue of how to allocate currently unassigned minerals rights. Clearly imposing new taxes. The argument goes like this. Suppose that there will be some period in which the last bit of government holdings is sold off. At that time the government can lose no revenue on future sales of mineral rights if it introduces a new tax on operating mines. Therefore, regardless of previous promises, it will be in the government's interest to introduce a royalty at that time (if it has not already done so). Potential buyers, knowing that a royalty will be put on the last bit sold, will accordingly pay little or nothing for minerals rights in this period. In the period before this, the government knows that firms expect a tax in the last period no matter what is done in the next-to-last period. Therefore it is in the government's interest to introduce a royalty at least by the next-to-last period. Applying this line of reasoning repeatedly, we conclude that the firms will expect royalties to be introduced right from the start, and that therefore the government can gain nothing by abstaining from the temptation to introduce a tax.

if there were no costs to obtaining and holding exploration rights or mining rights, then any mineral rights with positive value would already have been claimed. The fact is, however, that the current rules requiring a minimal level of exploratory expenditure per acre make it costly to hold an exploration licence. The mineral rights to some areas of land may be valuable if firms are allowed to explore at their own pace, but not valuable enough per hectare to justify the intensity of expenditure required for an exploration licence. (Similar remarks apply to mining leases.) It would be very interesting to have some empirical estimates of the amount of revenue that could be raised from an auction of currently unassigned minerals rights.

Tax Reform and Existing Property Rights

We now turn to the question of how to treat mineral rights to areas in which exploration licences or mining leases have already been assigned. We have argued that the current system of royalties and the lack of full institutions of private property in mineral rights lead to inefficient allocation. To an economist, the presence of inefficiency means that under current technology it would be possible to rearrange institutions to enable an allocation of resources that makes someone better off without harming anyone else. A logical point of great practical importance for questions of institutional reform is the observation that if the current state of affairs is inefficient and an alternative allocation is efficient, it does not logically follow that the alternative situation is at least as good for everyone as the initial state of affairs. Therefore it is possible to move from an inefficient situation to an efficient situation in such a way that many individuals are badly damaged by the change.

For example, if current holders of leases and exploratory licences were presented with full saleable mineral rights to the land on which they currently hold leases or licences, and if the government agreed to abolish all royalties on mining, the institutional change would be from an inefficient set of institutions to an efficient one. Stockholders in mining companies would certainly be made better off. On the other hand, taxpayers who did not own significant amounts of mining shares would probably be worse off than they are currently because they would have to bear a larger share of the national tax burden. Alternatively, the government could move to a more efficient system by abolishing royalties, cancelling existing licences and leases, and auctioning the mineral rights on all sites to the highest bidder without compensating the current holders. This change would most likely be to the detriment of stockholders in existing mining companies and to the

benefit of taxpayers who do not hold significant amounts of mining stock.

A change in tax policy, even if it is from an inefficient system to an efficient system, will be bitterly opposed and probably blocked politically by any substantial interest group that is damaged by the change. From the viewpoint of those adversely affected, the policy change is equivalent to confiscation of wealth. In a country where tax structures can be unexpectedly changed to the detriment of some property owners, investors are faced with an extra source of insecurity. Aside from issues of equity, the effect of a confiscatory change in tax policy on investor's expectations will tend to reduce investment, both by Australians and by foreigners, in property subject to Australian taxation. It is therefore not sufficient simply to point out that an existing tax system is inefficient. If reform is to be seriously considered, a practical way should be found to correct the inefficiencies in a way which is beneficial, or at least not harmful, to almost everyone.

To find a workable method of nonconfiscatory tax reform is a difficult task and one that deserves a great deal more attention than it has been given. Here we will discuss some of the difficulties involved. We will also suggest a method which, though far from a full solution, may inspire others to devise better mechanisms to solve the problem. Suppose that it was decided to eliminate the current system of taxation of mining by royalties in favour of a form of taxation which did not tax marginal output. If the government could collect exactly as much revenue by means of a lump sum tax[7], taxpayers would be no worse off and stockholders of mining companies would be better off than under the royalty system, since they could now profit from some activities which had previously been unprofitable because of the royalties. In the language of public finance, profits of the mining companies would increase by the amount of dead-weight burden of the tax. In fact, because of the efficiency gain, it would be possible to share some of the benefits with non-mining taxpayers by collecting a bit more revenue with the lump sum tax than was collected under royalties.

The impracticality of this procedure is seen when we ask how the government could find out the amount of royalties a firm expects to pay over the life of a mining project. Of necessity, the firm itself will know more about its future plans than the government. Possibly the government could simply ask mining firms to estimate the time stream of their future output and hence the stream of royalties that they intend

7. By a lump sum tax we mean simply that the amount to be paid is independent of the output level. Thus a lump sum tax might involve a schedule of deferred payments rather than a total amount paid immediately.

to pay. Suppose that the government then set up a system of lump sum taxes whereby the present value of a firm's payments under the new system equalled the present value of the royalties that the firm said it expected to pay. Clearly such a system would give firms a strong incentive to understate their expectations about future activities. While the government might be able to make independent estimates of future activities of each mining project, this would be a very expensive and imperfect project and would itself introduce distortions, as mining companies would try to conceal anticipated activities by avoiding actions which would signal their intentions.

We would like to devise a workable mechanism that induces firms to reveal their estimates of the current market value of royalty payments they expect to make in the future from existing mines. An interesting possibility is to hold an auction for the returns from all future royalties to be assessed against each existing mine.[8] Let us first examine the effects of such an auction in the simple but unrealistic case in which many firms have the same information about the potential of a mine. Suppose that market value of the random flow of returns from the royalty in the absence of reform would be an amount x and suppose that the market value of the dead weight efficiency loss from the tax is y. The right to collect royalties will be worth $x + y$ to the current mine owner since if he owns these rights, he can eliminate the inefficiency caused by a tax on marginal output. If someone who did not own the mine were to buy the royalties, then in the absence of further transactions with the owner of the mine, the value of the royalties to him would be only x. However, it is reasonable to expect that if someone other than the mine owner obtained the royalties, he would either sell them to the mine owner or he would buy the mine so that the effects of the tax could be internalized.

In the event that the royalty revenues are purchased by someone other than the mine owner, there will be a situation of bilateral monopoly between two parties who stand to increase their joint profits by striking a bargain. There are a number of competing theories of the outcome of such a bargaining situation. The best known of these theories is the Nash bargaining solution. The assumptions of the Nash theory are quite appealing when applied to this instance and the implied solution is very simple to work with. In particular, the Nash theory would predict that if the owner of the mine and the owner of the royalty revenues are different people, then the solution will be that the mine

8. This discussion was very strongly influenced by conversations with and suggestions from Peter Hartley.

owner buys the rights to the revenue from royalties for $(x+y)/2$. (Another solution consistent with the Nash theory but, for our purposes, equivalent to the above is that the owner of the royalties buys the rights to the mine for $(z+y)/2$ where z is the value of the mine in the absence of tax reform.) Therefore according to the Nash theory, someone who does not own the mine would be willing to bid up to $(x+y)/2$ for the rights to the royalties since he would be able to resell them for that amount. The owner of the mine would also be willing to bid up to $(x+y)/2$ to purchase these rights from the government. Even though these rights are worth $(x+y)$ to him, he will not bid more than $(x+y)/2$ to buy them from the government, since if he does not buy them from the government, he can purchase them from the winning bidder for $(x+y)/2$. The Nash bargaining theory would therefore predict that if a standard auction with sequential bidding were held, the government would receive an amount $(x+y)/2$. This is a gain for taxpayers other than the owners of the mining company since in the absence of the tax reform, government revenue would have been a random flow whose market value is only x. The owner of the mine will also be a net gainer because he pays $(x+y)/2$ for the elimination of royalties while the value to him of doing so is $(x+y)$. While other theories of bargaining would lead to somewhat different predictions, the results from applying almost any reasonable bargaining theory to the auction proposed above will be similar, with some gains accruing both to mining companies and to other taxpayers.

In a more realistic model, we would expect to find that different bidders have different amounts of information about the prospects of a mine. Usually we would expect that the owner of a mine would be better informed about its prospects than others, and that other potential bidders would be aware that he is better informed. Analysis of auctions for royalties under differential information presents some fascinating problems for study. Such an analysis, however, we leave to be done elsewhere.

We suggest auctioning royalties as a method of replacing the current system of royalties largely to stimulate thought about methods of nonconfiscatory tax reform. More analysis of the effects of such an auction under differential information would be necessary before one could persuasively advocate or oppose such a scheme. Perhaps others can think of better schemes or important modifications. Some might view this proposal as too unusual or radical to be politically appealing. While one could respond that many existing forms of government activity seem at least as strange to an analyst who is interested in efficiency, it might be interesting to look for modifications of the ideas

we have suggested which seem less radical and untried but have similar effects.

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