Mineral Taxation Policies in Developing Countries: An Application of Resource Rent Tax

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THE CENTRAL PROBLEM of mineral taxation policy in developing countries is to establish a stable fiscal framework that, under conditions of uncertainty, obtains a high share of mineral rent for the resource-owning country while, at the same time, ensuring for the investor the prospect of a return on his investment commensurate with his risk. Garnaut and Clunies Ross (1975) proposed a resource rent tax which, they argued, meets these requirements more effectively than the available alternatives. This paper reviews their proposal briefly, comments on some difficulties with it, and outlines a simple extension designed to improve the economic desirability and political acceptability of their approach. The main concern here is to outline a practical framework for mineral taxation that can be applied in developing countries to a wide variety of situations.

In recent years the developing countries have increasingly asserted their national sovereignty over their mineral resources. As a result, relations between mineral investors and governments have radically changed, as the once stable and relaxed political and fiscal environment has transformed into one of unstable agreements and escalating demands for higher taxes and greater national participation. The mineral investor perceives a high likelihood that a favorable agreement reached before investment will be changed if the investment is success-

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ful, thus increasing his reluctance to participate in such investments in developing countries. The increased political risk causes him to require a greater minimum return on investment, and, in turn, reduces both the level of mineral investment and potential government revenue. Thus, while consuming countries grow alarmed by the potential scarcity and high price of future mineral supplies (because of underinvestment in mineral development), so governments of developing countries find it increasingly difficult to maintain their desired level of mineral exploration. [1] In particular, government authorities who have renegotiated fiscal terms to yield the maximum government revenues from existing mines find all too often that in doing so they have choked off any new investment, leading to a loss of revenues in the longer run.

In part, of course, the unstable investment environment is a consequence of the emerging political independence of these countries. But, in part, it is a function of factors specific to mining investments and to the nature of the institutional arrangements that govern the sector. It is no accident that many of the major conflicts arise from disputes in the mineral sector.

Mining is distinguished from manufacturing by its resource rents and its unusually high risk. Resource rent, defined as the profits remaining after deducting the company income that corresponds to the minimum return necessary to attract investment to new projects, is essentially the sales value of the property rights to the mineral deposit. The government, as owner of mineral rights in developing countries, can exact payments from the investor in excess of normal taxes in return for the right to mine. The resource rent varies between deposits, according to ore grade and quality, location, and so on.

Mining is also distinguished by unusually high risk—geological, commercial, and political. Geological risk arises because large exploration expenses have to be incurred, with a high probability that no commercial deposits will be discovered. Diversification of mineral properties, even for large companies, can only partially reduce these risks. Commercial risk, common to all investments, is exacerbated in mining by the large minimum economic scale of production, the fixed single-purpose nature of the

[1] According to Manners (1978, p. 101): "Between 1961 and 1975 . . . the share of the [mining] companies' exploration investment in the developing countries worldwide fell from 57% to 15%."

investment, the long construction lags (often three to five years), which restrict flexibility of response to changing market conditions, and the strongly cyclical pattern of some metal prices. A combination of these features contributes to high perceived commercial risk even following mineral discovery.

Because of the high perceived project risk, the mineral investor typically insists on knowing the policy environment (especially fiscal terms) that will apply in the event of a commercial discovery before exploration is far advanced. He argues that this is essential so that he can assess whether the prospective returns are commensurate with his judgment about the risk of exploration failure. This posture is not surprising in view of the high costs of exploration and the sharp reduction in geological risk that occurs as exploration proceeds. Both investor and government know that, when the incremental expected return is just sufficient to justify project development after discovery, it is considerably below the *ex ante* expected return that would justify the initial exploration program. The investor seeks fiscal terms that recognize his exploration risk, and such terms are obviously best achieved prior to exploration, when the (often hypothetical) alternative for the government that disagrees with the investor's assessment of risk is to accept those risks itself. But, before exploration, it is impossible to know the value of the mineral deposit, and, hence, what would be appropriate resource rent charges. Inevitably, *ex ante* fiscal terms based on a fixed share of output or profits will prove later to be either too severe or too generous. If the terms are too severe, the investor will seek revised terms (or will not proceed); if they are too generous, the government will seek a higher share of the resource rent. The political risks for the investor are acute because of the high probability that renegotiation will take place many years later in a context of immensely reduced geological risk and in a situation where those risks can easily be forgotten by governments (often different governments) that are short of revenues. The political risk, then, is a result of inflexible fiscal agreements agreed before the value of the mineral deposit has been determined.

The result of these conditions is a cycle of instability that has been termed the "obsolescing bargain." [2] Before exploration,

[2] See Vernon (1971, pp. 46–59).

with the investor holding the bargaining leverage, generous fiscal terms are agreed to induce him to make the desired investment. Although much expensive exploration is unsuccessful, once the occasional commercial discovery is brought into production the terms of the original agreement seem overgenerous, leading to strong political demands for new fiscal terms. In some cases, the *ex post* profitability exceeds the *ex ante* supply price of investment, [3] and the government forgoes resource rent because of the inaccurate original valuation of the deposit. In this case, revised terms may permit the government to recapture part of the resource rent, but, in so doing, the process of renegotiation raises the political risk perceived by new investors and, hence, the supply price of new investment. In other cases, the high profits represent the appropriate reward for the *ex ante* risk, which is forgotten once profits are earned, so that revised fiscal terms reduce the *ex post* return below the initial supply price of investment. These terms are certain to halt new exploration and development.

On efficiency and distributional grounds, welfare will be maximized by taxing all rents and the consequent payment to all factors of production at no more than their supply price, while using the revenue proceeds to advance development programs. Under conditions of certainty, this involves setting rent charges so as to equate the net return on investment with the market interest rate. [4] Under conditions of uncertainty, expected rent charges should be set to equate the expected return on investment with the supply price of investment. But, prior to exploration, the expected rent charges cannot be determined, even within a broad range, because the future revenue stream deriving from the investment is wholly uncertain and the supply price of investment is imperfectly known by the government. Furthermore, the supply price of investment is itself a function of government policy.

[3] The term "supply price of investment" is used to refer to the minimum expected (probability-weighted average) return on investment consistent with a decision to invest.

[4] Given perfect competition, information, and foresight, resource rents could be efficiently taxed through competitive bidding for mineral rights. In the real world of uncertainty, risk aversion, and imperfect markets, this approach is not efficient. For a further discussion, see Steele (1967).

From the above statement of the problem it follows that an equitable and efficient mineral tax regime should meet the following basic requirements:

1. The investor's expected tax liability in the event of commercial exploitation should be predictable in advance of exploration.
2. Actual tax liability should be based on revealed *ex post* profitability to avoid the tensions arising from inaccurate *ex ante* forecasts.
3. Actual tax liability over a project's life should be no higher than that for nonmining projects, where it turns out to be marginal or worse (i.e., *ex post* returns are less than or equal to the *ex ante* supply price of investment).
4. Actual tax liability over a project's life should automatically capture for the government a high share of the resource rent (i.e., profits in excess of the *ex ante* supply price of investment).
5. The tax structure should minimize distortions in the allocation of resources and preserve incentives for managerial efficiency.

While, obviously, no tax system alone can eliminate the tensions between mineral investors and developing country governments, a properly designed tax system that meets the above objectives can do much to improve the prospects for a stable and mutually beneficial host-investor relationship.

Problems arise in respect of mineral exploration because governments typically are not prepared to accept the exploration risk themselves. In principle, a developing country could extract the entire economic rent if it was willing to finance the risky exploration stage. Once the commercial value of a deposit is determined, the return to a private partner would be set to reflect his relatively low risk, while the government would appropriate the rent and receive the return for taking the exploration risk. In practice, this option is rarely adopted because of the very high initial costs (not uncommonly reaching US$50 million) and the lack of sure returns. Even where a sound economic case for government exploration can be made, spending on social and economic projects with more immediate and certain returns has tended to dominate. Consequently, very few developing countries (until recently) have engaged directly in exploration.

In this paper, up to the concluding sections, it is assumed that the whole of the exploration and development risk is assumed by the private investor and that the government obtains its share of revenues from taxation alone. It is assumed also that the government is unable to influence the world price of the mineral output. In the concluding sections, there is a brief consideration of some policy modifications that are required if the government funds the exploration or if the government (alone or with others) has some influence on output price. It is then necessary to consider policy instruments (such as government equity and royalties) in addition to taxation.

I. Risk Taking and Taxation

It is widely accepted that decision makers in large mining firms are averse to risk; they accept increased risk only if it is compensated by a sufficient increase in the expected return on investment. [5] Risk aversion tends to increase as the scale of investment increases relative to the firm's net worth. It implies that, if there is a substantial risk of failure, a firm will not invest even where the expected return exceeds the return on riskless investment by a considerable margin. It also implies that, for each investor, there is a positive relationship between increasing risk and the minimum acceptable expected return on investment. The sensitivity of each investor's supply price of investment to risk is determined by his psychological attitude to risk bearing, and this will differ between investors and countries and over time. The important point, stressed by Garnaut and Clunies Ross (1975), is that perceived risk and, hence, the supply price of investment, is strongly influenced by government policy—directly through the tax structure, which determines the posttax probability distribution of possible outcomes, and indirectly by its "track record," which influences the investor's perceptions of political risk. The lower the supply price of investment the greater are the expected rent revenues accruing to the government consistent with a decision to invest.

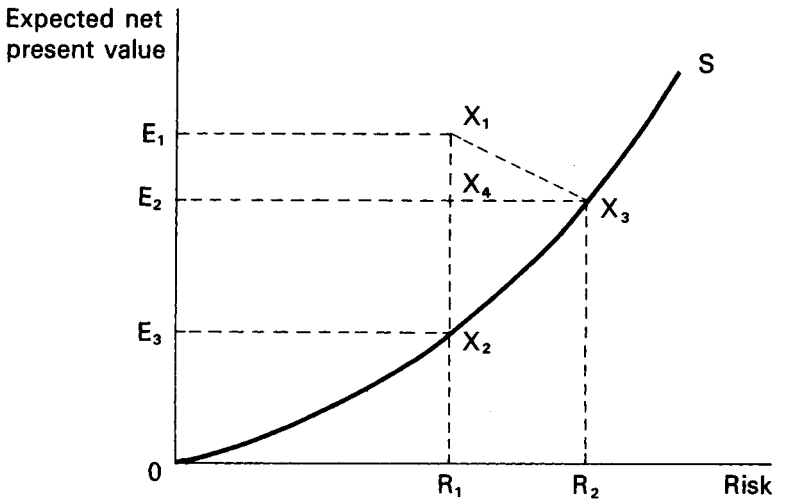
[5] A risk-neutral investor would value a 50:50 chance of either 0 per cent or 20 per cent equal to a certain 10 per cent; a risk-averse investor would require a 50:50 chance of, say, either 5 per cent or 25 per cent—an expected return of 15 per cent—to be equal to a certain 10 per cent.

It is envisaged that each firm will maximize a utility function depending on both the expected return and risk. For risk-averse investors, a supply price of investment function can be defined, specifying the minimum expected risk premium for each level of risk that would give the investor a utility equal to a riskless investment. In Figure 1, the line OS illustrates such a curve. [6] The vertical axis is the expected net present value, discounting at the riskless return, and the horizontal axis is some appropriate measure of risk. The position and slope of OS for each investor depends on his attitude toward risk. The steeper the slope of OS at any point, the more risk averse is the investor. The minimum risk premium that induces investment in a risky project is given for any level of risk, say R_1, by the vertical intercept of OS (OE_3). Consider a project X_1 with a pretax expected net present value of E_1 and risk R_1. The imposition of a tax reduces the investor's expected return and in general affects his perception of the risk. The maximum expected government revenue consistent with a decision to invest depends on how tax policy affects risk. If risk is unaffected by the imposition of a tax, then the posttax risk and return of X_1 lies along X_1R_1, and the government can extract expected revenue equal to E_1E_3. If the tax increases the risk, then the posttax risk and return of X_1 lies along a line from X_1 with a negative slope, such as X_1X_3, in which case maximum expected revenue is reduced to E_1E_2.

Risk may usefully be thought of as a combination of pure risk and pure uncertainty. Pure risk refers to uncertain outcomes for which the evidence of past identical events can be used to determine a probability distribution of possible future outcomes (e.g., gambling or insurance). Pure uncertainty refers to the uncertain outcome of a unique event for which past history cannot be used as a guide to future outcome. Every investment combines both risk and uncertainty—some aspects of a project being more predictable and others less. In mining, geological and commercial risk (for the large firm, at least) are closer conceptually to pure risk, while political risk is closer to pure uncertainty. At the predevelopment stage, firms can, and do, generate probability distributions of such input parameters as ore grade, costs, and metal prices based on past experience, and from these data they

[6] The curve is drawn to show increasing marginal risk aversion. This property, which is not essential to the argument, follows from an assumption that the marginal utility of income declines as income increases.

FIGURE 1. SUPPLY PRICE OF INVESTMENT SCHEDULE



generate a probability distribution of possible outcomes. In contrast, evaluation of political risk must be based on separate, wholly subjective judgments.

Before the impact of taxes on risk and uncertainty, and hence on the supply price of investment, can be evaluated, some operational measure of risk is required. In principle, this requires knowledge for each investor of the utility weights that he applies to each of the possible outcomes, but in practice these weights will not be known. Consequently, it is necessary to use a summary measure of risk that best captures the sense of what investors are observed to mean when they speak of risk. Domar and Musgrave (1944) and Markowitz (1965) note that, in practice, decision makers associate risk with failure to attain a target return. [7] Here, we follow this approach and measure risk in terms of the (absolute) expected value of outcomes with negative present value discounting at the supply price of investment.

If $q_1, q_2 \cdots q_k, q_{k+1} \cdots q_n$ are expected present values discounted at the investor's supply price of investment with respective probabilities $p_1, p_2 \cdots p_k, p_{k+1} \cdots p_n$ such that $q_1 \cdots q_k$

[7] Also see Fishburn (1977). Some studies use the variance of expected outcomes as a proxy for risk, but this is not appropriate where the distribution is skewed, as is usually the case after taxes or royalties, since the effective rate structure is not proportional for all (including loss) outcomes.

$< 0 < q_{k+1} \cdots q_n$ and $\sum_{i=1}^{n} p_i = 1$, then risk, as measured by the expected value of "losses," is $\sigma = -\sum_{i=1}^{k} q_i p_i$.

Investors are, of course, concerned not only with the probability of outcomes worse than their target but also with the prospects for more favorable outcomes. But in developing countries it is anticipated that the investor will tend to discount rather strongly the utility of exceptionally favorable outcomes because of the likelihood that they will increase the political risks of renegotiation or nationalization.

Political risk is evaluated in terms of the likelihood that circumstances will emerge that would act detrimentally on the "rules of the game." A host of general political and economic factors enter this evaluation, but certain sector-specific factors are important. Most important is the past behavior of the country toward mineral investors. Renegotiation of past agreements, even where justified because of inappropriate *ex ante* terms, increases perceived risk; and the terms of the renegotiated arrangement are used as a guide to likely future treatment of a potential investor. Thus, a stable but flexible mineral regime is important to the host government as well as to the investor, since the absence of conflict reduces the supply price of future investment. Also important is the existence of generally applicable mining legislation, since general laws, in contrast to specific negotiated agreements, provide assurances against *ex post* discriminatory treatment.

There is evidence that investors respond to uncertainty by requiring a short payback period from investments (i.e., the period until undiscounted cash proceeds equal initial investment outlays). [8] The rationale is that uncertainty (especially political risk) escalates very sharply over time, and a short payback period is seen as reducing the likelihood of unforseeable outcomes. Projects may have a satisfactory expected return but still be rejected because the profile of benefits is unacceptable. A related reason for concern over the payback period is the need for high liquidity in the early years. Mineral projects are financed to a large extent by borrowings, so that high interest

[8] For example, see Mao (1970).

and capital payments become due in the early years of production. The investor values highly arrangements that increase front-end liquidity, since, by reducing bank risk, his cost of borrowing is reduced, and the period during which the banks have claims over the project assets and may impose restrictions on dividend policy is shortened.

The mineral tax regime must take account of these attitudes toward risk. Two taxes of equal expected yield are of different investor disutility if they affect risk differentially. The impact of the tax on risk arises through its effect on the expected value of unfavorable outcomes and on the expected payback period. Expected government revenues consistent with a decision to invest are higher for the tax that exposes the investor to relatively less risk. The practical importance of this depends on the sensitivity of the supply price of investment to risk. In developing countries it is probable that the trade-off is of great practical importance, implying that a tax regime that operates to reduce risk can significantly increase expected government revenues. [9]

The question then arises as to what constitutes optimal risk sharing between investor and government. In general, this depends on the relative attitudes to risk and the expectations of investor and government. [10] Excessive risk aversion or excessive expectation of risk by firms incurs social costs in the form of underinvestment in exploration and development and results in less government rent than would be socially efficient. If the government judges that this is the case, then it should increase its risk taking. In developing countries, the clearest divergence between social and private perceptions of risk center on political or sovereign risk. Since this is not a social cost, there is a presumption that the government should increase its risk sharing until the utility of increased expected rent is just offset, in its

[9] First-best policy would be for the government to insure the investor against risk that cannot be diversified, but in developing countries this is usually not feasible, especially in relation to political risk.

[10] Leland (1978) has considered this question in terms of the properties of the utility functions of firms and the government. He shows that for identical expectations the less risk averse the government is relative to the investor the greater the risk it should assume. He also shows, for one class of utility function with information asymmetry in favor of the investor, that the optimal payment schedule is progressive with respect to expected wealth.

judgment, by the disutility of extra risk. [11] This judgment would, of course, differ among developing countries.

II. Resource Rent Tax [12]

The resource rent tax proposed by Garnaut and Clunies Ross (1975) is a "profit tax that begins to be collected when a certain threshold internal rate of return on total cash flow has been realized." [13] There is a tax-free period until the threshold return has been earned, with a high proportional tax rate being applied to all net cash flows in excess of this return. In its simplest form, the resource rent tax is similar to a company profits tax with (1) no deductions for interest payments, (2) immediate 100 per cent deduction of all capital expenditure, and (3) unlimited carry-forward of losses bearing interest at the threshold rate of return. If the threshold return and tax rate are correctly set in relation to the supply price of investment, the resource rent tax will tax away the resource rent.

The resource rent tax system avoids the problem of *ex ante* ignorance about costs and prices because it is based on revealed profitability, adjusting automatically to obtain a high share of profits in excess of the threshold rate of return. "By raising the probability of the company's receiving moderate returns and lowering the probability of . . . high returns, 'progressiveness' in the resource rent tax under conditions of risk aversion lowers the expected after-tax profitability (and so raises the expected revenue charges) associated with a given company utility." [14] This gain is obtained by the government at the expense of deferring the timing of revenues and of assuming some risk. Because of the provision for immediate deduction of capital expenditure in the year incurred, rates of taxation could be high for a profitable project in the later years without discouraging new investment.

[11] The evidence of a sharp fall in exploration in developing countries in recent years is certainly consistent with a judgment of suboptimal mineral investment in these countries because of (socially) excessive expectation of risk.

[12] This section is based closely on Garnaut and Clunies Ross (1975). That article contains a detailed discussion of the resource rent tax.

[13] Garnaut and Clunies Ross (1975, p. 277).

[14] Garnaut and Clunies Ross (1975, p. 280).

Under conditions of certainty, if the threshold rate of return is set equal to the interest rate, with tax rate t, then marginal projects pay no tax and the government obtains a share t of resource rents. To appropriate the entire rent, the tax rate is set at the highest level judged consistent with the maintenance of adequate managerial incentives, and the threshold rate of return is adjusted so that the net project return equals the interest rate. Garnaut and Clunies Ross (1979) have analyzed the neutrality conditions for the resource rent tax under conditions of uncertainty. [15] Strict neutrality requires that for each project the government know the investor's expected distribution of possible outcomes and supply price for investment. Since these vary among projects and among investors, strict neutrality implies a different threshold and a different tax rate for each investment. Since the information requirements for such an approach cannot be met, the threshold and tax rate must be set at a level believed, on average, to minimize distortions in investment decisions while maximizing expected rent revenues. They note that "the resource rent tax, even if crudely applied, will have less distorting effects on investment than specific or *ad valorem* royalty systems, than additional proportional taxes on corporate profits . . . or than annually calculated progressive taxes on profits, if each . . . is geared to yield the same expected revenue. . . . The challenge in applying the resource rent tax is to minimize the costs of non-neutrality associated with the collection of appropriate levels of revenue." [16]

In summary, the superiority of the resource rent tax over the available alternatives under conditions of uncertainty arises from the fact that it does not depend on *ex ante* forecasts of expected tax liability but responds automatically and progressively to a wide range of outcomes; by more efficient risk sharing it maximizes expected rent charges consistent with a decision to invest; and it is more neutral than equal-yield alternatives with respect to investment (and reinvestment) decisions.

[15] In their usage, a tax is neutral if it does not change the ordering of possible investments after tax, compared with the ordering in the absence of tax.

[16] Garnaut and Clunies Ross (1979, p. 200).

III. Drawbacks of Resource Rent Tax

As Garnaut and Clunies Ross clearly recognized, the resource rent tax in its ideal form has a number of drawbacks. First, in larger, more industrial economies, where major natural resource projects are funded domestically, the ideal resource rent tax would distort the sectoral allocation of capital. [17] Second, because of the system of foreign tax credits, the long tax-free period under the resource rent tax may not benefit the investor but may simply transfer taxes to the tax authority in the investor's home country. Assuming that the investor incorporates in the host country, dividends distributed prior to the resource rent tax liability are fully taxed by the home country of many foreign investors. In addition, once the resource rent tax is payable, the definition of the tax base is such that it may well not qualify as a creditable tax in some countries, thus increasing the burden relative to a company profits tax. Third, and most important here, the ideal resource rent tax is not likely to be politically acceptable in developing countries. A certain and extended tax-free period, during any year in which high profits may be earned, inevitably invites political demands for changes in the fiscal terms, despite assurances that the resource rent tax will obtain a large share of profits in the future. In practice, it is important for political stability that some significant contribution to government revenues be made in any year that the project is highly profitable.

For these reasons, the resource rent tax would in practice have to be combined with the standard company profits tax, with payments of the latter deductible when assessing the resource rent tax. But, while such a compromise reduces the problems mentioned above, it also strikes at one of the sources of superiority of the resource rent tax (namely that it lowers the supply price of investment by reducing risk). Such a hybrid resource rent tax reduces the probability of earning moderate returns, since tax is imposed before the project reaches the resource rent tax threshold return without increasing the prospect of high returns. If the investor is not to be disadvantaged

[17] In small developing economies, where such projects are funded externally, this concern is not relevant. See Garnaut and Clunies Ross (1979).

under the hybrid resource rent tax, then the resource rent tax threshold will have to be raised, with a consequent loss in expected government revenues.

IV. A Tripartite Tax Proposal

The hybrid resource rent tax needs to be modified so as to reduce the risk of unacceptably low returns or of an unacceptably long payback period without involving *ex post* any loss of revenue from profitable projects. Immediate write-off of initial capital expenditure against company tax liability would reduce risk, and, for projects which subsequently turned out to be profitable, the loss of revenue in the early years would be substantially recouped in later years through higher company tax payments and earlier resource rent tax. But this has the same disadvantages, in lesser degree, as the resource rent tax, in that an extended tax-free period for even very profitable projects would be politically destabilizing and lose potential foreign tax credit benefits.

A preferable alternative is to combine the resource rent tax and the company profits tax with a provision for *conditional accelerated depreciation* that is designed to provide tax relief only in the range of possible outcomes whose expected returns are less than the supply price of investment or whose expected payback period exceeds the desired period. The provision outlined here focuses on the payback period and is designed to ensure that tax relief is available to projects whose cash flow after normal taxes is inadequate to achieve payback within a specified target period. [18] Increased capital deductions in excess of normal depreciation would be permitted against company tax liability, but they would be restricted in time to the payback period and in amount to the extent necessary for after-tax cash flow in any year to equal a fraction, x, of initial investment, where x is the reciprocal of the target payback period (e.g., if the target payback period is four years, x is 0.25 or 25 per cent). [19] The fraction x would be selected by the government to corre-

[18] A current tax relief measure designed to reduce directly the probability of low (discounted cash flow) returns would be difficult to design under uncertainty because of the absence of any determinate relation between annual accounting profit and the discounted cash flow return over the project life.

[19] Numerical examples are given in the next section and in the Appendix.

spond to the period judged appropriate, given investor perceptions of risk and the government's desired level of mineral investment. By reducing risk the threshold rate of the resource rent tax can be lowered, thereby increasing expected rent revenues. *Ex post,* the provision involves no revenue loss for a large range of successful outcomes and ensures some contribution to government revenue from the start of production for any outcome with a high cash flow in the early years. For these reasons the tripartite proposal should contribute to the stability of the fiscal arrangements. It would also minimize distortions arising from different tax treatment of different sectors.

The proposal does not significantly conflict with the maximization of foreign tax credits, although in view of the differing laws for capital-exporting countries, no single uniform approach can fully exploit tax credits. Taking the U. S. system as an example, dividends distributed free of tax from a subsidiary in a developing country would be fully taxed by the U. S. authorities, but undistributed earnings would be exempt under the deferral rule. Since tax relief with the accelerated depreciation provision applies only in the early years for projects with a low cash flow, when debt repayment is high and when dividend restrictions typically apply, distributions in this period would normally be minimal and thus the tax benefits would be effectively retained. Once significant dividend distributions become possible, the tax relief would have terminated, thus avoiding revenue loss at the expense of foreign tax authorities.

V. Simulation Model

In comparing taxes, important concerns are both the impact on the investment decision *ex ante* and the distribution of profits *ex post* between capital income and rent. A simple simulation model has been constructed to illustrate the relative effects of different tax structures. The model calculates the present value of private and public cash flows for specified hypothetical input variables. Monte Carlo simulation is used to generate from a given dispersion of input variables a probability distribution of possible present value outcomes, and public and private expected yield and risk are calculated for each distribution. This

permits the isolation of differential tax-induced risk associated with alternative equal expected-yield tax structures. [20]

All three taxes investigated in this section are levied on profits. Despite the fact that specific or ad valorem royalties on sales value are a familiar form of mineral levy, they are not considered here, since from an economic perspective they are inferior to profits taxes. [21] Even under conditions of certainty they distort the allocation of resources by raising costs at the margin and thereby reducing production and investment below their optimal levels and inducing waste of economic ores. Under the conditions of uncertainty and relative risk aversion postulated earlier, the disadvantages of royalties relative to profits taxes are further magnified. All cost uncertainty (not correlated with revenue uncertainty) must be borne by the investor, thereby increasing his supply price of investment and reducing expected government rent.

The three profits taxes which have been modeled are Tax 1—resource rent tax; Tax 2—the tripartite resource rent tax-company tax-accelerated depreciation system; and Tax 3—a proportional company profits tax (with declining balance depreciation and unlimited loss carry-forward). [22] To evaluate the distributional effects of these taxes, their rates were set so as to generate equal expected tax yields, and the division of profit between capital income and rent was compared for different *ex post* outcomes.

It should be stressed that the rates of tax used were selected arbitrarily (within a realistic range) and have no special significance. The results illustrate the relative merits of the tax structures, and the rates could be adjusted without changing the conclusions regarding structure.

EX ANTE

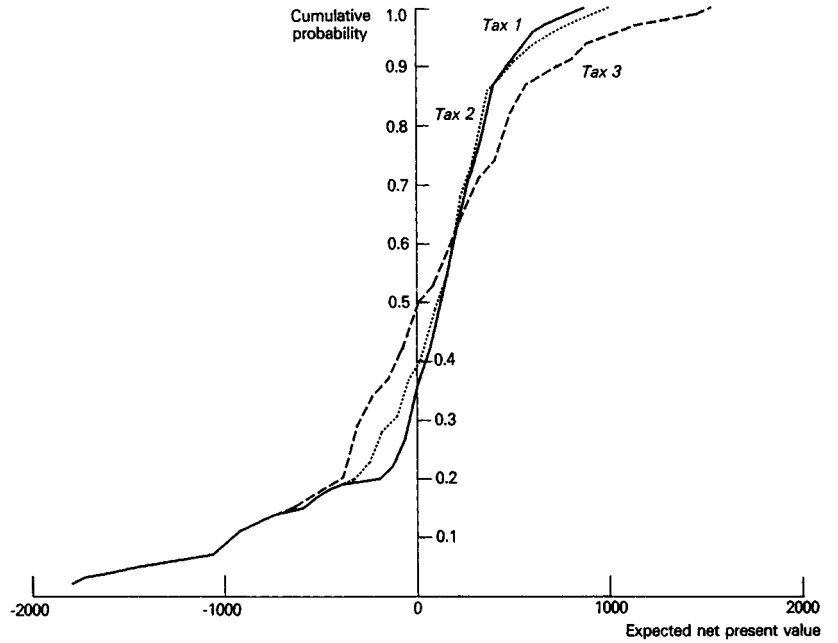
Figure 2 shows the relative impact of the three taxes on the same pretax distribution of possible outcomes when their rates

[20] Addition of investor and government risk-return utility functions would permit calculation of the optimal risk-sharing tax, but, since quite arbitrary utility functions would have to be assumed, this has not been done here.

[21] The economic disincentive effects of royalties are discussed in Steele (1967) and Leland (1978). The widespread use of royalties in the past stemmed from administrative simplicity, without sufficient consideration being given to their distorting effects.

[22] See the Appendix for further details.

FIGURE 2. CUMULATIVE PROBABILITY DISTRIBUTION OF POSSIBLE OUTCOMES WITH EQUAL NET EXPECTED YIELDS [1]



[1] Tax 1, resource rent tax; Tax 2, tripartite tax; Tax 3, proportional profits tax.

are adjusted to generate equal expected public and private returns. Along the horizontal axis is the net present value of private cash flows discounted at 10 per cent (the discount rate arbitrarily assumed to be applied for both private and public cash flows). Private risk, as defined earlier, is represented by the area under the cumulative probability curve that lies to the left of the origin. Private risk is progressively reduced when shifting from Tax 3 (the proportional company profits tax) to Tax 2 (the tripartite tax) to Tax 1 (the ideal resource rent tax), because increasing amounts of revenue are forgone in respect of outcomes with negative present value. This reduction in risk is compensated for by higher average tax rates on outcomes with positive present value. Table 1 summarizes for the same case the relative private and public risk associated with each tax (see also the Appendix).

With tax rates adjusted to give equal expected yields, private risk with the resource rent tax is 16 per cent lower, and with the

TABLE 1. RELATIVE RISK FOR TAXES WITH EQUAL EXPECTED YIELDS [1]

Tax System	Private Risk		Public Risk	
	Expected value of "losses"	As per cent of Tax 3	Standard deviation (÷ mean)	As per cent of Tax 3
1. Resource rent tax	216	84	797 (0.96)	121
2. Tripartite tax	223	87	758 (0.91)	114
3. Proportional profits tax	256	100	660 (0.80)	100

Source: Fund staff calculations.

[1] The taxes generate equal expected public and private yields, discounting at 10 per cent.

tripartite tax 13 per cent lower, than with the proportional profits tax. Conversely, public risk is higher for the resource rent tax and the tripartite tax. [23] For the resource rent tax, if the threshold rate of return equals the supply price of investment, private risk is unaffected by the tax. The results confirm that if the rate for the proportional profits tax (Tax 3) was set in any situation to maximize expected rent and investors are risk averse, then expected rent can always be increased by adopting the tripartite tax or the ideal resource rent tax. In terms of Figure 1, if Tax 3 is set to leave the investor at X_3, then by adopting Tax 1 with equal expected yield, private risk is reduced to OR_1 and expected rents can be increased from E_1E_2 to E_1E_3 without deterring investment.

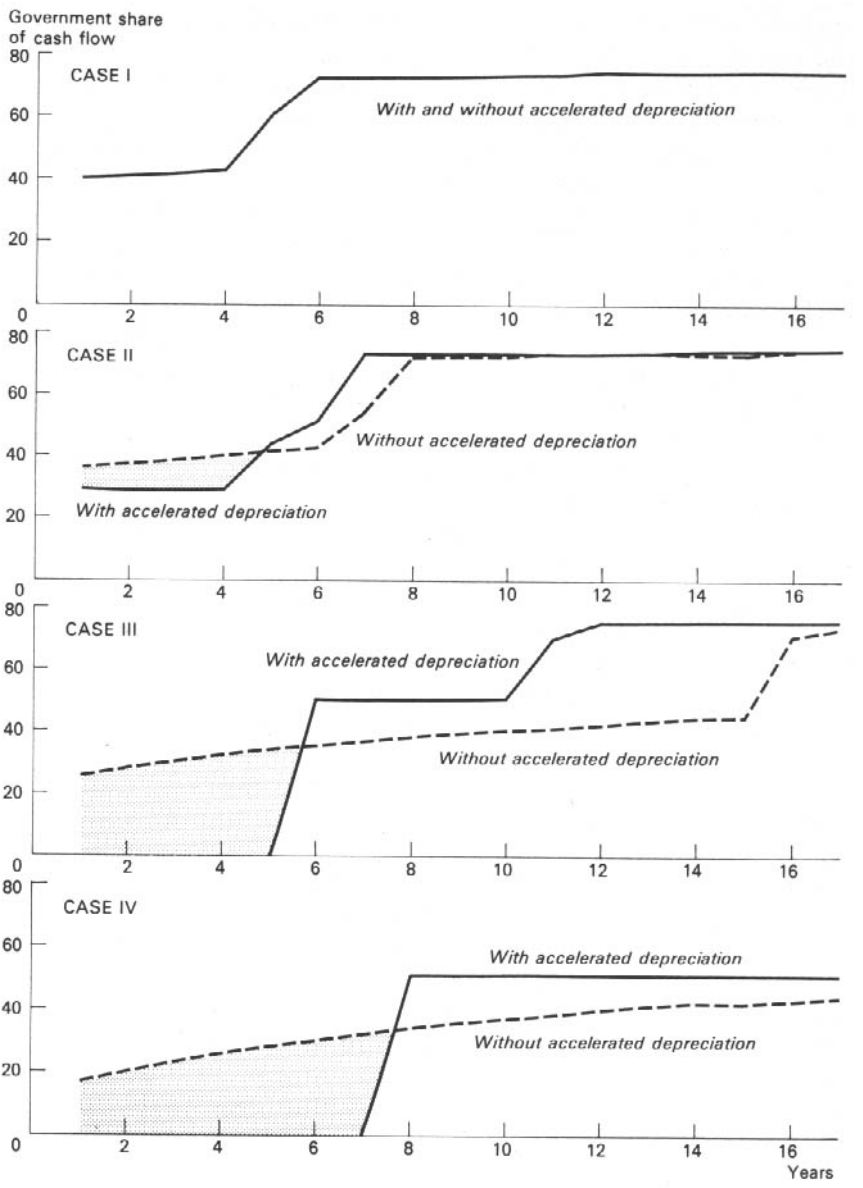
EX POST

This section has two aims: first, to clarify the characteristics of Tax 2 (the resource rent tax-company tax-accelerated depreciation combination) and, second, to compare the effectiveness of the alternative taxes in extracting the resource rent.

To illustrate Tax 2, we use a company income tax rate of 50 per cent, a resource rent tax threshold return of (real) 10 per cent and a tax rate of 50 per cent, and a target payback period of four years. Figure 3 shows, for Cases I through IV of decreasing *ex post* profitability, the profile of government revenues over time

[23] Public risk is measured as the standard deviation, since there are no "expected losses." Total project risk is the same in all cases and is simply shared differently between the parties.

FIGURE 3. PROFILE OF GOVERNMENT REVENUES WITH TRIPARTITE TAX FOR ALTERNATIVE LEVELS OF EX POST PROFITABILITY [1]



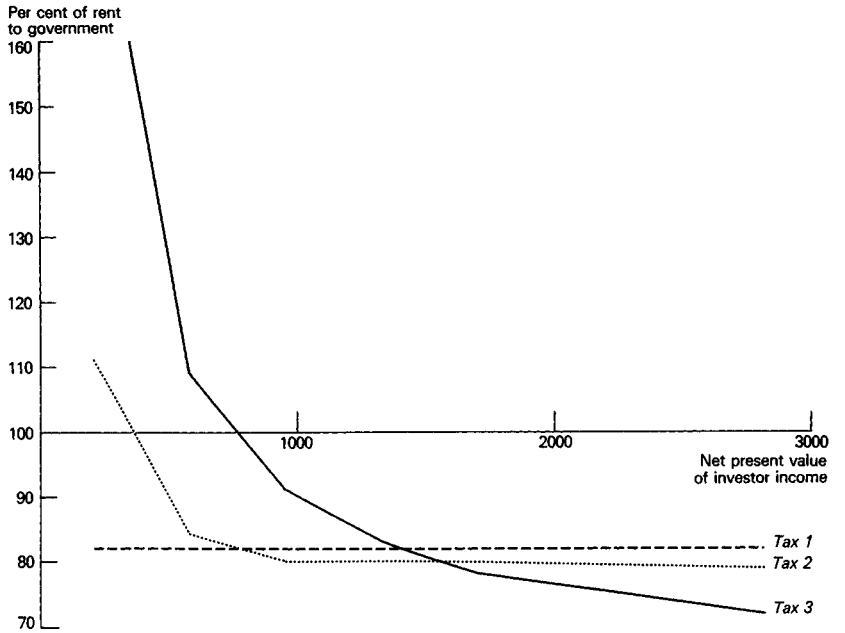
[1] Net of tax internal rates of return with accelerated depreciation are Case I, 21 per cent; Case II, 17 per cent; Case III, 12.5 per cent; and Case IV, 9.6 per cent. In Case I, accelerated depreciation does not apply.

with and without conditional accelerated depreciation. Several characteristics are noteworthy. First, the average tax rate of the system is progressive with respect to achieved profitability over the project life. The more profitable the project the less applicable is accelerated depreciation and the earlier the start of the resource rent tax. Second, for Cases II, III, and IV, the lower effective tax rates in the early years, due to accelerated depreciation, are compensated for by higher rates in the later years (compared with the situation without acceleration). Two factors are at work here. First, since accelerated depreciation is restricted to the initial investment, lower company tax in the early years is compensated for by an offsetting increase later, so that the true cost is only the interest forgone on the deferred tax. The second factor is that with the resource rent tax an extra unit of receipts in year 1 increases the resource rent tax liability in the first year of payment, year t, by an amount $(1 + i)^t$, where i is the threshold rate. Consequently, the undiscounted total of government revenue can be higher with accelerated depreciation than without it. Even on the most conservative assumption that the resource rent tax threshold is unchanged both with and without accelerated depreciation, the net (discounted) loss in revenue from faster write-off will be negligible or zero for all outcomes with returns higher than the investor's discount rate. [24]

To compare the effectiveness of the alternative taxes in extracting the resource rent, the rates for each system have been set to yield equal expected government revenues. Figure 4 shows for each tax structure the share of resource rent (present value of pretax income discounted at 10 per cent) appropriated by the government over a wide range of *ex post* profitability. An efficient tax will appropriate a high share of rents but will not reduce the investor's return below his supply price of investment. By this criterion, Tax 3 is clearly the least efficient, since it taxes the lowest share of rent from very profitable projects but taxes considerably greater than 100 per cent of the rent from low profitability projects (i.e., reduces the net return below 10 per cent). Tax 1 is most efficient, appropriating a constant share of the rent—the share being determined in this case by the tax rate

[24] With the parameter values used here, the discounted loss in revenue, expressed as years of tax holiday equivalent, ranged from zero for a 20 per cent net return to one year for a 15 per cent return, and to four years for a (marginal) 10 per cent return.

FIGURE 4. SHARE OF RENT PAID TO GOVERNMENT FOR ALTERNATIVE PROFITABILITY OUTCOMES [1]



[1] Tax 1, resource rent tax; Tax 2, tripartite tax; Tax 3, proportional profits tax.

alone, since the threshold rate is set equal to the discount rate. Tax 2 is more efficient than Tax 3, since it reduces the range within which the investor's net return falls below 10 per cent, while taxing away a higher share of rent from very profitable projects. [25]

The simulation results confirm that, if risk aversion is a characteristic of mining investors, then investment and expected government revenues can be progressively increased by shifting from Tax 3 to Tax 2 to Tax 1 but at a cost of increased public risk. They also confirm that *ex post* equity (in the sense of taxing a high share of rent but not reducing the investor's return below his supply price of investment) can be progressively increased by shifting from Tax 3 to Tax 2 to Tax 1.

[25] The relative slopes of the lines, not their level, determine the efficiency. The level is altered by changing the tax rates.

VI. The Case of Papua New Guinea

Papua New Guinea introduced mining tax legislation in 1978 along lines very similar to Tax 2. The legislation was preceded by detailed discussions with over 30 mining companies on draft proposals, so the final law provides some indication of the magnitudes of the major tax variables that might be appropriate in comparable situations in other developing countries.[26] For large nonpetroleum mineral projects in the mid-1970s, the supply price of investment was judged to be 10 per cent in excess of the return on riskless investment (measured as the prime lending rate in the United States) from time to time; the tax rate on returns in excess of this was set at 65 per cent. Given the level of perceived risk and cash needs for debt amortization, the accelerated depreciation provision was geared to a target payback period of four years. The case of Papua New Guinea demonstrates the administrative feasibility of the approach, which in practice is no more difficult than the standard company profits tax.

VII. Other Considerations

A practical problem associated with any shift from royalties to profits based taxes is the measurement of profit and the avoidance of transfer pricing. The potential for manipulating output price differs considerably among products, depending on the extent of arm's-length transactions. Where trade is primarily between associated companies, national legislation may be required to govern output pricing. Similarly, on the cost side, legislation or agreements may be needed to limit allowable deductions for certain classes of payments between associated companies (e.g., to amounts approved by the government in advance). Although monitoring transfer prices will always be a problem in some industries and will incur some costs, these should be weighed against the advantages on grounds of equity and efficiency of adopting the sort of profits based taxes discussed here.

[26] For details of the tax law and discussion drafts, see Papua New Guinea Government (1976, 1977, and 1978).

So far it has been assumed that the private investor undertakes all the exploration and development expenditure and that the government is strictly a tax agent. If the government itself engages in, or finances, these risky expenditures then, obviously, it (and not the private investor) should be rewarded for risk taking in the event of a commercial discovery. The same tax package can still apply to the project, but the investor should only earn a return commensurate with the risks that he has undertaken. If he joins with the government after discovery to develop a project jointly, then he should pay a risk premium to the government exactly as he would if he joined with another private investor. [27] The amount of the risk premium would be set so as to equate the private investor's net return to his required incremental expected return following discovery. This can be achieved through the issue to the government of either free equity or carried-interest equity. In the former case, the government receives shares equal to some negotiated multiple of its risk outlays, and the return on risk taking is the corresponding dividend flow. The carried-interest option is essentially the same, except that some portion of the government's share of development costs is financed by the investor and repaid by the government with interest at a rate below the firm's opportunity cost of capital. Here, the interest subsidy—the return on government risk taking—is combined with a painless way of financing a share of the large development costs. In either case, the result is to dilute the investor's return on capital to reflect his lesser risks and to reward the government for its risk taking, while the tax provisions continue to ensure that the government receives a large share of the mineral rent.

It has also been assumed that the government is unable to influence the world price of output. In this situation, ad valorem royalties on sales (or export taxes) are undesirable because they reduce the rate of production and investment more strongly than the tax alternatives. But if the government, alone or in concert, is able to influence world prices, then this factor can be incorporated into the tax package by imposing an additional optimal royalty or export tax at the level that is considered to maximize producer monopoly rent. The ad valorem royalty will then extract the monopoly rent, leaving the resource rent tax to appropriate the differential resource rent.

[27] Sole-risk provisions in the oil industry adopt this approach.

VIII. Conclusions

Despite the trend away from foreign equity investment in developing countries toward new institutional arrangements (e.g., service contracts), there is certain to be a continuing need for foreign risk capital in mining projects for the foreseeable future. There is, therefore, a need for a framework of mineral taxation that adequately recognizes the right of the government to a large share of the resource rent, while also preserving adequate incentives to invest in these projects.

This paper has been concerned with outlining a practical framework of mineral taxation based on the concept of the resource rent tax that meets these objectives. Under conditions of uncertainty and risk aversion, and given the practical problems of the ideal resource rent tax, the resource rent tax-company tax-accelerated depreciation framework outlined above (Tax 2) appears to be more efficient in extracting the resource rent and more neutral with respect to investment allocation than the alternatives and should thus prove both economically and politically attractive.

APPENDIX

Simulation Model Parameters

A simple hypothetical model is used to generate pretax income. Common data are used, except for sales price, which is varied to generate outcomes of varying profitability. The basic data are

Capital investment	year 1 = 1,000, 2-20 = 0
Sales volume	year 1 = 0, 2-20 = 1
Sales price	year 1 = 0, 2-20 = variable (100-700)
Operating costs	year 1 = 0, 2-20 = 100
Depreciation	10 per cent declining balance
Financing	100 per cent equity (for simplicity only)
Private discount rate	10 per cent
Public discount rate	10 per cent

Ex ante: For the results presented here, sales price distribution has a mean value of 350; normal distribution with standard deviation of 50 per cent of mean.

TAX PARAMETERS RELATING TO FIGURE 2

Tax 1: threshold rate of return of 10 per cent; tax rate of 80 per cent.

Tax 2: company tax rate of 50 per cent (unlimited loss carry-forward); resource rent tax threshold of 10 per cent and rate of 50 per cent; payback period of four years.

Tax 3: company profits tax rate of 62 per cent.

Table 2 presents a summary cash flow for Tax 2 to clarify the calculation. Accelerated deductions apply in years 2 to 5, payback is achieved after 4 years of production, and resource rent tax is payable from the seventh year of production.

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TABLE 2. ILLUSTRATIVE EXAMPLE OF TRIPARTITE TAX PROPOSAL: RESOURCE RENT TAX-COMPANY TAX-ACCELERATED DEPRECIATION SYSTEM

	Year											
Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Investment	1,000											
Sales value		400	400	400	400	400	400	400	400	400	400	400
Costs		100	100	100	100	100	100	100	100	100	100	100
Depreciation		200	200	200	200	20	18	16.2	14.6	13.1	11.8	10.6
Taxable income		100	100	100	100	280	282	283.8	285.4	286.9	288.2	289.4
Company tax		50	50	50	50	140	141	141.9	142.7	143.4	144.1	144.7
Net profit		50	50	50	50	140	141	141.9	142.7	143.4	144.1	144.7
Cash flow		250	250	250	250	160	159	158.1	157.3	156.6	155.9	155.3
Target cash		250	250	250	250							
Extra depreciation		100	120	140	160							
Accumulated net cash flow	−1,000	−850	−685	−503.5	−303.9	−174.2	−32.7	122.2	157.3	156.6	155.9	155.3
Resource rent tax								61.1	78.6	78.3	78.0	77.7
Net cash to company	−1,000	250	250	250	250	160	159	97	78.6	78.3	78.0	77.7
Net cash to government		50	50	50	50	140	141	203	221.4	221.7	222	222.3

Source: Fund staff calculations.