Policy, Planning, and Research

WORKING PAPERS

Public Economics

Country Economics Department
The World Bank
September 1988
WPS 90

# A Framework for the Analysis of Mineral Tax Policy in Sub-Saharan Africa

Robert F. Conrad
and
Zmarak M. Shalizi

Overreliance on production sharing and resource rent taxes can expose small, open economies that are neither diversified nor wealthy to unacceptable risks and fluctuations in revenue.

Policy, Planning, and Research

WORKING PAPERS

Public Economics

Given the dual role played by the government as resource owner and tax collector in many Sub-Saharan economies, it is important to separate "resource factor payments" from taxes through the use of different instruments. The instruments to be considered are:

• A factor payment system that includes "ad rem" or "ad valorem" royalties. Production sharing, resource rent schemes, and fixed fees could also be used, but *some form of unit payment is necessary* and justified, because natural resources in the ground are inputs into the production process. Determined in a reasonable manner, such a royalty would signal the opportunity cost of extraction and development, capture the "natural resource rent" and offer an acceptable level of risk to the country.

• A cash-flow and withholding-tax system, initially for the mineral sectors and eventually for other sectors of the economy. The cash-flow tax would capture a share of the "economic rent" from each sector and be neutral across sectors. The withholding system would enable application of an income (as opposed to a consumption) tax base at the individual level.

• A depletion account to preserve the economy's capital stock. Natural resources are part of an economy's capital stock, which will fall unless "replacement investment" is made as the resource is depleted. To ensure adequate saving for this "replacement investment," the account can be funded by the value of depletion each year, equal to the minimum amount necessary to keep the aggregate capital stock constant.

This paper is a product of the Public Economics Division, Country Economics Department. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Ann Bhalla, room N10-061, extension 60359.

## TABLE OF CONTENTS

## Chapter 1: MINERALS IN SUB-SAHARAN AFRICA: A SURVEY OF FISCAL TRENDS AND REVENUE POLICIES

### I. CONTRIBUTION OF MINERALS TO THE ECONOMIES SURVEYED

1.1 Two major benefits accr[illegible] to developing economies from the presence of major mineral resources: foreign exchange and revenue (via taxes and other mineral payments).[1] Downstream linkages to diversified modern manufacturing are largely absent in many developing countries because of the enclave nature of most mineral investments. Domestic demand for finished mineral products is generally insufficient to justify extensive capital-intensive downstream developments for local markets. Thus, mineral products are generally exported, generating substantial foreign exchange earnings.

1.2 Government revenues from the mineral sector include income taxes, indirect taxes and mineral factor payments which may vary from a fixed percentage of gross revenues to complex production sharing agreements where state owned enterprises either own the operations completely (e.g., Zambia) or work in conjunction with foreign investors (e.g., Cameroon).[2]

#### A. Share of Mineral Output to GDP

1.3 The mineral share of Gross Domestic Product for a sample of Sub-

---

1/ A distinction will be made between "taxes" and other payments throughout this report. The major justification for this distinction is found in Chapter 3.

2/ Other benefits to the economy include transfer of technology and employment. Because of the high capital cost per job the employment effects are generally minimal. Transfer of technology can be important. However, these benefits accrue only after a long period of time and most operations in the countries under investigation still rely on foreign skilled labor for both design and operations. For a more extensive discussion of the benefits of the mineral sector to developing economies (including a comprehensive definition of the concept of "Retailed Value") see Gillis, et. al. (1978).

Saharan economies is presented in Table 1.1. These shares vary both across countries and through time within a country. Cameroon's increasing share is an indication of its recent oil development which has just reached potential. A similar trend is found in Botswana with respect to diamonds and other industrial minerals. The declining shares for Liberia, Zaire and Zambia reflect the maturity of the industry, declining ore quality (and consequent increasing costs), depletion and the recent decline in real mineral prices. Only Zimbabwe has had a relatively constant share of mineral value to GDP over a significant period of time. Zimbabwe is also the only country where the share of minerals in GDP is consistently less than 10 percent reflecting Zimbabwe's more diversified domestic economy relative to other mineral producers in the region. Thus other things equal, Zimbabwe may be able to withstand changes in the international market for minerals without large disruptions in the domestic economy.

Table 1.1: Share of Minerals in GDP (percent)

| Year | Botswana | Cameroon | Gabon | Liberia | Nigeria | Zaire | Zambia | Zimbabwe |
|---|---|---|---|---|---|---|---|---|
| 1970 | 10.85 | 0.30 | 30.70 | 29.46 | 7.58 | 21.74 | 36.03 | 6.58 |
| 1971 | 10.77 | 0.65 | 29.65 | 29.03 | 11.63 | 18.59 | 23.14 | 5.79 |
| 1972 | 10.81 | 0.22 | 30.39 | 30.46 | 13.08 | 16.98 | 24.07 | 5.36 |
| 1973 | 10.82 | 0.30 | 30.85 | 26.35 | 18.04 | 22.39 | 32.36 | 6.70 |
| 1974 | 8.50 | 0.37 | 50.12 | 25.74 | 32.88 | 22.03 | 32.61 | 7.31 |
| 1975 | 8.45 | 0.40 | 44.44 | 31.93 | 22.01 | 14.74 | 13.59 | 6.56 |
| 1976 | 12.27 | 0.30 | 33.76 | 23.97 | 25.18 | 12.70 | 17.97 | 7.02 |
| 1977 | 13.33 | 0.41 | 39.52 | 17.62 | 24.98 | 11.22 | 11.77 | 6.78 |
| 1978 | 15.49 | 0.52 | 43.10 | 13.80 | 24.85 | 11.66 | 12.74 | 6.60 |
| 1979 | 22.75 | 2.80 | 49.15 | 11.88 | 27.99 | 16.09 | 17.64 | 8.00 |
| 1980 | 30.04 | 7.24 | 49.89 | 13.70 | 31.23 | 21.78 | 16.38 | 8.29 |
| 1981 | 26.14 | 11.09 | 49.17 | 21.71 | 25.13 | 15.75 | 14.01 | 5.68 |
| 1982 | 16.60 | 11.68 | 52.81 | 20.82 | 21.83 | 11.55 | 11.03 | 4.21 |
| 1983 | 27.83 | 14.76 | 45.63 | 20.01 | 17.03 | 16.63 | 15.34 | 6.41 |
| 1984 | 31.69 | 15.72 | 49.87 | 18.37 | 18.32 | 29.48 | 13.66 | 6.82 |
| 1985 | 36.30 | 17.22 | 46.17 | 17.99 | 21.48 | 28.05 | 12.79 | 6.49 |
| 1986 | 46.87 | NA | 24.41 | 17.98 | 16.65 | NA | 24.62 | 6.25 |

Note: Blank entries imply lack of data--Minerals produced by country--
Botswana: diamonds, copper; Cameroon: petroleum; Gabon: petroleum, uranium; Liberia: iron; Nigeria: petroleum; Zaire: copper, petroleum; Zambia: copper; Zimbabwe: gold, asbestos, nickel, copper.

Sources: See references.

B. Share of mineral exports in total exports

1.4 As shown in Table 1.2, the share of mineral exports in total exports far exceeds the share of mineral value added in GDP and of mineral revenue in total revenues. For instance, more than a third of Zimbabwe's export earnings accrue from mineral exports. A number of factors are responsible for this trend. First, most mineral output is exported, while a significant proportion of output from other sectors is used for domestic consumption. Second, with the exception of minerals, the export base of most of these economies is small.[3] The major non-mineral exports are either agro-based or more traditional manufactured exports, such as textiles. The figures highlight the importance of mineral development in terms of foreign exchange earnings in these economies.

Table 1.2: Share of Mineral exports in total exports (percent)

| Year | Botswana | Cameroon | Gabon | Liberia | Nigeria | Zaire | Zambia | Zimbabwe |
|---|---|---|---|---|---|---|---|---|
| 1970 | 14.8 | NA | 39.9 | 83.2 | 57.6 | NA | 95.3 | 17.7 |
| 1971 | 17.5 | NA | 55.8 | 85.0 | 73.7 | NA | 92.8 | 20.2 |
| 1972 | 43.5 | NA | 55.5 | 88.1 | 82.0 | NA | 90.6 | 16.6 |
| 1973 | 33.8 | NA | 65.1 | 75.9 | 83.2 | NA | 94.2 | 10.9 |
| 1974 | 46.8 | NA | 94.2 | 73.0 | 92.6 | NA | 92.7 | 17.2 |
| 1975 | 51.5 | NA | 94.4 | 79.2 | 94.0 | 72.27 | 90.4 | 22.0 |
| 1976 | 58.3 | NA | 81.6 | 75.1 | 91.8 | 74.55 | 91.6 | 20.0 |
| 1977 | 57.1 | 3.4 | 70.3 | 65.9 | 92.7 | 55.68 | 91.2 | 23.5 |
| 1978 | 68.4 | 14.1 | 87.7 | 60.5 | 89.6 | 56.6 | 87.0 | 20.0 |
| 1979 | 68.7 | 29.6 | 68.9 | 61.4 | 93.3 | 85.41 | 82.6 | 22.8 |
| 1980 | 81.5 | 53.0 | 86.9 | 57.2 | 96.1 | 87.57 | 98.5 | 26.3 |
| 1981 | 64.6 | 63.8 | 77.1 | 66.5 | 96.9 | 88.82 | 93.3 | 18.3 |
| 1982 | 65.8 | 66.9 | 78.2 | 70.7 | 95.4 | 92.53 | 92.3 | 26.5 |
| 1983 | 76.0 | 67.1 | 77.6 | 66.6 | 97.8 | 87.75 | 88.4 | NA |
| 1984 | 79.9 | 68.2 | 90.2 | 64.1 | 97.3 | NA | 83.8 | NA |
| 1985 | 84.5 | NA | NA | 65.2 | 97.1 | NA | 79.9 | NA |

Source: See references.

3/ With the exception of Zimbabwe.

C. Share of Mineral Revenue in Government Revenue

1.5 Table 1.3 contains a computation of the proportion of mineral revenue in total government revenues. The shares for Botswana and Liberia do not include the income from production sharing contracts or other taxes which might be mineral-specific, leading to an underestimate of the true share.[4] The figures for these two countries would be closer to the general trends represented if the data were available. If this adjustment is made, then, with the exception of Zambia, the share of mineral revenues in total revenue is close to or exceeds the share of mineral value added in GDP.

Table 1.3: Share of Mineral Revenue in Total Government Revenue (percent)

| Year | Botswana | Cameroon | Gabon | Liberia | Nigeria | Zaire | Zambia |
|---|---|---|---|---|---|---|---|
| 1972 | NA | NA | 15.2 | 17.4 | 55.0 | NA | NA |
| 1973 | NA | NA | 17.6 | 15.6 | 67.9 | NA | NA |
| 1974 | NA | NA | 43.4 | 12.8 | 81.2 | NA | 56.8 |
| 1975 | NA | NA | 58.9 | 13.0 | 79.1 | 26.9 | 15.2 |
| 1976 | NA | NA | 54.8 | 13.0 | 78.1 | 26.3 | 3.0 |
| 1977 | NA | 5.3 | 56.3 | 17.2 | 74.0 | 26.3 | 0.0 |
| 1978 | 28.4 | 5.8 | 61.1 | 7.6 | 67.4 | 15.0 | 0.0 |
| 1979 | 36.1 | 9.4 | 54.6 | 5.2 | 82.6 | 36.9 | 0.0 |
| 1980 | 37.5 | 39.8 | 60.4 | 4.3 | 81.5 | 28.3 | 5.9 |
| 1981 | 27.3 | 46.3 | 66.5 | 3.4 | 76.8 | 21.4 | 0.1 |
| 1982 | 28.7 | 53.8 | 65.5 | 2.1 | 65.6 | 10.5 | 0.0 |
| 1983 | 37.6 | 41.8 | 64.6 | NA | 61.2 | NA | 5.6 |
| 1984 | 49.3 | 44.1 | NA | NA | 74.5 | NA | 8.7 |
| 1985 | 56.8 | NA | NA | NA | 72.2 | NA | 12.9 |
| 1986 | 60.3 | NA | NA | NA | NA | NA | NA |

Note: Zimbabwe is excluded due to lack of data.

Source: See references.

1.6 It appears that Zambia is an exceptional case. Zambia's proportion of mineral revenues in total government revenue is below the

4/ No computation includes indirect taxes (e.g., import duties) which could not be specifically identified.

values of other countries and this revenue share is significantly below the mineral sector's share in GDP. A number of factors may be responsible for this outcome. First, the fall in mineral prices combined with the large share of debt service paid by Zambia led government to restrict foreign exchange allocations to the state mining company. This led to a decrease in maintenance and plant expansions which in turn led to Zambia's current position as one of the world's highest cost producers.[5] Second, direct budgetary subsidies were made to the state owned enterprise which reduce--or eliminate--the net taxes paid by the enterprise to the government. These factors (combined with the elimination of royalties and the need to reorganize the mining operations) have led to a significant decrease in the sector's contribution to government revenue.

## II. REVENUE INSTRUMENTS

1.7 A combination of revenue generating devices are employed by each country. A general description of these instruments is contained in this section. A detailed description of the instruments employed by each country is contained in Appendix 1. The distinction between "tax" and "factor payment" will not be made for present purposes. The distinction will become important in later chapters.

### A. Income Related Payments

1.8 Major provisions of the combined corporate and mining income tax laws for the Sub-Saharan countries are found in Table 1.4.[6] There is considerable variance in the tax rates. The countries with tax rates above

---

5/ World Bank Report, Zambia 1985.

6/ Details of these laws are found in Appendix 1.

55 percent tend to be petroleum producers (e.g., Cameroon and Gabon), with the exception of Zambia. However, Zambia's system is a two-tier system. One payment is the generally applicable income tax law which applies at the lower rate of 50 percent. The second payment is the "Mining Income Tax". This payment is progressive; is computed in a manner identical to the corporate income tax, and is deductible from the corporate income tax.[7]

Table 1.4: Income Taxes on Mining in Sub-Saharan Africa

| Country | Tax Rate | Expensing of Exploration | Expensing of Development | Depletion Allowance |
|---|---|---|---|---|
| Botswana | 35% | No | No | No |
| Cameroon | 57.5% | Yes | Yes | No |
| Gabon | 73% | Yes/No | Yes/No | Not Known |
| Liberia | 50% | Not Known | Not Known | Not Known |
| Nigeria | 45% | Yes | Yes | No |
| Zaire | 50% | Yes | Yes | Percentage |
| Zambia | Max 76% a/ | Yes | No | No |
| Zimbabwe | 51.75% | Yes | Yes | No after 1982 |

a/ Combined rate of Mining Tax and Corporate Tax on Copper. Rate varies for other minerals.

Source: Appendix 1.

1.9 Immediate expensing of exploration costs is generally allowed by all Sub-Saharan countries. Such expensing is also general practice

7/ Prior to the early 1980s there were no output taxes on minerals and thus the Mining Tax was considered the tax which collected the resource rent (see Garnaut and Clunies Ross, 1983). However, since the tax base is identical to the income tax both taxes are combined for the present analysis.

throughout the world.[8] One justification commonly given for immediate expensing of exploration expenses is the risk associated with the exploration state of the mining process. Immediate expensing is perceived as a means of allowing firms a zero effective tax rate on this proportion of the investment and thus serves as an incentive.[9] However, for new operations (or for new firms operating in a country) immediate expensing provisions may be of little value since there is no income to be offset by the deduction. Therefore, unless the tax system is indexed and loss carry forwards are generous immediate expensing may be offset, at least in part, by the time lag necessary to realize the deduction.

1.10 Immediate expensing of development cost is generally allowed by the countries under study. Like exploration, expensing of development expenditures is standard international practice.[10] Development expenses (intangibles, in particular) are economically speaking self-constructed assets with little or no salvage value: i.e., development expenses are costs associated with the sinking of shafts, removal of overburden, etc. Under standard international conventions, development expenses are a residual category being defined as capital expenditures which are not

---

8/ In the United States domestic exploration expenses are allowed to be expensed subject to recapture. However, in most other developed economies expensing of exploration expenses without recapture is fairly standard practice.

9/ It is well known that immediate expensing of assets on a 100 percent equity investment makes the effective tax rate zero. Since exploration is considered risky it is generally assumed that equity investments are used at this stage of the mining cycle (to the extent that debt can be attributed). Thus the statement in the text is based on these assumptions. If investment is financed by debt and interest can be deducted when computing taxable income, then the combination of full-expensing plus interest deduction can lead to negative effective tax rates, that is investment is subsidized.

10/ The U.S. law restricts this expense for "major" oil producers but other mining operations are not so restricted.

classified under other depreciation categories (e.g., machines). There appears to be two reasons for this type of expensing. First, development expenditures in large measure are made before the mineral is extracted. Granting a zero effective tax on this expenditure (assuming it is an all equity investment) is consistent with the notion of offsetting some of the risk of these large up-front expenses. The second justification is largely administrative. A large component of development expenses include labor and variable materials expenditures which are used to construct assets and there is an administrative problem in determining what part of labor and materials should be capitalized and what part should be allowed as deductions for ordinary operations.[11]

1.11 Prior to 1982 only Zaire and Zimbabwe allowed a deduction for depletion allowance and these allowances were computed according to percentage depletion. In theory, depletion allowances are similar to depreciation. The owner of an "economic interest" in the mineral resource should receive a deduction for the "user cost" of capital: i.e., the reduction in the present value of the mine from depleting the resource. Under western legal concepts the term "economic interest" extends both to the owner of the resource and the operator.[12] Most developing countries have not followed this logic and thus depletion allowances are not generally granted to operators.

---

11/ This problem is present with all self-constructed assets. One solution to this problem would be to state that all expenditures made before the date of commercial operations are development expenditures and can be capitalized. However, this system would work only for new developments for firms which have no other operations in the country.

12/ For example, if a producer pays a bonus to the resource owner of 1,000 and the owner's cost basis of the property is 9,000 then the depletion deduction would be split between the producer and the owner in proportion to their economic interest: i.e., 10 percent to producer and 90 percent to owner.

B. Output Taxes

1.12 The general structure of output levies for each country is found in Table 1.5. Payment schemes based on output vary from country to country. In oil producing countries (Nigeria, Cameroon and Gabon) the output payments are called production shares and are based on contracts with the foreign operator. In Gabon and Nigeria it appears that these payments are determined on a contact by contract basis. In Cameroon the output share is thought to be progressive and based on cumulative production.[13] Output levies are generally flat rate with the exception of Liberia and Cameroon. Thus, these countries have not adopted windfall taxes and other progressive revenue devices which have become somewhat popular in other countries (e.g., Indonesia and some provinces in Canada) and in the economic literature (Conrad and Hool (1984a)).[14]

C. Other Revenue Instruments

1.13 Mineral producing countries obtain additional revenues via equity participation in projects. Paid equity is included as part of the production sharing contracts in Cameroon, while free equity was historically part of the concession agreements in Liberia. State owned enterprises are responsible for the industry in Zambia and Zaire (with the exception of petroleum). Thus any fiscal residual after tax also accrues to these countries. Zaire also receives 15 percent of the net of tax

---

13/ The actual form of the production sharing arrangements in Cameroon is not known with certainty. The information contained in Table 1.5 and in Appendix 3 are based on the World Bank staff's information about the form of the contracts.

14/ The distinction between an output levy and export levy is largely semantic in the present context, since most of the output from operations in these countries is exported. That is, the economic incentives created by either instrument are identical if 100 percent of the output is exported. Thus, both types of levies have been group together in table 5.

profits from petroleum operations (a type of free equity) and Gabon receives 10 percent free equity in its petroleum operations.

Table 1.5: Royalties, Output and Export Taxes on Mining in Sub-Saharan Africa

| Country | Name | Base | Rate |
|---|---|---|---|
| Botswana | Royalty | Value | Varies with mineral |
| Cameroon | Production share | Value | 60% 1st 15 mb<br>65% 2nd 15 mb<br>70% excess a/ |
| Gabon | Production Share | Value | Varies with contract |
| Liberia | Export | Volume & Value | $US 0.05/ton base tax plus 1% of excess value above administered price |
| Nigeria | Royalty | Value | Varies with contract |
| Zaire | Royalty | Value | 7% base plus progressive rates from 4 to 40% |
| | Royalty | Value | 12.5% |
| Zambia | Exports | Value | 10% plus 3% surtax |
| Zimbabwe | Not Known | | |

a/ mb = million barrels of cumulative production.

Source: Appendix 1.

1.14 The use of equity participation can be justified on the grounds that the country and the investor bring two different but necessary types of capital into the operation: the country brings the resource itself and the firm brings physical capital and expertise. However, this analogy is limited. The investor sees "free equity" as a reduction of his return on the physical capital above the reductions already incurred via income and output payments. In effect, free equity is perceived as a means of

increasing the country's returns beyond those generated via other fiscal instruments. Equity (either free or paid) also may not generate the returns one expects. The investor will have an additional incentive to transfer price income out of the country via excessive debt, management fees, royalties for technical know-how, etc., if free equity is employed. Finally, the returns from equity participation on any specific project will accrue, if at all, only after considerable period of time. In general, a significant portion of the physical capital must be recovered and debt repaid before any significant dividends are declared.

## III. THE COSTS OF MINERAL DEVELOPMENTS

1.15 Significant mineral discoveries in a developing economy are not free of economic costs. At least four economic costs are part of the mineral development process. First, governmental administrative costs are increased with mineral discoveries. The size of the these costs depends on the nature of the fiscal arrangements and how the country chooses to organize the sector's activities. Most countries have chosen to organize the sector via state-owned enterprises (SOE's). Contract negotiations, fiscal arrangements and mining policy decisions are part of the SOEs mandate. The labor and capital employed by the SOE must come at the expense of other sectors incurring an opportunity cost for foregone output.

1.16 Second, the return to mineral ownership is uncertain. This implies that the economy may bear additional risks as a consequence of the mineral discovery in exchange for the rewards of mineral ownership. The extent of risk bearing will be determined (either explicitly or implicitly) by the manner in which the government structures the mining sector. For instance, if the government sells rights for a flat fee and allows private investors to make all decisions then there is little risk borne by society

from the minerals per se.[15] Most countries do not follow this strategy. Rather mineral contracts contain various payments which vary with income, output or value and thus the society is exposed to the risks of relative changes in mineral production and profitability.

1.17 The third cost, related to risk bearing, is the cost of portfolio diversification. A resource rich economy is by definition relatively poor in other assets. Governments in this type of economy must decide the extent to which diversification of the economic base should be undertaken. Portfolio diversification can be difficult because minerals in the ground are not fungible (as the discovery of a $1,000 in cash would be). In addition, the country may not have complete access to international capital markets which makes it difficult to diversify the asset base without physically extracting and selling the resource.[16] This implies that diversification may only occur through time as the asset in the ground is extracted and sold making diversification a costly and dynamic process.

1.18 The final cost which may be imposed on the economy is the so-called "Dutch Disease".[17] The causes of this phenomenon are now fairly well known. The discovery of significant enclave resource deposits increases the wealth of the economy by the present value of the flow of net

---

15/ There is still some residual risk if mineral prices are correlated with other prices in the economy. However, the statement above relates only to the risk of direct ownership.

16/ If capital markets were perfect, costless and developing economies had complete access to these markets then the country could sell shares in the mineral discovery, engage in various hedging strategies, etc. which would diversify the asset base to accommodate a particular level of risk.

17/ For an extensive discussion of Dutch Disease see Harberger (1984), Benjamin and Devarajan (1885a, b), Benjamin et. al (1985) and van Wijnbergen (1984).

revenues.[18] If tradables and non-tradables are normal goods, the increase in wealth will increase the demand for both types of goods, as well as increase the opportunity costs of production in the traditional sectors of the economy. If non-tradables are not in perfectly elastic supply and/or the increase in wealth increases the real wage then the real exchange rate will rise (i.e., the price of tradables in terms of non-tradables).[19]

1.19 An increase in the real exchange rate combined with a change in comparative advantage created by the mineral discovery and the capital-intensive nature of mineral production will force the economy to adjust to a new combination of output and a new wage-rental ratio (assuming capital is in perfectly elastic supply at the world rate of return). This adjustment may make traditional exports non-competitive at world prices creating structural unemployment and capital losses in the traditional export sector.[20]

1.20 "Dutch Disease" may also work in reverse as the mineral is depleted. Eventually, extraction will create an erosion of the comparative advantage in minerals creating the need for the economy to adjust once again to a new equilibrium. Thus "Dutch Disease" and portfolio diversification may be interrelated in the sense that a change in mineral prices may be negatively correlated with the value of traditional exports

---

18/ Net revenues will be a function of contract arrangements. Thus, risk sharing will necessarily not be a part of the process.

19/ Real effects are discussed exclusively in this section. For a discussion of the monetary effects of "Dutch Disease" see Lewis (1984).

20/ It is not necessary for the real exchange rate to rise for Dutch Disease to occur. The structural changes may be induced by the properties underlying the Rybczynski Theorem (1955). A natural resource discovery may shift the economy's transformation curve in such a manner that the production of minerals will increase and the production of other tradables will fall given world prices.

via the real exchange rate. Such a correlation could be a desirable portfolio strategy (i.e., it could be a hedging strategy) if the traditional sectors survive the transition and adjustment costs are kept to a minimum.

1.21 It should be noted that "Dutch Disease", is a problem created by an increase in the economy's wealth. It is impossible to eliminate the problem.[21] However, the problem can be divided into two components: (1), who gets the benefits and who bears the cost of mineral development?; and (2) what should the government do to prepare the economy for the transition to and from a relatively mineral-intensive economic base?

1.22 The distribution issue involves consideration of who benefits from the increased price of non-tradables, the distribution of mineral revenues and who bears the cost of the transition. Government expenditure and revenue policy could be designed to compensate for these adjustments.[22] Government policy will depend on whether the mineral find is perceived to be permanent or transitory. The need for stabilization of traditional exports, etc., will be more important if resources are planned to be

---

21/ Any comparative-static or dynamic change in the nature of comparative advantage in an economic system will necessitate adjustments. The only way to avoid these costs is to leave the resources in the ground. But as long as the increase in wealth is greater than the adjustment costs it would not be in the interest of the economy to follow such a strategy.

22/ Technically speaking, the creation of new wealth via a mineral discovery is not a real but a pecuniary externality. Abstracting from risk bearing, efficiency issues are not a concern. Furthermore, if those adversely affected by Dutch Disease were all wealthy with diversified portfolios then there would be little justification for any government action. The real issue is the cost borne by poor, nondiversified individuals in the traditional sectors whose welfare may fall if no compensation is made.

exhausted in ten years rather than one-hundred years.[23]

1.23 For any single country, resource endowments are generally perceived as temporary. Thus, it is advisable for governments to make both short-term and long-term adjustments. Short-term adjustments include assistance to those hurt by the change in relative prices. Long term policies revolve around the use of mineral revenues so that the transition both to and from the new comparative advantage is made as smooth as possible.

1.24 An implication of this discussion is that revenue and expenditure policy in the natural resource area might be more intimately linked than in other sectors. The timing of revenue flows and the method used to accrue revenue may affect the government's flexibility, the size of the total benefits (in present value terms) which will accrue and the nature of risks borne by the economy. Government policy should be designed to account for these factors by using as many tools as possible and thus revenue/expenditure/savings policies should be coordinated.

## IV. SUMMARY

1.25 The preceding discussion contains a number of implications. First, the importance of mineral revenue in total revenues should not be considered an indication of "over taxation" in the mineral sector.

---

23/ This problem is similar to a professional athlete who knows that his/her playing days are numbered. If his/her wealth from athletics is high than development of alternative types of human capital may not be necessary. A good financial plan will ensure high steady-state consumption. However, a player who is not paid a great deal during his/her playing days must be concerned about employment after retirement from athletics. This may require human capital investments in alternative jobs skills, etc., skills which are not necessary for the super star.

Government receives payment of both taxes and "royalties" for the mineral rights. Thus it is expected that "total revenue" (return for mineral interests plus taxes) would meet or exceed the share of revenue from other sectors in which the government does not have an ownership interest. Large shares of mineral revenue to total government revenue may indicate either a narrow revenue base from other sectors or reduced rates of taxation (and/or enforcement) on other sectors.[24] The importance of minerals in GDP and government revenue also indicates that the economies may be subject to variability resulting from changes in market conditions. In particular, Zambia, Zaire and Nigeria have experienced recent difficulties which resulted in part because of their dependence on minerals for government revenues.[25]

1.26 Second, the structure and level of taxes and other levies on the minerals sector in Sub-Saharan Africa (with the possible exception of Zambia) are similar to other mineral exporting countries.[26] Both output and income related levies are used. Profit sharing is also common where minerals are extracted under contract. The computation of income for either tax or profit sharing purposes is similar to definitions used in most countries and thus the tax systems are subject to the usual administrative problems of transfer pricing, thin capitalization, etc.

---

24/ This phenomena appears often. For instance, there was a significant drop in tax effort in Indonesia after the increase in world petroleum prices. (Conrad 1984).

25/ Expenditure policy may play an important role in diversification efforts and buffering shocks. This issue will be discussed in Chapter 4.

26/ See Gillis (1978), Gillis and Beals (1980), Conrad (1980) and Conrad and Convery (1981). The fact that the taxation of copper in Zambia is high may be irrelevant since the industry has paid little or no taxes in recent years. It is not clear whether the lack of taxes is caused by the high rate of taxation or other factors.

which are part of any system where the objective is to measure the base on an accrual basis. Output levies are based on value, not volume (except Liberia), and this practice requires a determination of output prices for commodities which are not homogenous in the world market.

1.27 Third, even though the levy structures are comparable to international standards, this does not necessarily imply that improvements are not necessary with respect to structure or intent. In particular, the costs of mineral development do not appear to have been adequately addressed. For instance, the inclusion of all mineral levies in government revenues makes the distinction between tax and factor payments impossible to identify. The role of risk sharing with respect to both contracts and tax policy may be equally ambiguous.[27]

1.28 At least three costs have been discussed for a mineral rich economy: (1) the intertemporal opportunity cost of extraction (or scarcity value of the resource); (2) risk and portfolio effects; and (3) Dutch Disease (which may be related to point 2). These costs do not require just "tax policies", but also sound policy for government as resource owner. Compensation for these costs should be part of efficient resource and/or contract policy. Economic costs and tax policies can become confused when the mineral owner is also the tax collector. However, clear identification of objectives and instruments is essential for a thorough understanding of the development of rational alternatives. For this reason, the subsequent chapters will be divided so that a separation of tax from factor payment policy will be maintained. Traditional "tax analysis" will be contained in

---

27/ It is impossible to second guess the policymakers in each country responsible for developing mineral policy. However, actions and policies such as nationalization, windfall profits shares, etc., indicate that risk sharing, Dutch Disease, have not received adequate attention in policy planning.

Chapter 2. Contract policy will be discussed in Chapter 3. Chapter 4 will contain an evaluation of current policies in Sub-Saharan Africa based on the discussions contained in the previous chapters. Alternative strategies are also discussed in Chapter 4.

# Chapter 2: MINERAL TAXATION: GENERAL PRINCIPLES

## I. INTRODUCTION

2.1 Taxation, as opposed to factor payments[1] , of the minerals sector may create incentives on all margins: exploration, development, extraction and domestic processing (see Section II). This chapter contains a description of these allocative effects. Tax instruments included in the discussion are: output taxes (both per unit or "specific", and per unit price or "ad valorem") which have either flat or variable rates; profits taxes (either flat or variable rate); and special types of so-called "windfall" profits taxes or resource rent taxes.

2.2 Mineral tax analysis applied to most developing countries is complex for a number of reasons. First, the government must play a dual role because the mineral rights are often held by the state. In this role government is responsible for reasonable mineral development and ensuring it (the government) receives payment for an input which it owns (i.e., the mineral in the ground). Thus, it may be difficult to separate the role of resource owner from tax collector in practice. Tax analysis will be examined below by assuming that all factor payments are exogenous.[2] This assumption will facilitate the discussion since all additional payments to the government are clearly defined as taxes and thus allocative effects can be examined.

---

1/ An analysis of factor payments is contained in Chapter 3.

2/ Alternatively, it could be assumed that the resource producer is also the resource owner.

2.3 Second, mineral development is conducted primarily by either multinational enterprises or state-owned enterprises, particularly in early stages of development. International tax issues are raised by the presence of foreign firms, whereas tax analysis of public sector enterprises requires an analysis of the behavioral and institutional constraints in which these entities operate.[3]

2.4 The analysis will proceed as follows. Section II contains a brief description of the mineral extraction process. Traditional tax analysis under conditions of perfect certainty is contained in Section III. Uncertainty is introduced in Section IV. Taxation of foreign investors and SOEs is found in Section V. Section V also contains a tax analysis of various contract terms.

## II. THE MINING PROCESS

2.5 The mining cycle[4] includes the following four general components:[5]

(1) Exploration: Exploration is generally composed of two parts. Wide areas are examined to determine the presence of geological anomalies and promising formations in the initial stage. The second phase involves intensive efforts in promising areas via drilling and sampling, to determine the extent of the mineralized area and the area's particular geophysical/geological properties.

---

3/ Gillis (1977) and Gillis et. al (1980). The discussion of state owned enterprise is deferred until Chapter 4.

4/ The description provided below is based on Conrad (1978a, b, 1981a, b, 1982, 1984), Conrad and Convery (1981) and Conrad and Hool (1980, 1981, 1984a, b).

5/ A more detailed description of this process is contained in Appendix 2.

(2) Pre-Development Planning and Development: Preliminary financial and engineering analysis is conducted during this phase. Alternative plant sizes and extraction methods are developed given the geological information obtained during exploration. These studies are used to determine the potential profitability of development and extraction under a variety of circumstances. At the development stage financing is obtained and construction begins.

(3) Extraction: Once extraction begins the firm is constrained by all prior decisions. Short-run xtraction decisions are limited to currently developed areas. Quantity and quality extracted are determined relative to fixed capacity and the design characteristics of the downstream activities, if any. For instance, concentrators in metallic minerals are designed to make "runs" assuming a constant average grade of ore (within a range) and adjustments to changes in the ore quality are timing consuming and costly.[6]

(4) Processing: Different degrees of processing can take place close to the ore or closer to final markets depending on transport costs and the type and size of market served.

2.6 These components lead firms to form a series of sequential problems. That is, exploration decisions are made which impose constraints

---

6/ See Conrad (1981), and Gillis and Beals (1982) for a description of this process.

on development and development decisions impose constraints on extraction. The cash flow generated from extraction (and the ability to raise outside funds) feed back onto future exploration decisions and impose a constraint on the number of plays which the firm can take in any time period.[7]

2.7 Taxation can have different effects depending on the stage in which the firm is operating. For instance, a severance tax which rises at the rate of interest given exogenous recoverable reserves can be neutral if the ore body is developed and the investment made.[8] However, if such a tax is imposed during exploration the firm may reduce the number of promising exploration areas and/or reduce the investment for areas with proven reserves. An understanding of the effects of taxes at different stages in the mineral cycle is particularly important for countries which must compete in international markets for both capital and for sales of output. A country can change the relative profitability of deposits in its jurisdiction by tax policy. Such policy could result in a reallocation of development and extraction both within and between countries. For this reason, the analysis summarized below will be based on the assumption of price taking behavior. This assumption will allow a more realistic analysis of the effects of taxes on the countries under study.[9]

---

7/ It should also be noted that the structure of information flows imply that all decisions are interdependent. The firm receives new information about the structure of reserves during extraction (i.e., extraction has an exploration component). This information will affect future development plans within the same deposit.

8/ See below for further discussion of this type of tax.

9/ This statement means that a country may have a monopoly on its own resources but it does not have a monopoly with respect to close substitutes. In such cases, price taking behavior is a reasonable assumption. For analyais of non-price taking behavior see Peterson (1976).

## III. TAX INCENTIVES UNDER PERFECT CERTAINTY

2.8 The imposition of a tax can have at least three effects: (1) a tax can change the time when particular ore quality and quantities are extracted (e.g., high grade ore could be reallocated in time); (2) a tax can effect the time profile of extraction (given an ordering of grades and total quantity to produce); and (3) a tax can affect the level of economically recoverable reserves.[10] The level of reserves in non-fuel minerals are determined relative to the "cut-off grade". Cut-off grades are a function of many geological variables.[11] However the concept can be reduced to the following simple form for present purposes:

$$\alpha = \frac{MC}{P}$$

where $\alpha$ = cut-off grade, measured as a proportion of metal in a tone of "ore"

MC = marginal cost of extraction

P = price of output

2.9 Zero marginal profit with respect to ore quality is implied by this expression. Qualities above the cut-off grade accrue profits (given marginal cost), while ore qualities below this value would incur marginal losses and thus will not be extracted. A tax that changes the cut-off grade will change the level of recoverable reserves in the present context.[12]

---

10/ See Appendix 2 for a more complete analysis.

11/ See Thomas (1976).

12/ A tax can affect the level of recoverable reserves in cases where the grade is uniform but the miner must dig "deeper" to get reserves; i.e., if marginal cost is an increasing function of the depletion. This is similar to the effect described for petroleum [see below]. In the present case all these affects can be represented via the cut-off grade with no loss of generality.

2.10 Hydrocarbon deposits are generally considered homogenous and therefore grade effects may not be present. However, a tax may affect the time profile of extraction and the level of economically recoverable reserves in a manner similar to that for non-fuel minerals. Costs are an increasing function of depletion in hydrocarbons since pressure is inversely related to reserves; i.e., an increase in output this year will shift the marginal cost curve in the future to the left. A tax that affects this margin will affect the level of recoverable reserves. This is analogous to the cut-off grade described above.

2.11 The incentives created by each tax are described below. The results are summarized in Table 2.1.

A. Per Unit Output Tax

2.12 This tax may be imposed on either extraction of ore or metallic content. However the general nature of the incentives are the same.[13] Also this tax may not be mine-specific but might be imposed as an export tax.[14] The clear benefit of this tax is administrative. No measure of value or costs has to be computed since the tax is related only to the volume of production. If this tax remains constant in either nominal (or even in net-of-price inflation) terms then the present value of the tax per unit will be lower in the future. That is, the firm will pay a lower tax in present value terms by deferring extraction. Thus, the miner has an incentive to reduce the present value of taxes by changing either the quality selection profile, the extraction profile or both from the present to the future. That is, the miner prefers to pay a fixed amount of nominal

---

13/ See Conrad and Hool (1981) for a development of the difference between these two taxes.

14/ See Conrad (1984) for the application of this tax in Jamaica.

Table 2.1. Summary of Allocative Incentives Created by Various Mineral Taxes

| Tax Instruments | Grade Selection Profile a/ | Recoverable Reserves | Extraction Profile |
|---|---|---|---|
| | **Taxes Based on Output** | | |
| Per Unit of Final Output: | | | |
| Flat Rate | Present to Future | Decreased | Present to Future |
| Progressive: | | | |
| Base Rate: b/ | Function of Discounted Price Path and Rate of Growth of tax | Decreased | Function of Rate of growth of Tax |
| Rate of Growth | Same as Base Rate | Decreased | Future to Present |
| | **Taxes Based on Value of Output** | | |
| Ad Valorem: | | | |
| Flat Rate | None | Decreased | Function of Discounted Price Path |
| Progressive: | | | |
| Base Rate: b/ | Function of Rates of Growth of Prices and Tax Rate | Decreased | Function of Rate of Growth of Prices and Tax Rate |
| Rate of Growth | Same as Base Rate | Decreased | Generally Future to Present |
| | **Taxes Based on Income** | | |
| Profits Tax: | | | |
| Flat Rate | None | None | None |
| Flat Rate with Cost Depletion | Future Present | Increased | Future to Present |
| Flat Rate with Percentage Depletion | None | Increased | Function of Discounted Price Path |
| Progressive: | | | |
| Base Rate: b/ | Function of Time Path of Discounted Prices and Profits | Function of Time Path of Nominal Profits | Function of Time Path of Nominal Profits |
| Rate of Progression b/ | Same as Base Rate | Same as Base Rate | Same as Base Rate |

a/ In hydrocarbons grade is not an important factor. Thus, the column "Grade Selection Profile" does not apply for this case.

b/ In cases where the effect of the taxes have the same general effect (e.g., the base rate and rate of progression of the progressive income tax), the magnitudes of the effects will be given. The table above should therefore be interpreted with respect to directions of change and not the size of the allocative effect.

taxes further in the future, given an exogenous reserve base, and this tax reduction is accomplished via a reallocation of extraction to the future.

2.13 Economically recoverable reserves are also affected by this tax via an increase in the cut-off grade. That is, this tax may induce the miner to "high-grade" the deposit since the tax reduces the net of tax revenue each period, i.e.,:

$$\alpha^* = \frac{MC}{P - T}$$

where: T = the per unit tax.

2.14 An increase in the cut-off grade can lead to premature mine closure depending on the quality distribution in the deposit. Exploration and development are also reduced since the tax reduces the present value of all future exploration and development leading to an increase in the cost of the marginal play or marginal development well.

B. Ad Valorem Output Tax

2.15 This tax is a fixed proportion of the mineral output price. The tax may be on exports, on industry-wide production, or on a mine-specific basis, like the per unit tax. The similarity of this levy to ad valorem sales taxes is one source of its popularity. The administration difficulty with this tax is determining the "arms-length" price of output. Many mines sell output to related parties (both domestically and internationally). Thus, a quality adjusted arms-length price for the output of a specific mine may not be available. Schemes such as "net-back" pricing have been developed to determine the f.o.b. value of the material in such situation.[15]

---

15/ Net back pricing is a method of computing the mine-mouth (or well head) value of output. Generally, the net back is computed by subtracting transportation and processing from the first arms-length price. The residual is defined to be the f.o.b. value of output at the point of extraction.

2.16 In the case where total mineral yield is exogenous, the nominal (or net-of-inflation) tax payments are a function of the time path of output prices. Thus, the miner has an incentive to reallocate extraction to periods with lower discounted prices in order to reduce the present value of the tax payments. For instance, if discounted prices fall through time, the allocative effect is similar to the per unit tax (i.e., present to future). However, there is no incentive for the miner to change the intertemporal ordering of the grades, since the tax is proportional to value. Finally, recoverable reserves are reduced since the cut-off grade is increased:

$$\alpha^* = \frac{MC}{P(1-\beta)}$$

where: $\beta$ = tax rate

C. Profit Tax

2.17 It is well known that pure rent taxes are neutral in cases of perfect certainty. Under an income tax regime, it is immaterial how the rent accrues. Rents could arise via market power, non-constant returns to scale in the long-run, or from the scarcity value of the resource. The difficulty with this tax is administration. Profits must be measured relative to empirical, not theoretical, standards and profits which accrue to particular deposits must be "sourced" in the country or even to specific deposits.

2.18 The administrative problems of the income tax are known.[16] Income taxation of mineral production generates additional administrative

16/ The problems include depreciation rules, and indexation. See Conrad (1984) for a more complete discussion.

difficulties. First, accounting for exploration and development must be addressed. The costs are "capital" expenditures since the benefits from each activity accrue over more than one period of time. The administrative difficulty arises in defining the exact nature of each expenditure and determining the amortization period.

2.19 Exploration expenditures are relatively easy to define if the mine has not been developed. However, once the mine is developed exploration generally continues. The determination of exploration costs in this context may be arbitrary. There are also alternative accounting methods for pre-production exploration costs including immediate expensing, or capitalization with amortization for successful exploration and subsequent expensing for unsuccessful exploration. The appropriate method should be determined relative to the overall objectives of tax policy. For instance, if cash-flow accounting is used then immediate expensing is appropriate. If accrual concepts are employed then one type of capitalization method should be used.

2.20 Development expenditures are part of the general classification of self-constructed assets. A significant proportion of these expenditures include "intangible costs", including costs for shaft construction, wells, access roads, etc. Either immediate expensing or capitalization (with amortization over some specified period) may be used for income accounting. The appropriate method to employ will depend on the overall objectives of the policy, like the methods for exploration costs; i.e., immediate expensing (capitalization) is appropriate under cash-flow (accrual) methods.

2.21 Immediate expensing of exploration and development expenses is generally allowed in Sub-Saharan Africa and the rest of the world.[17]

---

17/ See Chapter 1 and Appendix 3.

Other assets are not afforded the same treatment. Thus, there is inconsistent treatment of different asset classifications resulting in lower effective tax rates of exploration and development. Such treatment may decrease the overall effective tax rate on mineral investments relative to other economic sectors. Administrative difficulties and/or explicit policy intended to favor mineral development may be responsible for such non-neutral treatment. Regardless of the motivation, such policies create potential welfare costs resulting from intersectoral reallocations of capital. That is, capital may flow from other sectors to mining lowering the value of the marginal product of capital in mining below its social value.

2.22 A second mining-specific income tax administration difficulty relates to "so-called" depletion allowances. A resource, like a machine, loses value with use and it is appropriate to recognize this type of economic "depreciation" under accrual accounting concepts.[18] While sound in principle two issues arise. First, there is the issue of "who" is entitled to this depreciation. With respect to a machine the answer is the "owner", not the renter since the depreciation reflects the reduction in the value of the machine to the owner. However, western economies (and some developing economies (e.g., Zaire)) allow the owner of the "physical capital" and the lessee the allowance.[19]

2.23 Part of the difficulty is attributed to the concept of "economic interest" and is related to exploration and development expenses. Two

---

18/ For present purposes depreciation is measured as the reduction in the present value of the deposit via extraction.

19/ It is not clear whether the incidence of this allowance is independent of who legally gets the allowance. However, from a legal perspective some countries allow depletion when producers have an "economic interest" in the producing property even though they do not own the reserves.

generic types of capital are required to extract minerals: physical capital and the resource in the ground. If the owner of these assets are separate persons then each person should compute their respective basis (or economic interest) in the property. The resource owner's basis would be the value of the land and mineral rights. The lessee's basis would include exploration, development, other intangibles and any prepaid rental payments (e.g., bonuses).[20] Each party could then amortize their respective basis through time once the basis are computed.

2.24 Practical and/or political problems may make this separate determination difficult. First, the common use of immediate expensing for exploration and development significantly reduces the lessee's basis. Second, determining the value of the owner's interest may be difficult because market values for minerals in place are not available. Furthermore, the use of historical cost accounting will underestimate the true value of the mineral rights since the exchange price was based on an uncertain capital gain from discovery.[21] Third, the amount to amortize in any period and the length of time over which the basis should be amortized is uncertain.[22]

---

20/ Royalties paid on production are economically equivalent to wage payments and should be deducted.

21/ An additional difficulty is created when the lessee (an exploration company for example) either leases or sells its interest to another person (e.g., a production company). Three separate interests must be computed in this case. It should be noted that none of these difficulties would be present under cash flow accounting since all expenditures would be immediately expensed making depletion unnecessary.

22/ None of these problems are unique to minerals. Machines can change value through time creating capital gains and loses. In addition, the economic life of a machine is not known with certainty. Thus, the problems discussed above are inherent in any accrual accounting framework.

2.25 Cost depletion is one solution to the third difficulty. An estimate of recoverable reserves is made and each party's interest is amortized in proportion to extraction relative to reserves; e.g., if 10 percent of remaining reserves are extracted in the current period then 10 percent of the remaining basis is deducted.[23] Adjustments to the basis can be made via open ended accounting where additional exploration and development expenses for the operator are added to the basis as incurred. Reserve estimates can be periodically revised to accommodate changes in the size of recoverable reserves relative to extraction.[24]

2.26 A second solution is to determine the basis relative to the proportion of total revenues attributable to each party and to employ percentage depletion. For instance, if the resource owner were paid a 12 percent royalty and no bonus payments were made then the resource owner's economic interest would be 12 percent and the producer's 88 percent.[25] Whether these proportions reflect economic reality and the incentives created by this attribution rule depend on the facts and circumstances. Thus, the effects on investment cannot be predicted. The use of percentage depletion also creates allocative incentives which are equivalent to a negative ad valorem output tax. The deduction is computed by

---

23/ This procedure is equivalent to the unit of production depreciation for machines.

24/ Allocative incentives may remain. If there were perfect information then the values for cost depletion would be exogenous from the perspective of owners and operators with no allocative effects. Without perfect information the present value of the deductions for cost depletion become an endogenous variable with incentives like a negative per unit output tax.

25/ If constant returns and perfect competition prevailed then 12 percent would be the correct figure for the resource owner, since 12 percent would be equal to mineral's share in value added. This would also imply 0 percent for the producer since the producer does not own the resource in the ground.

multiplication of the rate times the person's share of total revenue. Thus the higher the discounted price the greater the deduction given output. Finally, the present value of the total deductions under percentage depletion can be greater than or less than the person's economic interest in the property. This fact can reduce or raise the effective tax rate on mineral investments relative to other sectors.

2.27 The discussion has three kinds of implications for Sub-Saharan African (and other) resource rich economies. First, the neutrality of a pure profits tax is maintained only in a partial equilibrium framework. If the effective tax rate on mineral investments is higher (lower) than other sectors then capital may flow between sectors generating a welfare cost even when there are no allocative effects within the industry. The effective tax rate may also affect the inter-jurisdictional allocation of resources.[26] For instance, a country (being a price taker) could design a pure rent tax to collect 50 percent of the rents and a foreign firm would prefer to invest in another country where the tax on pure rent is less than 50 percent.

2.28 Second, the tax treatment of exploration, development and other intangible expenses is related to overall business tax policy. If a country adopts cash flow accounting for all sectors then immediate expensing is appropriate. Also no depletion allowance of any type is needed. If accrual accounting is the established norm for tax policy then all pre-production expenses should be capitalized and amortized during the life of the project.

---

26/ This statement may be qualified because of international tax and foreign tax credit considerations which affect the effective tax rate for many multinational investments.

2.29 Third, the operator's basis for depletion should be limited to bonus payments, exploration, development and other expenses. This is true because the government holds title to the resources. That is, the government itself should account for depletion of the resource base, not the producer.[27] Cost depletion could be employed. Alternatively a method could be implemented where the deduction is independent of production to remove the allocative incentive created by cost depletion. There is a trade-off in developing an alternative to cost depletion, however. If this method is not determined correctly then the effective tax rate on mineral investments could be higher (or lower) than anticipated creating intersectoral incentives. Thus, the policymaker must weigh the relative incentives created by cost depletion to some alternative method.

D. Progressive Taxes

2.30 Three types of progressive (or variable rate) taxes have been employed in recent years, i.e., per unit, ad valorem and profit. Justifications for the use of these instruments include a desire to preserve net of inflation tax revenue and/or to capture "windfall" returns.[28] Design of each tax requires the choice of at least three variables: the base tax (or rate), the rate of growth through time (or the rate of progression in any time period) and an economic variable which determines the rate. Rates of growth can be a function of output prices (or some substitute), present value, current profits or the rate of return on investment. A number of allocative incentives may be created, depending on the nature of the specific tax.

---

27/ A method for computing depletion and the use of these revenues is discussed in Chapter 4.

28/ Such taxes have been imposed in the United States, Indonesia, Jamaica, Papa New Guinea and Canada.

2.31 Variable output related taxes tend to reduce the level of recoverable reserves (i.e., increase the cut-off grade). There is also an incentive to reallocate extraction between periods depending on the relationship between the marginal tax rate with nominal prices and the time path of discounted prices. Variables rate income taxes will have no marginal effects on either the intertemporal grade selection profile or the cut-off grade (given investment). However, other intertemporal allocative incentives are present. The marginal tax rate is an endogenous variable under a progressive income tax. Thus the firm has an incentive to reallocate extraction from periods with high marginal tax rates to periods with lower marginal rates. The firm can smooth the time path of nominal taxable profit, avoid being in high marginal brackets and reduce the present value of tax payments by following such a strategy.

## IV. TAXATION UNDER UNCERTAINTY

2.32 Uncertainty can alter the results of the previous section. The nature of the incentives created by taxation will depend on the miner's preferences toward risk taking. If the miner is risk neutral then the results in the last section are applicable.[29] If the miner is risk averse then the tax incentives could be different. Below two simple models are summarized which show the nature of the effects.

---

29/ This section is based on Conrad (1987b). The analytical basis for the discussion which follows can be found in Appendix 4. It is commonly assumed that corporate managers should be risk neutral. The empirical validity of this assumption will not be discussed here. Rather, the analysis is presented so that comprehensive results are available.

A. Cut-off Grades

2.33 Economically recoverable reserves are important components of the size of investment made by the miner. Cut-off grades (and thus estimated recoverable reserves) must be adjusted for uncertainty in prices and costs. A risk averse miner will compute cut-off grades which are higher than those which would be computed using the mean values of prices and costs.[30] Recoverable reserve estimates and thus investment will be smaller than they would be if mean values were employed. The introduction of a tax in this environment could offset or complement the effects of uncertainty depending on how the tax affects the mean present value and the risk perceived by the miner. Table 2.2 contains the sign of the incentive created by three taxes (ad rem, ad valorem, and profit)[31] in an uncertain environment with two assumptions regarding the miner's risk preferences: constant and decreasing absolute risk aversion.[32] Note an increase in the cut-off grade and thus a fall in expected extraction is indicated by a positive sign.

2.34 Both ad rem and ad valorem output taxes increase the cut-off grades in a manner similar to the miner's behavior when all variables are known, regardless of the type of risk aversion. Both taxes decrease

---

30/ This result is based on the concavity of the expected utility function.

31/ Variable rate taxes have the same general incentives as their flat-rate counterparts discussed above. These taxes are not discussed here because of the similarities. Profits taxes with no loss offset provision will generally, but not always, follow the same pattern as profits taxes with perfect loss offsets. See Conrad (1987b) for further discussions.

32/ Absolute risk aversion is defined as $(U''/U')$, i.e. the ratio of the second derivative to the first derivative of the expected utility function with respect to wealth. Constant (decreasing) absolute risk aversion implies that the difference between actuarially fair odds and the odds which the miner would be willing to accept a gamble is independent (a decreasing function) of wealth.

expected revenue while not affecting costs. Thus, other things equal, the risk averse miner will plan to extract a lower quantity. Some "risk-sharing" is present under an ad valorem tax which is not present under the ad rem tax. However, down-side risks are increased under both taxes since costs are not considered.

2.35 A pure income tax will also increase the cut-off grade, regardless of the type of risk aversion. This result is in contrast to the absence of allocative effects under perfect certainty. There is complete "risk-sharing" under the income tax since loss-offsets are assumed and all components of profit compose the tax base. However, expected wealth is also reduced by reducing after tax profits when they are positive. The reduction in expected wealth accounts for the fall in planned extraction.

Table 2.2: Effects of Taxes on Cut-Off Grade Under Uncertainty

| Tax a/ | Constant Absolute Risk Aversion | Decreasing Absolute Risk Aversion |
|---|---|---|
| Ad Rem | + | + |
| Ad Valorem | + | + |
| Profits | + | + |

a/ A positive sign indicates an increase in the cut-off grade and thus a decrease in recovery.

B. Intertemporal Allocative Incentives

2.36 Intertemporal incentives are found in Table 2.3. The effect of a tax on first period extracti. is the most important incentive for present purposes. What is planned for extraction in the early periods will not be available in later periods.[33] The effect on first period extraction will

33/ The results apply to planned extraction. Actual extraction in later periods will be different than planned because uncertainty is resolved through time.

be influenced by the producer's perception of the scarcity value of the resource. If all the resource is planned to be extracted then there will exist an intertemporal trade-off. This trade-off is absent when less than total reserves are planned for extraction. Results are thus reported for both cases. Finally, two different assumptions regarding uncertainty are used: (1) all of next period prices (including interest rates) are known while all prices in the more distant future are unknown; and (2) all economic variables are unknown.

Table 2.3. Effects of Taxes on First Period Extraction Under Uncertainty

| Tax | Constant Absolute Risk Aversion | Decreasing Absolute Risk Aversion |
|---|---|---|
| **A. No Binding Resource Constraint** | | |
| Ad Rem | - | - |
| Ad Valorem | - | - |
| Profits | - | - |
| **B. Resource Constraint Expected to be Binding: First Period Prices Known** | | |
| Ad Rem | - | - |
| Ad Valorem | ? | ? |
| Profits | + | + |
| **C. Resource Constraint Expected to Be Binding: First Period Prices Unknown** | | |
| Ad Rem | ? | ? |
| Ad Valorem | ? | ? |
| Profits | ? | ? |

2.37 All three taxes induce the producer to reduce extraction when the resource constraint is not perceived to be binding, regardless of the type of absolute risk aversion. These results correspond to the incentives created to change the cut-off grade. That is, each tax will induce the

miner to reduce planned extraction. The results are different when the resource constraint is binding. If first period prices are known then a per unit tax will reduce extraction in early periods if constant absolute risk aversion prevails and the income tax will increase extraction in early periods regardless of the type of risk aversion. The remaining results are ambiguous.

2.38 Per unit taxes create an incentive to defer extraction. However uncertainty about future prices and costs will tend to increase extraction in early periods if there is certainty in the early periods. The effect of uncertainty in future periods is mitigated when absolute risk aversion is constant. This incentive is not mitigated when absolute risk aversion is decreasing.

2.39 The ad valorem tax will induce the producer to reallocate extraction to the period with the highest discounted price when certainty prevails. This incentive is still present if future prices are uncertain. However, the condition must now be modified to state that the direction of change depends on the difference in risk adjusted prices. Thus, if known prices in early periods are lower than the risk adjusted present value of future prices, extraction will rise in early periods. The result is ambiguous if risk adjusted discounted future prices are lower than known present prices.

2.40 The income tax results imply that the risk averse producer will trade certainty for uncertainty when this tax is increased. That is, the firm would prefer to increase extraction in early periods and pay higher taxes than to defer extraction to the future even with the presence of risk sharing in the income tax.

2.41 Allocative incentives are ambiguous when uncertainty regarding the time path of all prices and costs is introduced. The general tendencies

remain. That is, per unit taxes tend to decrease extraction early, ad valorem taxes will create incentives relative to the time path of discounted risk adjusted prices, and the income tax will generate wealth effects. These incentives are offset by the additional uncertainty of early period prices and costs. The producer trades an uncertain near term for an uncertain future. How this trade-off is resolved will depend on the structure of uncertainty in each period and the preferences of the producer.

2.42 The results presented above indicate that government tax policy can affect the risks perceived by the producer in addition to affecting the expected value of extraction. The perceived risks can complement or offset the incentives created by the tax on the expected values. Tax policy development must incorporate both incentives in order to have the desired effects.

## V. TAX LIKE INSTRUMENTS VIA GOVERNMENT POLICY AND/OR CONTRACT DESIGN

2.43 A number of instruments used by government can create incentives similar to those of taxes. These instruments are used as a matter of fiscal policy or contract design. Some of these are discussed below.[34]

### A. Foreign Exchange Controls

2.44 Foreign exchange controls can be one of two general forms: direct allocation or multiple tiers. Foreign exchange controls can create significant incentives in mining, since mining is relatively capital-intensive and depends on imported materials. Direct allocation can increase the price of imported inputs (in extreme cases to infinity)

---

34/ Also see the analysis in Chapter 3.

retarding development and extraction. The opposite incentive is created in cases where the mining firm must surrender foreign exchange at less than the market rate. If the surrender rate is lower than the official rate then the relative price of imports to domestic goods is decreased. This occurs because most revenue accrues to mining firms in the form of foreign exchange (via exports). If the firm receives less domestic currency for each unit of foreign exchange relative to the free market rate an import bias is created.[35] There is a clear incentive for the firm to substitute imported capital for domestic labor.

B. Equity Participation

2.45 Government may require either free equity or the option to purchase equity at lower than market prices from the investor. These schemes are in effect profits taxes; e.g., 30 percent free equity is equivalent to a 30 percent net-of-all-other-tax reduction in the return to the firm. Tax-like effects may not be present when equity is purchased for a value close to the asset's value but there is a clear shift in the risk structure.[36] In extreme cases national ownership becomes complete (e.g., Zambia), the investor becomes an operating firm whose payment may be independent of profits. This increases the country's exposure to changes in relative profitability in mining. Two points should be noted here First, many major multinational firms maybe more diversified than developing countries. A "resource rich" country is relatively poor in renewable capital. Multinational firms are not limited to one resource base or even to one field of endeavor and the firm may have less costly

---

35/ This type of substitution occurred in Jamaica. See Conrad (1984).

36/ See Chapter 3 for further discussion.

access to world capital markets. Thus the cost of "risk bearing" for these firms may be lower than the country. Second, there is an opportunity cost to the purchase of equity in mineral investments over and above the capital held as resources in the ground. These investments are made at the expense of diversification either through other internal investments or in the world capital market. In effect, the government is taking a long position in one market which limits its flexibility to respond to declines (or increases) in mineral prices and/or profits. For these reasons a government must weigh the costs of requiring equity participation relative to any perceived benefits.[37]

C. Speeding Recovery

2.46 Governments have historically been eager to bring the benefits of the mineral development forward in time when minerals are discovered.[38] For instance, Liberia imposed penalties equal to "estimated taxes" for delays in development and extraction. Two counteracting forces need to be examined in order to evaluate the net effect of such strategies. First, it might be in the interest of the producer to leave reserves undeveloped for periods longer than socially optimal. Such behavior may occur when mineral markets are controlled by producers concerned with the strategic value of reserves. In this case, a government could induce the firm to begin extraction earlier than it would have with little or no social cost. This benefit may be offset by the potential cost of losing investment, lower investment or premature development. The discovery of minerals does not necessarily imply that rapid development is socially optimal. The

---

37/ See Chapters 3 and 4 for further discussion.

38/ See Smith and Wells (1974) for a complete development of this issued.

contribution of mineral production to social benefits is related to the time path of relative prices and costs. Assets in the ground are still assets with potential value. Thus, government must weigh the benefits of rapid development relative to loses in future revenues and relative to the overall development portfolio of the economy as a whole.

D. Allocations for Domestic Use

2.47 Contracts often contain provisions which require the investor to provide a certain quantity or proportion of output for domestic use. This requirement could be equivalent to an ad valorem output tax when domestic prices are controlled at levels below world prices or where the investor must "yield" the required quantity for domestic use independent of market prices (e.g., by being reimbursed merely the cost of production). The difference between the market value of the mineral and the value paid for domestic use is equal to an output tax on production which the government does not collect. Additional uncertainty for the firm is also created if domestic prices are controlled. A low domestic price relative to the world price may artificially increase the rate of growth of local demand for output through time (assuming the commodity is a normal good and real per capita income rises). Thus, the investor will be concerned about pressure from the government to increased the share of output devoted to the domestic market through time.

E. Downstream Investments

2.48 Government may require the producer to invest in downstream activities related to the mineral extracted (e.g., refining and marketing) or even in other industries. This requirement is similar to an entry fee combined with a marginal tax. The entry fee (the additional investment) may reduce the total return to the project if downstream activities do not meet the firm's investment criteria. The marginal tax will be equal to the

cost differential, if any, from domestic production of downstream goods relative to another location.

2.49 If an investor complies with these provisions there will be portfolio effects for the country similar to those described for free equity. Such effects may include lower diversification for the country as a whole. The long position in minerals is increased by attempting to capture the additional value added at world prices from downstream processing.

F. Foreign Taxes

2.50 The interaction of domestic and foreign taxes is important when investments are made by non-resident firms or domestic subsidiaries of non-resident firms. The foreign tax credit system is one important component of this interaction. A foreign firm is generally allowed a credit for taxes paid to the host government if the taxes are income taxes or payments "in lieu of" income taxes. A credit is not allowed for royalties, production shares, and all commodity specific taxes. Such payments are, however, generally allowed as a deduction in the home country since they are defined as a cost of doing business in the host country. The credit is further limited by the amount of taxes due the home country on the firm's foreign source income.[39]

2.51 "Net profits interest" and/or production sharing have become significant components of government revenues in countries where mineral rights are held by the state (particularly in petroleum). It is thus difficult to determine what proportion of government payments are income

---

39/ Two methods are used to compute the credit limitation. A separate limitation is computed by country under the per country limitation. Foreign taxes are pooled and a single limitation is computed under the overall limitation. In addition, there are provisions for carry-forward (back) of excess credits.

taxes (i.e., taxes for which there is no "tangible benefit received") relative to payments for the right to extract the resource. The distinction is important since tax credits are allowed only for the income tax component of host government revenue. Developing countries generally impose a minimum of two types of payments in an effort to distinguish the income tax from the resource payment.[40] The first, a royalty, is a payment for the right to extract the reserves and legally it is a payment to the owner of the resource. The second payment, an income tax or payments in lieu of income tax, is defined to be a tax on the return to invested capital for which the foreign tax credit is available.

2.52 In general, there is a desire for foreign firms to have all payments made to the host government available for foreign tax credits. There is some justification for host countries to accommodate this desire. A firm with a deficit of foreign tax credits can increase its payments to the host country with no allocative effects since the payment is a transfer from the home country's treasury to the host country. Such a strategy might require lower royalties and higher income taxes. The extent to which a host country can accommodate such a change must be tempered by two factors. First, the host country must be able to separate the value of the resource from taxes in order to efficiently allocate the resource.[41] If such accounting can be handled then accommodating the desires of the foreign investor is less difficult. Second, a change in the payment structure can change the nature of risks borne by the host country. For instance, a decrease in an ad valorem royalty with a compensating increase in income taxes will increase the variability of revenues to the host

---

40/ See Appendix 3.

41/ See Chapters 3 and 4, and Conrad (1987a).

country regardless of foreign tax credit effects. Accommodation is not costless to the host country and thus host governments should be prepared to explicitly trade-off various cost and benefits in developing policies for foreign investors.

## VI. SUMMARY

2.53 Tax and tax-like instruments can create incentives which affect recovery, investment and the intertemporal allocation of the resource base. The nature of these incentives may vary when uncertainty is present. Tax policymakers should be aware of these incentives when policy is made. It should be emphasized that the discussion to this point has assumed a separation of tax policy from factor payment policy. Any efficiency implications (or welfare costs) described in this chapter are relevant only for instruments unrelated to ownership of the resource. Factor payment policy will be discussed in the next chapter. Coordination of tax and factor payment policy will be deferred until the concluding chapter.

## Chapter 3: OWNERSHIP PAYMENTS AND CONTRACTS

### I. INTRODUCTION

3.1 The last chapter was devoted to a discussion of the incentive effects of taxes. This chapter contains one method of determining the proper role of fiscal policy when the government must simultaneously determine tax policy and resource investment policy.[1] Such a discussion would not be necessary if mineral rights were held privately. Government, having no ownership claim to the resource, would impose taxes on both mineral owners and producers. The incidence of these taxes would be determined via market transactions. Standard tax analysis is all that would be required in such a context.

3.2 The countries under study have, however, chosen to vest the mineral rights in the state. This implies that government must wear two hats: resource owner and tax collector. Government must be responsible for the development of the natural resource base in order to maximize the economic benefits to the economy. This role requires government to develop factor payment policies for the mineral sector consistent with welfare maximization. That is, government must determine the opportunity cost of mineral extraction and ensure that it receives the value of the marginal product of its factor input. As tax collector, government imposes taxes on all sectors of the economy including natural resource projects. Revenue objectives, distributional considerations and efficiency costs are factors which influence the tax structure.

3.3 Government's dual role may create confusion about fiscal policy in the mineral sector because two different types of payments may be made

---

1/ This analysis will provide the basis for the recommendations contained in Chapter 4.

to the same entity.[2] This confusion is enhanced when government reports all mineral revenues as government revenues attributed to general accounts. Government, however, must be able to "separately account" for the components of mineral revenues (at least at the margin) to ensure that society receives a competitive return on its resources and the appropriate share of taxes.

3.4 The analysis which follows is based on the assumption that "separate accounting" for resource factor payments is necessary for the orderly development of natural resource policy. Two justifications are offered for this premise. First, government as factor owner must determine whether the payments received from extraction are sufficient to cover the the permanent loss of an asset, to cover the opportunity cost of lower output in other sectors (e.g. Dutch Disease), and to cover the cost of risk bearing, if any is present. That is, government must ensure that it receives a competitive return on its natural resource endowment adjusted for risk. Second, government as tax collector should be concerned about the allocative effects of its overall tax policy. This implies that other things equal the mineral sector is not over- or under-taxed relative to other sectors of the economy, after the payments for the resource endowment are made. That is, government needs to determine the intersectoral effects of its tax policy after (or at least simultaneously with) the determination of a factor payment policy. Efficiency cost measures and the relative incentives of taxes on capital in the mineral sector can be computed only after the deduction of all other factor inputs.

---

2/ Such confusion is not present when mineral rights are held by private individuals and government collects taxes.

3.5 Terms such as "rent" and "natural resource rent" have common connotations which are often confusing. For this reason the following definitions will be employed in the analysis.[3]

Natural Resource Rent:

The payment (explicit or implicit) which accrues from either the scarcity value or ownership (or both) of a mineral resource. In a market economy this value will be equal to the "user cost" or the flow price to the resource owner. In equilibrium, natural resource rent will be equal to the value of the marginal product of the resource as an input into the production process at each point in time. In effect, natural resource rent is a wage paid for a factor input.

Economic Rent (or Rent):

Any payment above the minimum necessary to obtain a particular supply of any factor input or output.

Wind-Fall Gains and Losses:

A change in the return to any asset resulting from an unanticipated change in relative prices.

3.6 These definitions have the following implications:

- The natural resource does not have to be exhausted in a physical sense for natural resource rents to accrue. Rather, user cost includes both the physical exhaustion value plus replacement cost, if any, for obtaining additional inputs.
- In a competitive economy natural resource "rents" are not economic rents. Rather, the opportunity cost of extraction today relative to the future and the decision to allocate

---

3/ In practice it may be difficult to compute the value of each separate componert either ex ante or ex post. However, clear definitions are necessary in order to provide a consistent framework for analysis.

portfolio shares to mineral tracts is determined by the presence of natural resource rents. In effect, competition will lead to a situation where the "natural resource" rent are only sufficient to cover the opportunity of investing in mineral properties and extracting the deposit. That is, competition will lead to a situation where no "economic rents" are present.[4] This implies that natural resource rents serve an "allocative" function and not merely a distributive function.

- Unlike "wind-falls", natural resource rents can be present even in the presence of perfect certainty.

3.7 Defining natural resource rent as a wage is completely consistent with traditional natural resource theory dating from Hotelling (1931). The efficient allocation of a fixed stock of a resource requires a flow payment equal to the intertemporal opportunity cost of extraction at different points in time. If this payment is absent or not calculated then an efficient development profile cannot be computed. Treating this payment as a wage is also consistent with standard economic theory. Workers with different skills will allocate themselves between different sectors based on wage differentials. The presence of a wage is necessary to determine the opportunity cost of employment. In a similar manner, "natural resource rent" is a signal to investors regarding the value of mineral investments relative to investments in other sectors. The fact that minerals are an endowment which may not be replaceable does not alter this fact. Furthermore, the fact that government (or resource owners in general) have not paid for the mineral before discovery does not imply that the flow

---

4/ See Conrad and Gillis (1984) and Feldstein (1982) for a discussion of this issue.

price of mineral extraction should be independent of market forces. Rather, the value of minerals, "the natural resource rent" is necessary for resource owners, including government, to hold and develop the resource base.

3.8 Finally, natural resource rent accrues to the resource owner in a market economy. For a government resource owner 'taxing natural resource rent' is a misnomer. Labor does not 'tax' firms by demanding compensation for the scarcity value of its services and natural resource owners are not 'taxing' resource producers who do not own title to another factor input. In summary, 'natural resource rent' is a price necessary to determine the opportunity cost of extraction and the value of the marginal product of an input. The value of this input will be determined by the laws of derived demand in an identical fashion to the determination of wages for labor and other factor inputs.[5]

## II. OUTLINE OF A MODEL

3.9 Every mineral investment requires two types of capital, the enclave natural resource and physical machinery.[6] These stocks are combined with labor to generate the cash flows from the investment. When physical capital and the natural resource stock are owned by different parties two separate evaluations of the project are required. First, the

---

5/ The confusion regarding the role of 'user cost' in minerals may be related to classical rent theory dating from Ricardo and given significant emphasis in George. In neoclassical economic theory a distinction must be made between payments above the amount necessary to bring forth an additional unit of a factor input and the total cost of that input. Additional confusion may have been generated by emphasis on the nature of the intertemporal allocation of a fixed stock of the resource. However, such confusion is not warranted when it is understood that 'natural resource rent' is the efficiency price necessary to determine the optimal extraction profile and the optimal allocation of investment in stocks at different points in time.

6/ The model discussed in this section is developed extensively in Conrad (1987a). Proofs, etc. can be found in that paper. Emphasis will thus be placed on the implications of the model in the present discussion.

resource producer must determine whether the physical capital employed in the operation receives a competitive return adjusted for risk after the deduction of payments to all third parties including taxes, wages and factor payments for the resource. Second, the resource owner must evaluate whether the return from supplying a factor input is sufficient to cover any opportunity costs of alternative uses adjusted for risk. The latter computation is important for the resource owner. If the return from extraction is below the competitive return then the resource owner would be better off by holding reproducible capital rather than minerals. This implies either the resource owner "paid too much" for the resource endowment and has experienced a capital loss, or that future investments in mineral resources will be lower (or at a lower price). This result holds even if the resource owner did not pay anything for the minerals in the ground. The funds generated via extraction can be used for investments in other sectors. If the present value of the payments is below that of other investments then the resource owner would be better-off simply selling the rights and investing the proceeds in other assets.[7]

3.10 A contract must generally be negotiated when the physical capital and the natural resource are owned by different parties. This contract will determine how the cash flows from the investment will be divided between the two parties. A contract can be modeled as a principal agent problem from an economic perspective. For present purposes, the principal

---

7/ This is an extreme form of bringing extraction forward in time. An outright sell of the mineral rights is equivalent to extracting all the reserves today from the perspective of the resource owner. She has gotten all her capital out in the present period. If the sell price could be used to generate a competitive return in other sectors then the resource owner will experience a real gain in wealth by selling the rights and investing in other sectors.

will be defined to be the resource owner and the agent the producer.[8] The principal (the resource owner) wants the agent to maximize the returns from the resource base. The agent (the owner of the capital) wants to maximize the return to invested capital net of resource payments. Thus, there is a natural conflict of interest between the parties. Other things equal, a dollar paid to the resource owner will reduce the present value of the project to the producer. Finally, the resource producer will enter the contract if and only if he is no worse off by doing so. Self-interest on the part of the producer thus constrains the latitude of the principal in developing contract terms only for the principal's benefit.[9] The issue is to determine a contract which will maximize the total benefits from the contract. That is, a contract will be defined as "efficient" if the total value of the project is maximized adjusted for risk and both parties willingly agree to terms.[10]

3.11 The preceding discussion can be represented with more precision mathematically. Define the owner's expected welfare of the resource as:

---

8/ The designation of who is the principal and who is the agent is arbitrary and has no effect on the results. The use of a welfare constraint on the agent is necessary in order to avoid ambiguity with respect to the sharing of excess returns. The entire contract curve can be derived by changing the value of agent's expected welfare.

9/ The producer's welfare constraint implies that any surplus, i.e. economic rent will accrue to the resource owner.

10/ When the resource owner and the investor are the same agent there is no necessary conflict. However, the resource owner must still develop an extraction profile and an investment plan consistent with wealth maximization. This implies that the owner-investor must "shadow-price" the resource endowment in order to determine the optimal extraction profile. In effect, the owner-investor creates an implied contract where an implicit price for the resource is determined. If perfect certainty prevails then this shadow price will be equal to the price paid by the resource producer to the resource owner in an "optimal contract".

$$EW = EW[G[x_U,a] + H[x_W,a]] \qquad (3.1)$$

where EW = expected welfare of the owner

$G[\cdot]$ = present value of other assets held by the resource owner

$H[\cdot]$ = present value of resource payments to the owner

$x_W$ = quantity of the resource sold to the producer

a = quantity of other inputs used by the producer

$x_U$ = quantity of the resource used by the producer[11]

3.12 Expected welfare is used since all contracts are negotiated without complete information regarding the future. The function $H[\cdot]$ is the payment schedule determined by the parties. The function $G[\cdot]$, the present value of all other assets held by the resource owner, is included because a resource discovery could affect the value of these assets. In the present context, this function will represent the opportunity cost of extraction for the resource owner. An example is "Dutch Disease" discussed in Chapter 1. A developing economy must examine the "net benefits" of resource extraction. If Dutch Disease is created by mineral development then the value of $G[\cdot]$ will be lower.

3.13 The resource producer's welfare function is defined by[12] :

---

11/ For a development of why $x_W$ may be greater than or equal to $x_U$, see Conrad 1987a.

12/ This formulation of the problem implies that the resource producer will get the residual from the project after payments to all factors of production including payments for the resource base.

$$EU = EU[V[x_U,a] - H[x_W,a]] \qquad (3.2)$$

where EU = expected welfare of the resource producer

$V[\cdot]$ = Present value of the project

3.14 Given present assumptions, the resource owner will choose a payment schedule $H[\cdot]$ and an extraction profile $x_w$ to maximize her welfare. There are constraints on the resource owner however. First, the resource producer must be willing to enter the contract. This implies that the producer's expected welfare must be at least as large as it would be from not entering the contract at all. Second, the resource owner is constrained by the producer's response to the payment schedule and extraction profile. The producer will choose his actions, a, to maximize his welfare given a particular payment schedule.[13] A change in the payment structure may affect the producer's other actions (e.g. lower investment). This response might lower the welfare of the resource owner. Third, the quantity of the resource supplied by the owner must be at least as great as the quantity demanded by the producer. Otherwise the producer will be constrained further. Finally, the quantity supplied by the owner cannot exceed the quantity of reserves in the ground.

3.15 A complete development of this model is contained in Conrad (1987a) and will not be repeated here. The conditions for an efficient contract are:

- The quantity of the resource supplied by the owner will be equal to the quantity demanded by the producer; i.e. $x_w = x_u$.
- The marginal payment to the resource owner for the resource will be equal to the scarcity value of the resource plus the

---

13/ This implies the resource producer will equate risk adjusted marginal revenue with risk adjusted marginal cost for each factor under his control. This formulation also implies that the resource owner is not able to control all the activities of the firm, that is, the resource owner cannot choose the quantity of labor, etc. which the firm hires.

marginal value of any additional opportunity cost; i.e. $EW'H'x = \mu - EW'G'x$, where $G'\underline{x} \leq 0$ and $\mu$ is defined to be the user cost of the resource.

- Risk adjusted marginal revenue for the producer will equal risk adjusted marginal cost where marginal cost is defined to include both factor payments to third parties (e.g. labor) plus payments to the resource owner: i.e. $EW(V' - H') = 0$.

3.16 The last two conditions imply that each party is compensated just enough at the margin to make additional gains equal to the cost of further activity. These conditions combined with the first imply that gains from trade are exhausted. The implications of these results for efficient contracts will be explored in the discussion which follows.

## III. IMPLICATIONS FOR CONTRACT TERMS

3.17 A major implication of this model is that the resource producer must take three things into account when determining natural resource contract policy: (1) the opportunity cost of the resource; (2) the opportunity cost to other sectors; and (3) the cost of risk bearing. The model structure also implies that three different payments can be used to identify and measure each cost. That is, the contract can contain three readily identified payments serving three different functions. For convenience these three payments are defined as: R for resource rent payment; O for opportunity cost payment; and D for risk sharing payment. Each payment is discussed below. It is important to remember that the form of any one payment can affect the structure of the other two. This fact will become clear as the discussion proceeds.

### A. The Resource Rent Payment (R)

3.18 The purpose of this payment is to reimburse the resource owner for the sale of an input from her inventory. It is demonstrated in

Conrad (1987a) that the optimal payment can take the form of a fixed fee per ton of output. For example, an optimal contract can state that the producer will pay the owner $1.00 per ton of natural resource sold. This payment is equivalent to a wage contract where the worker accepts a job for a fixed wage per hour. This fixed fee does not imply absence of variability with respect to the owner's total payments. Variability could be present in the risk sharing and opportunity cost components.

3.19 This payment structure has two implications. First, the producer will treat the resource supply as perfectly elastic. This implies that no natural resource rent will be captured by the producer. Second, this is the only payment required if the resource owner does not want to bear any risk, no Dutch Disease (or some other form of wealth reducing effect) is present and there are constant returns to scale in production. This payment captures all the risks adjusted present value in excess of the minimum necessary to induce the producer to sign the contract. If decreasing returns to scale exist another payment for risk sharing might be required. This point can be illustrated by considering the case of perfect certainty. The present value of the entire project would be equal to the natural resource rent if constant returns to scale are present. Thus, a fixed fee per ton is equal to 100% of the present value if determined optimally.

3.20 Second, two components comprise the positive present value when production exhibits decreasing returns to scale: the user cost of the resource and producer surplus; i.e. pure rent. The only function served by the resource factor payment is to capture the user cost leaving the rest for the producer. If the resource owner wants to capture the rent component then she could engage in profit sharing, but this would require an additional payment. When uncertainty is present, the resource rent

payment would be equal to 100% of the project's risk adjusted present value without additional risk sharing, with constant returns to scale. That is, the resource rent payment and a 100% profit share (e.g. a "tax" with a 100% rate) would have the same present value of revenues (holding other things constant), but the risks would be different.[14] A 100% profits interest implies that the resource owner bears all the risk, while the fixed fee per ton implies that the owner bears risks only with respect to the quantity and quality of ore found.

3.21 Other methods could be used to capture the risk adjusted natural resource rent, including a fixed or variable ad valorem royalty, a flat or variable rate profit share, and the Resource Rent Tax proposed by Garnaut and Clunies Ross (1975, 1979, 1983). Each of these methods combine risk sharing and natural resource rent. Ad valorem royalties are commonly used and the current model has two implications for their use. First, net-back pricing can be used efficiently to measure the base for the tax. Net-back pricing is commonly used to compute the mine-mouth (well-head) value of the resource. This value is then adjusted for variable lifting cost to determine the net value of the resource. This procedure may be optimal since the purpose of the resource rent payment is to capture the value of the resource and not any other component of value added.[15]

3.22 Flat rate or variable rate income shares can be used to capture the resource rent. More risk is borne by the owner for the same expected revenue with this system. Also, negative payments are required by the

---

14/ Other things would not be equal in the final contract. Total output, etc. may be different because the resource producer will respond to the different levels of perceived risk.

15/ Net-back pricing would be optimal if the net-back could be computed without error. Note also that the fixed fee per ton would be equal to the entire difference between the mine-mouth value and variable lifting cost.

resource owner. Income sharing is not equivalent to an income tax with no loss offset in this context. That is, free equity is not implied by this system. Rather full equity participation is required similar to the system employed in the Cameroon.[16] A difficulty with these schemes is that the purpose of the payment may become confused. There is no way to identify the resource rent payment independently of the risk sharing component. This raises the possibility that the owner may be under compensated for the resource itself. The dilemma can be seen by noting that a 100% equity share is required to capture all the resource rent when there is perfect certainty and constant returns to scale are present. When uncertainty is present there is a trade-off between additional risk bearing via equity shares and the natural resource rent. The resource owner bears the risk of having all the resource extracted and paying the firm for extracting it. Such a strategy may be optimal for the owner, but clear recognition of the fact that at least two objectives are being served by one instrument with these schemes in practice is necessary.

3.23 The Resource Rent Tax (RRT) proposed by Garnaut and Clunies Ross has received increasing attention.[17] The RRT is structured so that the producer bears all risk when the present value of the project is zero or negative. Positive present values are shared between the owner and producer.[18] The rate applied to positive present values may be constant or variable. It can be shown that this scheme is optimal when used as

---

16/ See Chapter I and Appendix 1.

17/ See Virmani 1985 and 1986a,b.

18/ Garnaut and Clunies Ross appear to place emphasis on risk adjusted discount rates. No such assumption is made here or in Conrad (1987a). Knowledge of real interest rates is not required for any of the results present here.

the only instrument if the following conditions are satisfied.[19]

$$EU'\pi'_x\big|_{\pi > 0} \; Ek + C_{U'\pi'_x}\big|_{\pi > 0} \tag{3.3}$$

$$EU'\pi'_a\big|_{\pi > 0} \; Ek + C_{U'\pi'_a}\big|_{\pi > 0}$$

where $EU'\pi'_g\big|_{\pi > 0}$ = risk adjusted marginal profit for input g = a,x conditional on positive present value

Ek = expected share rate

C = covariance

$\pi$ = present value of cash flow

3.24 These conditions imply that the share rate must be variable. A constant share rate would have no covariance with the risk adjusted marginal profit of inputs, other than the resource, and unless the share rate is zero the second condition will be violated. In addition the covariance between the share rate and risk adjusted marginal profit for other inputs must be negative. If the share rate is progressive then risk adjusted marginal profit must be decreasing. This result implies that if the resource owner is risk neutral a progressive RRT is not optimal.[20] This implies that the resource owner must be risk averse before the RRT can be optimal. Optimality of the RRT is implied by this discussion, but only under certain circumstances. The general applicability of this scheme cannot be demonstrated.

---

19/ See Conrad (1987a).

20/ Marginal profit is increasing in wealth; i.e. higher profits implies higher marginal profit. Thus the covariance between the share rate and marginal profit will be positive. Note that this result does not violate the results of Virmani (1985, 1986 a,b). Virmani shows welfare gains from the RRT relative to other schemes when all parties are risk neutral. However, Virmani did not account for the opportunity cost of extraction and the analysis of gains was determined relative to a distorted base since exploration costs were never deductible in his base case.

3.25 In summary, the resource rent payment is the wage for the input. It is equivalent to the wage paid per unit of labor. This payment can be combined with risk sharing components (e.g. RRT's, shares, and ad valorem royalties), if the owner clearly understands the combined function of the payment. Finally, if the resource owner operates in a competitive market then the resource rent payment adjusted for risk would equal the price of the resource at the next highest cost mine. That is, the value of the resource itself might be market determined. The producer will not be willing to pay a risk adjusted price in excess of the next best alternative.[21] This implies that both risk and competitive pressure from resource producers will determine the efficient price for the resource.

3.26 These results also indicate that free equity is not in the interest of the resource owner, while schemes such as the RRT may be appropriate under certain conditions. The most important implication of this analysis is that it is imperative for the resource owner (the governments of the countries in Sub-Saharan Africa in this present context) to determine the minimum amount they are willing to accept for each and every ton of the resource extracted. A resource owner without this knowledge will not know whether the return generated by any contract will be sufficient to cover this basic cost.

B. Opportunity Cost Payment (O)

3.27 This payment represents compensation for the wealth reduction experience in other sectors due to mineral development. Dutch Disease is commonly associated with mineral development and this phenomenon will be

---

21/ In effect, the user cost may be an exogenous variable to both the owner and producer.

used to illustrate the nature of this payment.[22] Dutch Disease has been interpreted to be an increase in the real exchange rate leading to a decrease in the value of traditional exports or lower production of import substitutes. The function for other wealth, G, in this case can be defined as:

$$G = PeY \tag{3.5}$$

where G = present value of value added in traditional sectors in real domestic prices

P = Price of output

e = inverse of real exchange rate

Y = quantity of output from traditional sectors

3.28 If Dutch disease is present then increased mineral activity will cause the real exchange rate to rise; i.e. $e' < 0$.[23] The issue confronted by the resource owner is to determine what aspects of mineral development are responsible for the increase in the real exchange rate and to determine whether the change represents a marginal or total cost. If the resource payments are sufficient to enable the resource owner to be better with G=0 then no marginal payments are necessary. There are reasons why this is not the case in developing countries. First, the total loss in traditional exports would reduce the diversification in the economy. If the country does not have complete access to world capital markets then lower diversification is costly. Second, there may be a

---

22/ Other examples would include the reduction in agricultural land resulting from resource development, the loss of fisheries for off shore development, and the increased administrative costs to attract labor from other sectors.

23/ This formulation of the problem is for illustrative purposes only, since it is assumed that the quantity of output, 'Y', is fixed. One would expect additional effects in terms of output and capital losses to sector specific human and physical capital. The general results still apply in this case.

distributional issue. A mineral discovery can increase the overall wealth of the economy but make labor and capital in traditional sectors worse-off. These sectors have been owned by predominantly lower income groups, particularly small holder agriculture. Non-recognition of these costs could lead to adverse distributional consequences.[24] Third, mineral development will not last forever. Thus, the economy must prepare for the transition from its comparative advantage in resources (a negative Dutch Disease). If the traditional export sector is not maintained or an ample substitute developed then the economy could experience significant adjustment costs as the resources are depleted.

3.29 Dutch Disease is commonly associated with increases in mineral prices. If mineral prices are the sole factor responsible for Dutch Disease and this relationship is linear then:

$$G' = -PYbP_M = PYe' \qquad (3.6)$$

where $P_M$ = World Price of minerals

3.30 The owner would include in the contract a payment equal to: $\beta P - PYbP_M$ for every ton of the resource extracted. While this payment resembles an ad valorem output tax its purpose is entirely different. This payment is compensation for <u>opportunity cost</u> and thus no efficiency costs are present. The economic response would be the same as a tax. For instance, if discounted prices were lower in the future then output would be reallocated to the future in the case of perfect certainty. However, this would be an <u>efficient</u> welfare improving response given the nature of the costs.

3.31 It is clear that one factor creating a change in real exchange rate is mineral prices. Other factors could contribute as well. For

---

24/ This may be an issue for expenditure analysis. However funds collected from the contract could be a source of payments to offset distributional impacts.

instance, if the real exchange rate were a function of the present value of mineral development then a profit share might be appropriate. The resource owner must be responsible for determining the nature of these opportunity costs and incorporating them into the contract. Failure to incorporate such factors could lead to a net decrease in the economy's wealth adjusted for risk.

C. Risk Sharing Payment (D)

3.32 The third component of an efficient mineral contract is compensation for risk bearing.[25] The resource owner may be willing to bear some risk if both total and marginal compensation is sufficient. This payment is conceptually unrelated to the other two payments.[26] The resource owner must decide how much risk to bear and at what price after a determination has been made of the owner's opportunity costs. The extent to which the owner is willing to bear risk will depend on preferences and the ability to offset risks via diversification. The condition for an efficient contract is that risk adjusted marginal profit for the producer net of all other factor payments be unaffected by the risk sharing scheme. The simplest form of risk sharing would be equity investments by the resource owner equal to k% of the total. The base of the share would then be revenues less all costs including opportunity cost paid the resource owner: i.e.

$$D = k(Rev - Cost - O - R) \qquad (3.7)$$

3.33 The marginal independence requirement highlights the insurance aspect of the risk sharing and a flat rate profit share can be optimal

---

25/ For a complete discussion of risk sharing see Leland (1978) and Conrad (1987a).

26/ The preferences of the various parties and the co-variation in prices and costs may imply a statistical relationship, but risk sharing is still a different component of the contract.

since the resource owner is paid a "premium" in good times and pays the producer in "bad" times. Other factor payments made to the owner are deductible since they are a cost of doing business and the insurance aspect of risk sharing is related only to the producer's return. Deductibility is not necessary. However, the share rate 'k' cannot be determined independently of the other payments when deductibility is absent.[27]

3.34 Other types of risk sharing include free equity and the RRT. These schemes may be optimal, but additional conditions are required which are not necessary with equity participation.[28] These conditions are related to the covariation between risk adjusted marginal profit and the share rate. They are the same general form as equation 3.3. These restrictions may imply that the RRT and free equity are not as applicable as a flat rate equity share. For instance, neither free equity nor the RRT are optimal if the resource owner is risk neutral. This implies that the resource owner could capture larger total expected payments with flat rate equity participation than either of these two schemes.

## IV. IMPLICATIONS FOR GOVERNMENT POLICY

3.35 The preceding analysis contains a number of implications for government policy in Sub-Saharan Africa. Three points deserve emphasis. First, governments which are resource owners should collect payments for the permanent loss of the economy's endowment. Second, these payment are <u>not</u> taxes any more than the wage paid to a manufacturing worker or the price of a machine. These countries have chosen to vest the mineral

---

27/ See Conrad (1987a) for the conditions for optimal risk sharing in the non-deductible case.

28/ Flat rate or variable rate output levies which are always positive are never optimal. Variable rate output levies which have negative components may be optimal. See Conrad (1987a).

rights in the state and the state thus has a responsibility to collect factor payments. The incentives created by these payments may have tax-like effects on the behavior of the producer, in a manner similar to an overall increase in the wage paid to labor. However, these incentives do not decrease welfare, but increase it since they result from the application of efficient contract terms.

3.36 Third, government in Sub-Saharan Africa should consider separating the various aspects of mineral development in evaluating its mineral policy. The government may act as insurance agent for both traditional exports via compensation for Dutch Disease and the producer. The extent to which government can accommodate these functions without incorporating them into a contract will depend on the diversity of its revenue base.

3.37 Development of minerals policy in Sub-Saharan Africa depends on sufficient information and the ability to make rational trade-offs. The remainder of this chapter contains some of the aspects which can be used in mineral policy evaluation.

A. Factors Important To Investors

3.38 Investors, foreign, domestic or SOE's, use a variety of methods to evaluate mineral investments. The methods may affect the size of the present value and the degree of risk the investor may be willing to accept. Other information about the nature of the firm (and its shareholders) is an important input into government's contract strategy. Some of these factors are noted below.

3.39 The internal rate of return criteria is used by firms to varying degrees. This criterion is known to give inconsistent results for projects such as minerals, which may have large cash outflows at the end of the project for reclamation and closing. This criterion may also give

inconsistent rankings for alternative mining projects relative to the net present value rule. Government should be in a position to compute the internal rate of return for the project from the investor's perspective in order to understand how different contract provisions may affect the cash flows to the investor. Government should also be able to point out any inconsistencies with respect to the use of the internal rate of return rule.

3.40 Some firms also employ what is known as the "Divisional Cost of Capital". This method is used to allocate funds between departments and subsidiaries. In general, the "cost of capital" for departments such as exploration are higher than the average rate for the firm as a whole. This approach also contains a potentially severe limitation. A project under consideration by a "high risk" division may ultimately become part of a "low risk" division. For instance, the exploration division will evaluate a project and the production division will assume responsibility of a successful discovery. However, the exploration division may employ a uniform high discount rate for the entire operation when making its initial evaluation. This procedure can generate internal inconsistencies within the firm: e.g. the present value of extraction will be lower using the exploration department's rate than using the rate assigned to the production division.[29]

3.41 Government should be aware of these methods used by firms. For instance, the present value of a project could be higher under an equity or RRT system than an ad valorem system if a uniformly high rate is

---

29/ If risk adjusted discount rates are to be used then it would be better for the exploration department to use two rates, not one. A high rate could be used during the exploration period and a lower rate for the production period. This procedure is justified since geological uncertainty is resolved via exploration. Using a high rate for the production period implies that such risk is not resolved.

employed by the division responsible for contracts in the country. This results because an ad valorem royalty will require the firm to make payments earlier in the project's life relative to income related schemes. If a correction is made for the use of high discount rates during the production period the firm could have a higher present value under the royalty. Such a change could affect the firm's perceptions of the government's compensation.[30]

3.42 Well diversified firms are generally willing to take higher risks relative to less diversified firms, other things equal. This implies that large multinational firms might be willing to pay government more than local firms or SOE's for the same project. Local firms and SOE's may not be willing to undertake extensive high risk operations such as exploration which large well diversified multinational firms would undertake. This type of behavior could affect the ability of government to negotiate the same terms with different producing firms and affect government's share of risk bearing.

3.43 Diversified investors seek to recover losses from non-productive or low return investments with discoveries yielding abnormal returns (ex post). This implies that an RRT type scheme may discourage high risk exploration in a country. That is, a country with a progressive ex-post share system may become non-competitive relative to other resource producing countries.

3.44 All investors prefer stability in contracts. The risk of contract changes (or nationalization) increases the total risk to the

---

30/ For example, suppose a royalty would pay 500 each for 2 years while an equity share would pay 1040 in year 2 and zero in year 1. If the discount rate is 10%, the present value is 954 for the royalty and 945 for the profit share. The firm would prefer the equity sharing arrangement since the present value of payments to government is lower. If a 5% discount rate is used then the answer is reversed: i.e. 976 for the royalty and 990 for the equity share.

investor. Other things equal, an investor would be willing to pay more for a stable contract environment. This requires stability on the part of government both with respect to general policy and mining contract policy.

3.45 Cash flow methods used by investors may include different elements. Some investors may include items such as depreciation, overheads and administrative allocations from other departments. Many of these items should be eliminated from the cash flow analysis. Depreciation is not a cash outflow and should be excluded. Overheads and inter-departmental allocations should be eliminated if such costs would be incurred absent the project. Government should be capable of developing its own cash flow profiles for both the firm and the government. This approach will ensure consistency in government's approach. The understanding gained from such analysis will also identify sources of conflict between the parties.

3.46 Foreign investors would generally prefer a resource factor payment which can be legally described as an income tax for foreign tax credit purposes. Such accommodations can be made by government to the extent possible. However, government should be aware of the costs of such accommodation. For instance, the replacement of a royalty with an equal yield income share could increase the country's risk exposure.

B. What Government Decision Makers Need to Know

3.47 Government, as resource owner, must evaluate several factors in developing a natural resource policy. A paramount requirement is an understanding of the nature of natural resource rents. Natural resources in the ground are part of the capital stock of any economy. "Natural resource rents" thus serve an important allocative function and they are necessary to induce any member of the economy, including government, to

hold this type of capital. Like dividends from the ownership of corporate stock or wages paid to labor, "natural resource rents" are a signal of the "opportunity cost" of alternative investments or current consumption. Government has a legal and economic right to these rents adjusted for risk via ownership in a manner similar to legal title to wages for work effort. It must be clear that government payments for mineral rights and extraction are not taxes. Taxes, in addition to factor payments, may affect the total return to the project and create various efficiency costs. However, no efficiency costs should be generated via well designed contracts with government.

3.48 Government must determine its opportunity cost of funds (adjusted for risk) before it can develop a rational minerals policy. A standard to determine the relative profitability (either private or social) of alternative mineral policies is not available without this benchmark. A relative standard for government to compare projects is essential for even risk neutral governments concerned only with revenue maximization since the revenues will accrue at different points in time.

3.49 Revenue maximization may not be the sole criterion when risk aversion and other opportunity costs are present. Government may have to evaluate how much risk it is willing to bear. This decision should be based on a number of factors including:

- The real per capita income of the country and the rate of growth of per capita income.
- The degree of diversification in the economy with respect to its asset base and how the returns on this portfolio vary with mineral returns.
- The economy's access to capital markets. Constitutionally the mineral rights are held by the state. In a real sense,

this implies that each citizen is an equity holder in the mineral assets. However, government ownership unlike universal ownership of equity shares may restrict the ability of the citizens to diversify. Citizens are not able to increase or decrease their participation in government held mineral rights, unless access to world capital markets is complete.[31] This restriction could be mitigated if the individuals have access to efficient capital markets which would enable them to diversify their holdings. Such access is generally not available to all individuals in Sub-Saharan countries due to low incomes, high transactions costs and other barriers to the world capital market. Therefore, governments which hold the mineral rights in non-diversified less developed economies must take the lack of diversification (both private and social) into account when assessing the risks of alternative strategies.

- Lack of diversification is related to Dutch Disease and other changes in comparative advantage generated by mineral development. The present analysis has contained one method to explicitly incorporate such effects in developing mineral policy.

3.50 Risk neutral behavior is often considered appropriate for government. This judgment is based on the "Arrow-Lind Theorem"[32] or on

---

31/ No value judgment should be attached to this statement. Rather it is a positive statement which is a consequence of government mineral ownership and restricted assess to capital markets. Citizens with access to capital markets can diversify even if they cannot sell their equity. A citizen could, in theory, develop a portfolio to offset changes in government activity by changes in mineral policy.

32/ Arrow and Lind (1960).

assumptions upon which this theorem is based. This theorem can be applied only in cases where a project is "small" relative to GDP and the returns from the project are independent of the returns from other sectors of the economy (in the sense of co-variability). These conditions are not satisfied for any economy with mineral endowments in Sub-Saharan Africa. Minerals are a significant proportion of GNP and exports in Sub-Saharan Africa. The potential for "Dutch Disease" or other factors affecting traditional exports resulting from mineral developments indicate the presence of co-variation. Therefore, the assumption of risk neutrality and consequent revenue maximization from mineral investments may be neither in the short or long term interest of these economies.

3.51 The effects of inadequate diversification in Sub-Saharan Africa are apparent from an analysis of Table 3.1. The shares of minerals in GDP and the mineral export shares for 1981 are reported in the table. Each country is ranked by the perceived riskiness of its mineral revenue policies. This ranking is based on the differential in standard corporate income tax, the mineral income tax rates, accounting methods, the use of royalties (a low risk strategy), and the use of production sharing agreements where the investor recovers their capital before substantial payments are made to the government.[33] Zambia and Zaire form the "High" risk group. Government owns 100% of the non-fuel mineral investments in these countries which implies complete exposure to all the

---

33/ High risk in this context may imply full government ownership (regardless of whether the operation is a state owned enterprise). A somewhat less aggressive strategy is extensive reliance on resource rent instruments, production sharing, and equity sharing with high rates. These instruments expose the country to substantial risk because the mineral wealth of the economy can be developed, extracted and exported with the society never receiving any payment for the factor input. Finally, low risk is defined as extensive use of fixed fees (or bids) and royalties combined with traditional income type taxes imposed on all sectors, including minerals.

risks associated with mineral production. The "Medium" risk group consists of the oil producers plus Liberia. While Liberia employs royalties to some extent, there are provisions for 50% government participation. Botswana is a member of the "Low" risk group because it does not impose a supplemental tax above the regular corporate income tax, royalties are used extensively, operations are maintained by foreign operators, and equity sharing, while used, is not as important relative to other instruments.[34]

Table 3.1: **Ranking of Riskiness in Natural Resource Revenue Systems**

| | Mineral Shares | | | |
|---|---|---|---|---|
| | in GDP a/b/ | in Exports a/b/ | in Revenue a/b/ | Riskiness c/ |
| Botswana | 16.6 | 65.8 | 28.7 | Low |
| Cameroon | 11.7 | 66.9 | 53.8 | Medium |
| Gabon | 52.8 | 78.2 | 65.5 | Medium |
| Liberia | 20.8 | 70.7 | 2.1 | Medium |
| Nigeria | 21.8 | 95.4 | 65.6 | Medium |
| Zaire | 11.5 | 92.5 | 10.5 | High |
| Zambia | 11.0 | 92.3 | 0.0 | High |
| Zimbabwe | 4.2 | 26.5 | NA | Low |

a/ See text and Appendix 1 for definitions used and tax-revenue systems.

b/ 1982. See Chapter 1 and References for sources.

c/ The ranking is subjective. However, it gives an indication of the degree of exposure to international market conditions due to lack of diversification in economic and revenue structure.

3.52 While no normative judgments should be reached from this table, it is clear that the "high" risk strategy adopted by Zambia and Zaire is responsible, in part, for their current economic situation. Lack of diversification combined with full exposure to the risks of mineral development have contributed to the balance of payments and debt service difficulties which arose when mineral prices fell. Nigeria's situation is similar to Zambia's and Zaire's. Nigeria is also one of the less diversified economies in the region measured in terms of GDP shares and

34/ See Appendix 3.

exports shares. These countries may serve as illustrations of aggressive government mineral policies. The more aggressive a country's mineral policy the greater the down side risk for a non-diversified economy.[35]

C. Integration with Other Taxes

3.53 The factor payment method(s) chosen by the government should be designed to recover "natural resource rents", other opportunity costs and the cost of risk bearing. Taxation may create additional incentives. In general, tax policy should be designed for the economy as a whole. Mineral producers should not be treated differently than other sectors, if the factor payment is well designed. This implies that tax policy and mineral policy have different implications. Taxation's purpose is to transfer real resources from the private to the public sector, while factor payment policy is intended to capture the return from the ownership of an asset. Rational tax policy should be determined relative to the efficiency cost of the tax within and between sectors.[36]

---

35/ No claim is made that all the problems in these countries are attributable to the effects cited above. However, these effects have been contributing factors.

36/ The distribution of the tax burden is an incidence issue. In an open-economy the incidence of capital taxes will be borne by domestic labor, owners of domestic land, and owners of domestic natural resource deposits. This implies that factor payments made to government could fall as a result of a neutral income tax. This does not indicate that separation of tax and factor payment policy is artificial. For instance government could impose only the generally applicable income (or cash-flow) taxes with no factor payments: i.e. give the resource away. In this case, some (or all) of the value of the natural resource rents will accrue to domestic nationals in the form of higher wages and the government may recoup some of the natural resource rents via the tax. Such an approach would risk misallocation of resources on two accounts. First, there could be intersectoral misallocation of investment: e.g. too much investment in natural resources relative to other sectors. Second, the "supply-price" of reserves would not be known. Thus, the development profile may not be socially optimal. Therefore it is important to separate tax from factor payment policies. Neither the welfare cost of a tax nor its incidence can be determined without knowledge of the value of the resource. For a further discussion of the interactions between general taxes and resource payments see Virmani (1985 and 1986 a,b).

3.54 Equality of marginal effective tax rates across all sectors may be one objective of tax policy. The choice of instrument (either income or consumption taxes) is an economic policy decision. If the government desires to tax "income" then complete neutrality would require the following provisions for the taxation of minerals.

- Deduction of interest.
- Deduction of all mineral factor payments, regardless of structure.
- Deduction of "Real Economic Depreciation".
- Complete indexation for inflation.

3.55 Factor payments to government for the resource, other opportunity costs and risk bearing should be deductible since these payments are a cost of accruing income. Immediate expensing of exploration and development expenses should not be allowed. These expenses should be capitalized and subject to an "exogenously determined amortization schedule" similar to the depreciation deductions for machines and equipment. The schedule should be exogenous because an endogenous depreciation schedule (e.g. based on production) may create allocative incentives.[37] Resource producers should not be allowed depletion for the simple fact that they do not own the asset in the ground. Granting depletion to a resource producer is equivalent to granting depreciation to an agent who rents a machine. Since legally and economically speaking, depreciation should be equal to the reduction in the market value of the asset, this deduction should be available only to the party with an ownership interest in the asset.

---

37/ See Chapter 2 and Appendix 2. Arbitrary measures will be used in practice, similar to the arbitrary depreciation rules for machines and equipment, since it is impossible to measure true economic depreciation. However, if some assets are allowed endogenous depreciation and others are not (e.g. buildings) then there is a clear additional incentive to change the pattern of investment.

3.56 If cash-flow taxes (consumption taxes) are employed in other sectors of the economy, then different mineral tax policies are required to ensure neutrality. Specific provisions would include a deduction for resource factor payments (regardless of type), no interest deductions, and immediate expensing of all assets. Inflation adjustments are not necessary since cash-flow taxes are made on a current basis.

3.57 It has been noted that the choice of cash flow relative to an income tax is a general tax policy decision. The marginal effective tax rate on capital is zero for a consumption tax, while an income tax captures part of the capital's return. Both instruments "capture economic rents" (ex post). Economic rents accrue to all economic sectors. Thus, there is no justification for excessive concentration on economic rents in one sector such as minerals. If there are economic rents in the system then the government can capture them with either instrument and regardless of industry. If government employs an instrument which captures some rents from all sectors, the need for additional "rent" taxes on the mineral sector is mitigated if a well designed resource policy is in place.

3.58 Finally, there is little economic justification for output taxes in the minerals sector absent proven externalities and the presence of an integrated valued added tax system. Royalties may be appropriately used as a factor payment, but additional taxes of this nature will deter investment, change intertemporal extraction profiles and create excessive welfare losses to the economy as a whole. For this reason, such taxes should not be used for revenue purposes. Output taxes may be considered in the case of proven externalities. The social cost of extraction may be greater than the factor payments due to pollution, erosion, etc. and a well designed output (or input tax, if the input is the source of the externality) tax may be appropriate.

## V. SUMMARY AND SUGGESTED STRATEGY

3.59 One strategy for development and evaluation of natural resource policy is offered below. The strategy should be considered a flexible framework which can be varied to the needs of a particular country. The strategy is based on the preceding analysis and emphasis is placed on the identification of particular revenue instruments for specific objectives. More than one objective could be served by one instrument in practice (e.g. an ad valorem output level for both risk sharing and rent collections). However, a clear delineation of objectives is facilitated with separation of objectives and instruments. Multiple objective instruments should be used only after the objectives for which they will be used are clearly delineated.

3.60 A portfolio approach to mineral contract development is suggested by the previous analysis. This approach would contain five elements in addition to the generally applicable business income tax: a fixed fee (or bonus), a royalty (either ad rem or ad valorem), an equity share, a "surplus" scheme and an adjustment cost function. The bonus could be computed via competitive bidding or negotiation. Two functions are served by the bonus. First, the bonus would compensate government for the opportunity cost of the mineral rights during the exploration and development period. Government forgoes the right to land use and the right of allowing other parties to use the mineral rights during this period. Thus reasonable compensation is required for government to forgo other options. Second, the bonus can be used to capture any additional risk adjusted surplus which the producer would be willing to pay. The amount of additional surplus will depend on the entire contract structure including all risk sharing elements.

3.61 The royalty is the instrument to capture the value of natural resource rent. This payment should be used to compensate government for

mineral's share of value added in the production process. In theory, this share could be computed as the difference between the net-back price to the mine mouth less all extraction costs. That is, the difference between price and cost would equal resource rent at the margin. Practical considerations and measurement error will prohibit the accurate measurement of such a margin. Thus an ad valorem instrument combined with the net-back computation to arrive at a reasonable computation may be sufficient. A risk sharing element is introduced with an ad valorem system. Offsetting or complementary adjustments may then be required in other instruments to account for the presence of risk sharing.

3.62 The "equity" share should be fully funded, purchased equity: i.e., no free equity. Equity participation provides the risk sharing function. It should be emphasized that the insurance function served by equity participation is insurance for the producers. Government assumes profit risk and thus acts as an insurance agent. The base of the share should be defined by allowing a deduction for all other payments to government, since they are a cost of doing business. This base would clearly delineate the function of this payment as insurance, avoiding unnecessary ambiguity and computational complications in determining the appropriate rate.

3.63 An additional benefit of equity sharing is government's right to influence the producer's decisions. Efficient contract design requires joint and mutually advantageous decisions by producer and owner. Equity participation is a transparent means of achieving this objective.[38]

---

38/ The government, being sovereign, always has some right to influence decisions regardless of the payment method. Efficient contracts would also contain provisions where the rate of extraction and recovery are mutually agreed absent equity participation. For instance, a contract containing a royalty and mutual agreement on the rate of extraction could work as well as equity sharing. In this sense the benefit of equity sharing is solely its transparency to all parties.

3.64 The "surplus" scheme is an additional form of risk sharing combined with capture of ex post economic rents, not natural resource rents. The decision to employ a scheme such as a variable rate royalty or RRT should be tempered by the presence of the equity share, the presence of the generally applicable business income tax and perceptions regarding nature of uncertainty. Equity sharing and the generally applicable income tax are also instruments which can capture ex post economic rent. An additional surplus scheme could deter investment. For instance, if the government employs funded equity at a rate of 40% and a corporate income tax of 50% the combined rate would be 60% of the present value assuming the equity share is deductible from the corporate tax. This example highlights the need to ensure that all contract and tax elements are coordinated so that effective rates are commensurate with risks and expected returns.

3.65 The adjustment cost element would serve as compensation for 'Dutch Disease' and other general equilibrium effects on the economy. The exact form of this payment will depend on how mineral development affects the comparative advantage and real exchange rate of a particular economy. The world price of output would generally be one element of the base. An ad valorem rate (either flat rate or variable) might then be applied to the value of production in this case. This payment is not constructed to be a supplemental levy or tax. Rather, this element is one component of the economy's natural resource supply curve. Government will not be compensated efficiently if terms of trade effects and related factors are omitted.

3.66 The weights applied to each element of the factor payment policy will reflect the degree of risk government is willing to bear. For instance, if the government was willing to bear little or no risk then a

combination of fixed fee and royalty could be used exclusively, absent terms of trade effects. If government is willing to bear all risk then complete equity would be appropriate. It should be emphasized that risk of collecting negative revenue is present, even though natural resource rents exist under the latter scheme.

3.67 It is the authors' view that government should not exclusively employ an equity sharing, production sharing, or resource rent schemes for factor payments. Such schemes are equivalent to workers agreeing to work for a manufacturing firm for no wage and only the hope of future gains (through profit sharing schemes). It is common for all factors of production to charge a rate per unit of input which is at least equal to their opportunity cost. Given the common use of this method for other factors of production, there is little justification for resource owners to behave differently.[39] In addition, adopting such schemes may inhibit the computation of the country's supply price for the resource. This view is based also on the lack of diversification present in Sub-Saharan Africa, the lack of complete access to world capital markets and the apparent effects of changes in mineral prices on government revenue and terms of trade. For these reasons, a per unit royalty may be an essential part of any resource development scheme. Positive revenue will accrue as long as extraction takes place. In addition, government must confront the issue of the intertemporal opportunity cost of resource development and the supply price of its resource base. There is a tendency to treat the revenues from other schemes as "taxes" without regard for the opportunity cost of extraction. However, extraction

---

39/ Of course, charging a rate per unit of output includes the risk of unemployment. However, this risk is included in the computation of the rate itself and it seems economically irrational for factor owners to be willing to lower their rate to zero in order to be fully employed.

permanently reduces the wealth of the country and this loss requires reasonable compensation. The royalty would be a signal to both government and producers regarding the implicit (or explicit) value placed on the decrease in capital value.[40]

3.68 In summary, there is no "unique" resource development policy for any country. The correct policy for a given country will depend on the extent the government is willing to bear the risk, given the existing portfolio of assets held by the economy as a whole. The strategy outlined above provides a sound framework for analysis. Policy makers are forced to address each component of mineral development; opportunity cost, adjustment costs, risk bearing and taxes in a unified framework. Consistent application of the strategy will aid government and producers understand the nature of various instruments, the structure of risk, the objectives and the constraints of each party. Such understanding can aid in developing contracts which are mutually advantageous and less subject to dispute at later dates.

---

40/ Governments which choose not to use output related levies should still account for the opportunity cost of extraction. No measure of social gains and losses from alternative schemes can be made without properly pricing the resource. Low weight may be given to the royalty with the major revenue source being equity sharing or "surplus" payments such as the RRT.

# Chapter 4: A FRAMEWORK FOR REFORM

## I. INTRODUCTION

4.1 An evaluation of the tax/natural resource policies is contained in this chapter. Alternatives are discussed relative to the framework developed in chapter 3. The systems used by the Sub-Saharan countries are comparable to international standards.[1] The countries employ income related levies, production sharing, rent schemes and output levies. Comparability with other countries does not imply economic efficiency. A number of problems have been noted with the tax/resource policy systems commonly used by most mining nations and alternatives have been developed.[2]

4.2 The perspective of this chapter differs from the standard public finance approach usually adopted for evaluation in this area. Emphasis will be placed on the distinction between taxes on the return to invested physical capital and payments made to the resource owner for a factor input. These payments may be combined in an economy where the tax collector is also the resource owner. However, tax policy and mineral development policy, while related, serve two different functions. The economic objective served by tax policy is to generate sufficient government revenue in a manner which minimizes the efficiency costs to the economy. The role of mineral development policy is to ensure that mineral development is consistent with national objectives, when the resource owner is the government, and to ensure that the receipts from mineral development compensate the country for the risk adjusted valued of the resource net of

---

1/ See the discussion in Chapter 2.

2/ See Chapters 2 and 3 of this report. Alternative evaluations have been offered by Conrad and Hool (1980) and Conrad and Convery (1981), Virmani (1985) and (1986 a,b) and Garnaut and Clunies Ross (1983).

all economic costs. Mixing objectives in practice, combined with ambiguity regarding the difference between ex-ante economic rent and natural resource rent may have contributed to a confusion about the proper role of government mineral development policy. This confusion may be responsible, in part, for policy developments which are less than optimal. Thus, this chapter is organized so the differences and similarities of the two policies are highlighted.

## II. MINERAL-CONTRACT POLICY

4.3 Government as a resource owner must determine the following factors before a rational mineral development policy can be developed:

- The value government, as owner, places on the opportunity cost of the minerals;
- The amount of risk government is willing to bear in mineral development;
- The degree of access to world capital markets;
- The potential economic effects of mineral development on the economy's terms of trade and the economic effects on other sectors.

### A. Opportunity Cost of Mineral Ownership

4.4 Government evaluation of the minerals in place will determine the opportunity cost of extraction at different points in time. This value will determine the minimum amount that government is willing to accept for the resource. This computation is equivalent to computing the initial basis for any asset. Cost is the generally accepted economic basis for any asset; for example, if a firm pays $100 for a machine then the initial

basis is $100.[3] The difficulty with computing the opportunity cost for a mineral resource is no purchase has taken place since the endowment is a gift from nature. However, this does not imply that the opportunity cost of mineral development is zero.

4.5 Two computations may be required for determining the government's basis. First, a computation of the value of alternatives uses of mineral bearing lands may be computed. This value will determine government's opportunity cost based on next best use. Appraisal techniques are available to compute this value.[4]

4.6 Second, government should compute the present value of the deposit assuming that government will exclusively develop the deposit.[5] No taxes, levies, etc., should be included in this computation since the purpose of the exercise is to determine the value government places on the self development option.[6] Different assumptions might be used since this computation will be an expected value.[7]

---

3/ This basis would be equal to the true economic value in a market economy.

4/ Minerals are generally found in remote areas or off-shore. Again, this fact does not imply zero opportunity cost. Zero opportunity cost implies that government, or any land owner would be willing to give the land away. This might be possible, but it is highly unlikely.

5/ Both the methodology and technology are available to make these computations. For instance, the methods used by Kalter, et. al. (1974) and Virmani (1985 and 1986a, b) could be adapted for this purpose. The parameters for estimation could be adapted to the country's particular circumstances. This computation could be performed on behalf of government by international institutions such as the World Bank, etc., or by private firms if skilled manpower is not locally available.

6/ This computation will include both natural resource rent and producer surplus if decreasing returns to scale are present. The resource rent can be separated by computing the difference between price and cost, including capital cost at the optimal level of output.

7/ For instance, risk neutrality could be assumed initially to provide an upper bound. Then various degrees of risk aversion could be introduced.

4.7 The final step is to compare the present value of self development with the assessed value of the land without minerals. The higher value should be used for all subsequent portions of the analysis, since the option with the highest value represents the best alternative use by government. That is, the highest alternative value for exclusive government use will equal the minimum amount government will be willing to accept for the outright sale of the properties.[8] This value will serve as the benchmark to compare any other mineral development strategy considered by the government. Note should be taken of the fact that these computations are only estimates and are subject to error. This does not imply that the benchmark has no value. The process used to make the computations will force government to confront directly the costs of alternatives in a systematic way. Methods are also available to adjust errors in estimates.[9] Advantage should be taken of such methods to the extent they are cost-effective.

4.8 The measures of opportunity cost computed by these procedures will serve as the basis for determining the return, both total and marginal, for

---

8/ The fact that government may be constitutionally prohibited from selling part of the country to a third party, either domestic or foreign, is irrelevant, since the purpose of the exercise is to compute the value of one option available to government. That is, government always has the option of self-development and it needs to know the value of this option.

9/ More sophisticated Monte Carlo techniques can be used to attach standard errors to the estimates. It should also be noted that the amount of effort expended on this exercise will depend on the amount of information available for any point in time. However, information has a value and systematic evaluation is preferred to no evaluation at all. It should also be noted that this method can be used to determine the value of additional information. For instance, Garnaut and Clunies Ross (1983) suggest that government, perhaps with aid from donors engage in preliminary or extensive exploration. Whether this is a rational strategy will depend on the preferences of government for risk taking relative to the cost. Exploration, etc. performed by or on behalf of government reduces the risk to private investors. Thus, risk-reward trade-offs are present and it is not clear that such a strategy is in the interest of government a priori.

any mineral strategy and/or contract terms considered by government. Contract terms which generate present values below (in excess of) total opportunity cost, adjusted for risk, should be excluded from (be included in) the possible set of options. Alternative extraction profiles can also be evaluated once this value is determined. If the present value of deferred extraction per ton is greater (less than) additional extraction in early periods then extraction should be deferred (accelerated) from the social point of view. In effect, the measure of opportunity cost approximates the increased wealth from mineral development since the measures are computed as potential market values of the stocks.[10]

B. Risk Evaluation

4.9 Risk evaluation, access to capital markets and degree of economic diversification are related. The risk of mineral development that the government is willing to bear will depend on its access to world capital markets and the extent of the economy's diversification. The evaluation should contain an analysis of mineral risk in relation to other risks borne by the economy relative to existing wealth. Risk neutrality should not be assumed a priori. Risk neutrality could be a result if the economy is well diversified and potential mineral wealth is small relative to other economic sectors.[11] Some degree of risk aversion may be appropriate in other circumstances.[12]

---

10/ If outright sale is not constitutionally allowed then the negative difference between the risk adjusted return from the next best alternative and sale would equal the economic cost of the prohibition.

11/ Objective methods are available to determine the degree of exposure to risks, diversification, etc. For instance, the covariance matrix of returns in the economy could be computed. This covariance matrix could be computed with and without mineral investments to determine the contribution of mineral investments to the overall risk to the economy.

12/ The determination of any risk aversion parameter for government is ultimately subjective. Indications of risk aversion can be inferred from prior behavior regarding government investment policy, etc. Such inferences could be employed as initial indicators.

4.10 Access to capital markets will aid government in determining the degree of risk sharing which might be contained in mineral contracts. For instance, if access to world capital markets is complete and costless for both government and private citizens then almost any degree of risk sharing (even 100% full equity ownership by government) can be included in mineral contracts. Each agent can determine the level of mineral risks they are willing to bear via adjustments in their respective portfolios in this case. Costless complete access to world capital markets may be the exception rather than the rule for Sub-Saharan economies. Thus a determination of risk sharing strategies will generally be part of mineral contracts with third parties (or SOE's and/or other government departments).

C. Terms of Trade and Other Effects

4.11 Emphasis has been placed on "Dutch Disease" and other terms of trade effects throughout this study. Government should not evaluate mineral investments as separable projects when there is significant potential for general equilibrium adjustments in the economy. The transition to and from a relatively mineral-intensive economy can affect the terms of trade and the structure of relative prices in the economy. These adjustments can be costly and estimates of the size and timing of these costs should be included in government's evaluation.

4.12 The procedures used to evaluate these costs vary. Simple methods would include reduced form forecasting equations where the real exchange rate is estimated as a function of world mineral prices and other mineral related economic variables (e.g. world price of imported inputs, quantities extracted and/or total reserves). Complex methods include development of computable general equilibrium systems designed to estimate how mineral

developments change the structure of relative prices.[13] Portfolio effects could be estimated in a manner similar to methods described in the last section: e.g. computation of the covariance matrix of prices and cost in the economy. The appropriate method to employ and the extent of the analysis will depend on the potential (or realized) importance of minerals and the resources available.[14]

4.13 Real externalities such as pollution, environmental hazards, etc. should also be part of this process. Pricing externalities is important if the social cost of real externalities is high. Estimates of these social costs will determine socially optimal adjustments to extraction profiles, recovery and corrective pricing methods.

4.14 The extent to which the general equilibrium effects of mineral development should be incorporated into specific mineral contracts will depend on the degree of diversification, distributional objectives, government expenditure policy and wealth. If government has sufficient resources from other sectors to compensate those harmed by mineral development via changes in comparative advantage then expenditure policy can be used without recourse to incorporating specific contract terms. Some recognition of these factors should be incorporated in contracts due to lack of complete access to capital markets and the mineral-specific risks society might bear.

D. Policy Development

4.15 The factors discussed above are some of the elements essential to determine mineral development/tax policy. Policy development or re-

---

13/ For example of the computable general equilibrium methods see: Benjamin and Devarajan (1985 a,b) and Benjamin et. al. (1985).

14/ Such activities could be undertaken by donors such as the World Bank on behalf of government. The methods described in this section are extensions of standard project evaluation techniques. It is possible for the Bank to engage in this activity as part of its country studies and/or as a part of the Bank's review process.

evaluation will require a social evaluation of different alternatives to measure the gains and losses of each strategy. Some factors which should be considered in policy development are discussed below.

4.16 The cost of risk bearing should be explicitly considered. The cost of risk bearing is more readily identified if the strategy discussed above is used. Government ownership of both the resource base and a portion of the means of production will increase the economy's exposure to mineral risks. The payment structure selected by government will also affect the degree of risk exposure. The difference between the value of outright sale and the present value of alternative contract schedules discounted at a risk free rate will provide an estimate of the gains from risk bearing. A reasonable analysis will incorporate the structure of project specific risks relative to payment structure.[15]

4.17 One popular method for risk compensation is to compute a risk adjusted discount rate. Estimates of the risk premium can be obtained by market analysis commonly applied to mining and other industrial firms.[16] The risk borne however will depend on the contract structure making risk adjustments endogenous. For instance, an ad valorem royalty can never generate negative revenues, while equity sharing requires cash outflows which might never be recovered. This implies that if risk premium methods are used, the premium for an ad valorem royalty should never be greater than the premium for an equity share. Risk adjustment may also require

---

15/ Project-specific risks could be computed via estimates of the intertemporal covariance matrix of inputs and outputs. Minimum risk is derived via a determination of the amount of wealth necessary with perfect certainty to make an agent no worse-off relative to the agent's expected welfare in the uncertain situation. This value is known as the certainty equivalent value relative to the risky situation. This notion is basic to formulations of the "risk premium" derived from methods such as the Capital Asset Pricing Model.

16/ See Copeland and Weston (1980) for methods of estimating risk premiums in a variety of contexts.

different risk premiums at different points in time.[17] An example will aid to clarify this point. Suppose that project prices and costs are intertemporally independent and that the government employs the RRT. The presence of the RRT will create potential serial correlation of otherwise statistically independent variables. This occurs because realizations of high (low) cash flows in early periods will affect the RRT base (and perhaps the rate) in later periods. Ad valorem royalties and production shares with no loss offset provisions do not induce serial correlation since the base of each payment are period-specific only. This implies that different premiums might be present at different points in time for the RRT which would not be needed for other levy structures.[18]

4.18 Integration of taxes in addition to mineral-specific levies should be part of this process. The introduction of corporate income taxes, output taxes, etc. can complicate the analysis from the social point of view. Government as resource owner and tax collector has two choice variables in the mineral area relative to the one, tax policy, which it employs in other sectors.[19] This implies that government potentially can compensate for the adverse incentives created by one instrument via changes in the second. For instance, export taxes can be reduced with compensating increases in ad valorem royalties in contracts with no net change in the

---

17/ In general, certainty equivalence adjustments can be made via adjustments in the discount rate. However, it is important to understand that the nature of the adjustment is derived from the minimum ex ante compensation, both total and marginal, necessary to induce agents to bear risk.

18/ This result should not be considered a cost of the RRT. Rather, proper adjustment for the serial correlation introduced by the RRT is required before the net benefits of the RRT relative to other schemes can be determined.

19/ In reality, government has numerous instruments including regulation, price control, etc. However, the point emphasized in the text is still valid.

incentives faced by the investor. Such adjustments may be appropriate if proper identification of cost and benefits are maintained.

4.19 One approach to this type of problem is to compute the risk adjusted returns to government as resource owner with and without various taxes. The different values and extraction profiles will indicate the partial equilibrium efficiency costs imposed by the tax system.[20] If compensating adjustments in contract terms are deemed appropriate then this procedure will indicate the risk adjusted gains and losses to each party to the contract.

4.20 Tax policy, corporate tax policy in particular, should be considered part of the general economic policy of government. If compensating adjustments are contemplated in mineral contracts then intersectoral effects should be considered. It is not clear ex ante that exemption from all taxes with compensating adjustments in contract terms will be welfare improving.[21] If the effective tax rate in other sectors is higher or lower relative to the minerals sector then intersectoral allocations can be created reducing the efficiency of the entire economy. For this reason adjustments in tax policy to accommodate mineral producers should be done with care to ensure that all important factors are incorporated.

4.21 The final point relates to the use of the present value computations for the final contract terms. The present value of government payments, net of taxes, should be considered the government's basis in the minerals in place adjusted for risk. This value should be kept and

---

20/ If perfect certainty and an open economy is assumed, the difference in the two present values may be exactly equal to the tax revenues.

21/ Compensating adjustments identical to those in the tax law would have no effect.

adjusted for resource depletion as the resource is developed and extracted.[22] Two functions are served by this procedure. First, reduction in present value via extraction will indicate the loss in capital value to the economy which may lower living standards if not replaced by other investments.[23] Second, proper record keeping for lost value will aid in ex post evaluation and reformulation of mineral policy should the need arise. For instance, accounting for depletion enables a computation of the opportunity cost of timing differences resulting from levies such as the RRT. It is important for government to keep these accounts even if output levies are not charged. Government must price the resource to determine the opportunity cost of extraction and charge itself for inventory reductions for each sale. If a price is not determined then government will have no method to evaluate either the costs or benefits of its mineral policies.

## III. EVALUATION AND RECOMMENDATIONS

4.22 There is reason to believe that the resource/tax policies in Sub-Saharan Africa can be improved. A clear distinction between the various roles of government in this sector is not apparent from the policies discussed in this report.[24] There is little evidence that the resource

---

22/ Depletion accounting for government is entirely appropriate and necessary since title to the resource is held by this agent. The type of depletion discussed here and in Section 4 assumes government ownership and is different from the producer's depletion which was criticized in Chapter 2.

23/ One method for computing depletion is present in Section 4 of this chapter.

24/ A possible exception is Cameroon which has the benefit of experience in other countries since mineral development there is relatively recent. No attempt is made to second guess or read the minds of policy makers in these countries. Ex ante, the policies which have evolved could have resulted from direct application of the methods described in the last section. However, I do not believe this was the case.

base is priced or that the cost of adjustment via changes in terms of trade is priced explicitly. Emphasis has been placed instead on rent collection schemes (e.g. free equity and complete ownership) without appropriately considering the risk or the differences between natural resource and economic rents. Finally, no explicit policy has been noted which incorporates depletion and consistent internal government accounting.[25]

4.23 These concerns foster the conjecture that some of these economies have developed policies which undercompensate them for both the natural resource rent and the taxes on investment capital adjusted for risk. The basis for this conjecture is examined below and alternatives are offered for consideration.

A. Income Related Charges

4.24 In an economy where the mineral rights are vested in private hands there is no prima facia case for the taxation of capital invested in the mining sector to be any different than capital invested in other sectors of the economy. That is, the marginal effective tax rate on capital in the mining sector should be the same as the effective rate on any other sector. Given the structure of mineral income taxes worldwide (Sub-Saharan Africa in particular) there are reasons to believe that the effective tax rate on invested capital in the mineral sector is below that in other sectors.[26]

4.25 The reasons for lower marginal effective tax rates in mining include:

---

25/ This does not imply that such mechanisms are absent. However, lack of explicit policies raises doubt.

26/ This statement is restricted to the income tax and does not include output taxes. See Shoven (1982), Conrad (1983) and Gravelle (1983) for estimates which show that the marginal effective income tax rates on mining are below those of other sectors in the United States.

- Expensing of all exploration costs implies that the effective marginal tax rate on this activity is zero on an all equity investment.
- Expensing of development implies a zero effective rate on this activity as well.
- The share of exploration and development in total capital expenditures in mining is large (sometimes in excess of 80%). Thus, even if the other capital expenditures on mining are subject to standard depreciation, the effective tax rate on total investment would be lower than other sectors.
- Allowance for interest deductions (even with thin capitalization and transfer pricing rules enforced) may imply a further reduction in the effective tax rate when combined with expensing of large components of investment. These factors could create negative effective rates in this sector.[27]
- To the extent that percentage depletion is still used it is possible that the firm can deduct an amount greater than its initial basis in present value terms. This would further decrease the effective tax rate.[28]

4.26 In summary, expensing a large share of the investment combined with interest deductions and other incentives suggests that the effective tax rate on invested capital might in fact be substantially lower than

---

27/ Negative effective marginal rates may or may not be present depending on the rate of inflation. However, there is little doubt that the mining sector's effective rate is lower than other sectors, other things equal.

28/ See Harberger (1960) and Conrad (1983) for a discussion of this issue. Recall that depletion in excess of the capitalized basis of exploration and development (which may be zero) should not be granted to the owner of physical capital. The producer purchases the resource from the resource owner and thus the producer should receive a deduction for the cost of this input. Allowing a deduction for royalties, regardless of form, and a depletion allowance is double counting.

statutory tax rates. It is important to emphasize that a high tax rate (such as 65% in Zambia or 85% in Nigeria) is no indicator of the effective taxation of investment in the industry.[29] Absent compensating adjustments in other parts of the tax/contract system, capital will be misallocated economy-wide with too much capital allocated to the mining sector. This could make the economy more dependent on natural resources than is appropriate.[30]

4.27 Justifications for expensing combined with interest deductions include the high front end expenditures necessary to explore and develop minerals; the risks of exploration and development; the long lead times between initial exploration and generation of positive cash flow; and the need for financing, often over long periods of time.[31] These considerations have little foundation in the context of overall tax/natural

---

29/ High statutory rates could even increase the negative effective rate. Again, these claims relate only to the income tax and not the total tax bill which includes output taxes, export and import taxes, etc. The case for low effective rates is stronger when exemptions from import duties which are common in many mineral agreements are included.

30/ The presence of natural resource rents might lead a country to reduce the effective tax on other investments. See Conrad (1984). However, if the contract system does not compensate for the lost revenues from the tax incentives in the income tax then the present value of government revenues (tax plus factor payments) might be lower or even negative. One factor contributing to the current debt and balance of payments problems in some of these countries could be a policy of reduced taxation of other sectors, whether by law or reduced administrative effort, without due consideration for the "lower" present value of the tax revenues (adjusted for risk) from the mining sector created by all these incentives. This issue deserves further investigation and indicates that the role of mining taxes is best addressed in the context of overall tax reform. If adjustments have been made in natural resource policy to adjust for these incentives then the statements in the text should be tempered. The issue is whether such adjustments have been made and the form they have taken.

31/ A type of identification problem is present here. It is not clear whether large amounts of debt are necessary to finance mineral projects or whether equity holders are attempting to shift the risk of large investments onto debt.

resource policy. Explicit risk sharing provisions can be included in natural resource contracts. Such terms should be included where it is in government's interest to do so. Explicit consideration of risk in the contract process should mitigate the need for additional risk sharing implicit by discriminatory incentives in the income tax. The explicit inclusion of risks in natural resource policy will force policy makers to confront the trade-off between the risks borne by a particular firm against the risk and long lead times necessary to diversify and develop an entire economy.

4.28 The need for reform is indicated from this discussion. The income taxation of mineral investments must be placed into the context of the overall tax system and its objectives to ensure consistency. A complete discussion of tax reform is beyond the scope of this study. However, the following considerations could be incorporated into a reasonable income tax which might be compatible with the overall objectives of the mineral sector and the tax system for the economy as a whole.

4.29 Given the large cash flow component in existing mineral income taxes, consideration could be given to the development of complete cash-flow taxation (i.e. full expensing). Under such a system all investment expenditures would be immediately expensed. There would be no need for inflation indexing and depreciation rates, which are ultimately estimates, under cash-flow rules. Also, rules for other expenses such as intangibles would not be necessary. Interest deductions, however, would <u>not</u> be allowed under this system (this would avoid negative marginal effective tax rates which arise from double counting of capital expenditures due to the provision of immediate expensing of assets plus the allowance of interest deduction).

4.30 A potential problem with a correctly designed system of full-expensing is that the effective marginal tax rate on invested capital is

zero. That is, it is possible for the present value of taxes paid by the marginal firm to be zero.[32] Unless other sectors of the economy are also treated as cash-flow taxpayers then the mining sector will have more favorable tax treatment with a consequent reduction in the present value of government revenues.[33] In response, the following points deserve consideration. First, the cash-flow tax is an efficient method for collecting rent regardless of type (i.e. natural resource rents, rents accruing from market power or inframarginal rents present when production exhibits decreasing returns to scale). Rents not captured within the context of the contract would be captured by this tax. Second, risk sharing in the context of the tax would be clarified. Some agreements require the mining firm to bear all exploration and development risk. The firm is then allowed to recover much of its capital cost before the tax or contract provisions become operative. Cash-flow taxation will make such risk sharing explicit in the tax law itself without any concern regarding the debt structure. Third, new investments in mining have large front end negative cash flows. Unlimited loss carry forwards would allow firms to retain part of the expensing benefit. Loss carry forwards will increase the effective tax rate since the firm will lose the present value of the expense between the date of expenditure and the date of realization.

4.31 Comprehensive income tax concepts could be retained under a cash flow system at the corporate level if "withholding taxes" are continued and

---

32/ As stated above it is not clear at this point whether a zero marginal effective rate would increase or decrease the effective tax rate currently in existence in some of the Sub-Saharan countries.

33/ In addition, holding total tax revenue constant the move toward cash-flow taxation would require an increase in the effective tax rate on consumption. See Break, Holland and McLure (1986).

expanded.[34] Withholding taxes should be imposed on all distributions made by the firm to related or to third parties to obtain this objective: i.e. withholding taxes should be imposed on interest, dividends, management fees, royalties for technology, etc. The withholding tax rate should be uniform across categories to minimize the incentive to engage in artificial pricing. For instance, thin capitalization rules would not be necessary since interest is not deductible and both interest and dividend payments would bear withholding at a uniform rate.[35] Withholding taxes should be applied at the firm level and regardless of payee. If the payee is a domestic national then the government could choose to allow credits for these taxes paid at the individual level depending on the overall objectives of the general tax policy. If the payee is a foreign person then the withholding tax is the "final payment" from the perspective of the host government.[36]

4.32 In summary, the combination of a cash-flow tax with a withholding tax offers the potential for the country to impose both a tax on rent and a tax on the return to capital (via the withholding tax) which is consistent with current risk sharing arrangements and is not dependent on the corporate structure. The effective tax rate on domestic capital will be determined by provisions at the individual level.

---

34/ The effective tax rate on capital can be computed only after personal and corporate tax provisions are integrated. Cash-flow principles at the corporate level do not necessarily imply consumption taxation for the economy as a whole.

35/ The absolute incentive to reduce tax liabilities will always be present.

36/ However, withholding taxes are creditable in the home country so the economic incentives created by the tax on capital may be mitigated, in part, via the foreign tax credit.

B. Output Levies

4.33 A well-designed royalty can capture the share of value added which is attributable to the mineral. Minerals in the ground are inputs into the production process and the demand for these minerals is determined by the laws of derived demand for output of the finished products which the minerals are used to produced. The importance of government determining the minimum price it requires for the resource base cannot be overstated. Without such prices it is impossible for rational government policy to be developed or to collect the full potential of the user cost of the resource. Once the price is computed by government it will be apparent why the price should be charged and the payment collected. It will be efficient to do so as long as contract terms are consistan

4.34 Price determination on a per unit basis implies a government decision (explicit or implicit) regarding the supply curve of the mineral sales from its inventory in the ground. The payment on a per unit basis is the foundation of the pricing system for all consumption goods and other inputs such as labor, materials and capital and there is no economic justification to exclude minerals from this practice. Intertemporal considerations should be considered since a resource sale today will not be available in the future. This implies that the price charged should reflect the social cost of capital. In theory, government should set its output levy so that it is indifferent between a firm extracting the marginal ton of the resource today and any date in the future. That is the payment should reflect both the current value added of the resource and the loss in present value terms from the value added which would have accrued had the marginal ton been left in the ground.

4.35 The use of ad valorem royalties has a long history. Such a royalty will create no adverse incentives when constant returns to scale are present and real relative prices of outputs and inputs are constant. A

firm is indifferent between paying workers $5.00/hr or 10% of value added if 10% of value added is equal to $5.00/hr. The same is true for minerals under these assumptions if the rate is determined by the share of minerals in total value added.[37] Thus, ad valorem royalties may be a workable approximation to the share of value added attributable to minerals.

4.36 The major difference between an ad valorem payment and a per unit payment per ton (in real terms) is the risk sharing component present in the ad valorem payment. If profitability rises or falls due to changes in output prices the resource owner will share in the gains and losses. This risk sharing feature is not available with a per unit payment.[38] Thus two of the features of contract design are present with this levy.[39]

4.37 A reasonable ad valorem levy could be considered part of the overall mineral development compensation scheme adopted by government. The country will receive a payment for each and every ton of productive input and like any factor input it will bear the risks of changes in its relative value. A well designed output levy is relatively easy to administer with the major complication being the determination of the output price. However, the same price used for the income tax can be used for the output tax. Thus there is no need to replicate effort in the determination of the value of output.

---

37/ Alternatively, the ad valorem royalty could be considered equivalent to the resource owner's share of the "total capital investment". If the royalty is 10% of the value of output and the rate of return on investments is 8% real then in equilibrium both invested capital and capital in the ground will earn an 8% return (i.e., the 10% royalty would be equal to an 8% return on capital).

38/ If profitability rises or falls because of changes in other input prices the resource owner will not capture any of these gains or losses.

39/ A third component could be included if gains or losses in other sectors are proportional to output prices. The ad valorem royalty would serve as compensation for "Dutch Disease" if the real exchange rate is proportional to output prices.

4.38 The following points should be considered with respect to ad valorem levy design:

- It is redundant to have more than one ad valorem tax for the same purpose. It would be redundant to impose an export tax and a production levy when there are no export externalities and most production is exported. The effective tax rate is the combined rate of the two payments in this case. Separate payments may also produce confusion regarding the economic intent of the levy.[40] Also, a supplemental ad valorem tax over and above opportunity cost may not accrue much additional revenue because of the incentives created.
- There is no economic reason for the output levy to be the same across mines. Uniform levies might prevent the capture of sizable gains from rich deposits or the loss of development of low grade-high cost deposits. On the other hand, administrative difficulties might be present if rates vary across mines. However, these costs might be small, since the number of mines in a country is small and each operation may be operating under different contract terms.[41]
- For a given operation, the rate should be constant. The use of progressive rates in a royalty system creates additional

---

40/ Separation might be appropriate when a levy of 5% is imposed for resource compensation and an additional 3% is imposed as compensation of external effects.

41/ An optimal royalty will vary with the geological and cost conditions of a specific mine. Since ore deposits are heterogeneous both within and between deposits it might be the case that differing royalty rates are necessary to ensure a constant rate of return across deposits to the government as well as yield a more consistent ordering of development. See Conrad (1984).

economic incentives and there is little evidence to suggest that progressive rates capture any type of wind-fall.[42] Rates might be changed through time in light of changes in the economic and geological environment.[43] Clear procedures should be established in the contract if such changes are contemplated.

- The royalty should be deductible for income tax purposes. A royalty is a payment for an input and thus it is a cost of doing business. In addition, the royalty should not be used as credit against income taxes. This is the current practice in Zambia. The income tax and royalty generally should be used for different objectives. A royalty credit system effectively limits the number of instruments available to government. As a result risk sharing is not generally efficient and mixed economic signals are sent to the producer. Royalties and income taxes induce different responses by the producer and a royalty-credit system

---

42/ Efficient risk sharing via ad valorem royalties might require variable rates including negative rates. See Conrad (1987a). The royalty discussed above is primarily intended for compensation of natural resource rent however. Additional risk sharing or offsetting risk sharing can be accommodated in other contract terms.

43/ For instance, in the latter parts of a mine's life it might be desirable for both employment and foreign exchange reasons to lower the output levy in order to prolong the life of the operation and increase recovery.

effectively communicates inconsistent policy by government.[44]

- Output levies should be considered in the context of overall mineral policy. Ad valorem royalties may be used for risk sharing, collection of natural resource rent and the recovery of costs imposed by mining to other economic sectors. A clear statement of objectives is necessary to ensure consistent application. Other aspects of the mineral policy can be adjusted to ensure that the overall policy is consistent. For instance, the appropriate level of government risk sharing can be adjusted by changes in income tax or equity sharing rates.

C. State Owned Enterprises

4.39 State owned enterprises (SOE's) play an important role in each country under review. This role varies from joint ventures with foreign firms (e.g. Cameroon) to ownership of entire invested capital (e.g. Zambia). The development of SOE's is one empirical outcome of public ownership of minerals. The SOE facilitates centralization of decision-making in the mining sector and enables all the diverse talents required to operate the sector (e.g., engineering, geology, economics) to

---

44/ In comments on an earlier draft of this document it was pointed out that the justification of this system was to prevent the de-capitalization of the mining operations in Zambia. We are grateful for this insight, but are not convinced that a royalty-credit system is an appropriate means to accomplish this objective. The mixed signals may create more instability since downside risks are clearly increased by this system relative to an income tax with the royalty deductible. Alternatives to the mixed system might include suspension of the income tax, a move to cash flow taxation with a lower royalty, or a royalty combined with a type of RRT. Each alternative would generate government revenue from the mining sector in each time period while preserving consistent signals. The appropriate method will depend on an evaluation of the objectives for the sector to ensure that the current crisis does not induce further injury to the long term stability of the industry.

be organized under one central authority. These statements do not imply that the SOE be a separate corporation or even a government "profit center". SOE's could be treated as a cost center, like other non-revenue departments, e.g. external affairs. In this case no revenues would be attributed to the SOE and regular budgetary allocations would be made for operating expenses. No taxation or mineral resource payments would be required by the SOE in this case. Central government would bear the entire responsibility for policy development and attribution of revenues.

4.40 SOE's are, however, generally organized as separate legal entities. In such cases, important constraints are required to ensure efficient SOE behavior. The SOE structure should be treated as a "subsidiary" which is one component of the overall portfolio of firms (activities) operated by the government. Investment decisions and other resource allocation decisions for the SOE should then reflect the need for overall portfolio balance by government. Mineral resource policy and taxation can play an important allocative function in this context. First, it is important for government to send correct pricing signals to the SOE. Therefore it is <u>imperative</u> that the SOE be charged the social opportunity cost of the resource which implies charging a royalty of some form. Inconsistent policies and signals can be generated if the computation of opportunity cost is left to the SOE. Society as a whole owns the resource, not the SOE and thus government must be responsible for computing the price of this scarce commodity. The SOE should be treated as an allocator and not a price maker. An exogenous resource price will aid in developing incentives which induce the SOE to respond to social values and not private ones.

4.41 There is a weaker economic case for the other forms of taxation of SOEs. It is well known that government should allocate resources relative to social prices.[45] Adjustments by government and the SOE may be required to account for taxes imposed on the SOE. Such adjustments may not be made in practice. There is also a tendency for mining SOE's to become involved in other aspects of social policy (e.g. infrastructure and other types of expenditures), given their relative size and political influence. Such investments may not be socially optimal and could decrease the efficiency of the economy if left unchecked. SOEs may also be established [illegible]lly prior to the manpower development necessary to administer such firms. The inexperience of the domestic nationals who control the operations combined with the political influence which comes with state status can (and does) lead to inconsistent and/or inefficient decisions.[46]

4.42 In this practical context taxation of SOE's can impose a discipline on the firm and it's decision makers. Consistent application of income tax rules will aid the development of accounting systems which are necessary for rational decisions. The scrutiny of a third party (the Treasury) which is responsible for revenue collections can aid the development of a healthy sense of responsibility and accountability. Revenue collection via taxation will reduce the economic power of the SOE. Use of withholding taxes to third parties (including director fees, etc.) can limit the discretion of the SOE managers to pursue their own economic interest. For these reasons it is important that the SOE be subject to the same taxation system as private firms. Such treatment provides the incentives necessary for rational management and can limit the economic and

---

45/ Diamond and Mirrlees (1976).

46/ Gillis (1977).

political power of the SOE. Distortionary incentives created by taxation could be reduced or eliminated via government investment policy. This implies that investment and financing decisions should not necessarily be made internally, but by a board of directors which is responsible for the overall performance of all government investments.

4.43 This process may appear redundant and somewhat arbitrary. However, two points should be noted. First, the decision to have a state owned enterprise with any type of decision-making power is itself somewhat arbitrary. The SOE should be treated as a subsidiary and not as an independent entity in the first instance. Second, correct signals combined with checks and balances are required to capture the benefits of decentralized decision making. SOE's in the mineral sector may be a natural outcome of specialization, but it is important that both political and economic discipline be imposed to minimize potential waste.

## IV. USE OF REVENUES

4.44 All Sub-Saharan countries will ultimately lose their comparative advantage in mineral production. Depletion of economic reserves can be expected in ten to twenty years in Cameroon, Gabon and Zambia. Resource depletion and the loss in the comparative advantage imply that these economies will have to adjust to a new structure where minerals will be less important in both the internal and external accounts. This adjustment could be more difficult as a consequence of any type of "Dutch Disease" created by the development of the minerals in the first instance.

4.45 Mineral discoveries increase the economy's "wealth" by the present value of the cash flows retained. That is, the stock of savings is increased with a consequent increase in the economy wide capital/labor ratio. The capital/labor ratio may well increase further because of the

capital intensive nature of resource extraction. This implies that resource depletion with no replacement investment amounts to "dis-saving". The value of minerals in place is not part of common measures of savings or capital in government accounts and depletion of this stock is not recorded in net income.[47] Thus, no accounting mechanism is available to measure the lost capital value from mineral extraction. Lack of information could imply that economy wide saving may not be sufficient for replacement of both physical and resource capital.

4.46 A number of issues are raised by the loss of wealth from mineral extraction. First, compensation for the user cost is not tax revenue. Such revenues should be recorded as separate items in budget accounts. Second, it may be appropriate to treat mineral revenue as transitory rather than permanent income. If some (all) mineral income is treated as transitory then the income should be "invested" in reproducible capital either in the form of human capital or investments in the world capital markets. This would ensure that the reduction in the capital stock via depletion would be offset by investment in other assets. Such a procedure would preserve the economy's total capital stock and increase permanent consumption. The trade of natural resource capital for reproducible capital can be done in a number of ways. Revenues can be used to reduce foreign debt or increase investment, but the revenues should be used for investment and not consumption.[48] Investments in the domestic or international markets should be based on relative social benefits and portfolio diversification considerations. This implies that at least part

---

47/ Boskin et. al. (1986) have made recent attempts to compute the value of mineral lands in the United States.

48/ This type of earmarking may be appropriate. In general increased revenues are fungible. However, sources and uses of funds analysis will aid in ensuring that dis-saving does not occur.

of mineral revenues be used for diversifying the economy in a manner consistent with the long term objectives of capital deepening and income distribution.

4.47 Third, the mineral resource and the capital used to extract it are sector-specific and are not fungible ex-post. This implies increased exposure to world markets unless diversification strategies are developed. Governments have sought to increase their share of value added via increasing interests in operations (e.g., Zambia purchased the share of foreign operations) and by requiring increased local downstream investment. These gains should be tempered by the opportunity cost of alternative investments and lack of portfolio balance. Government's investment in the physical capital of mining operations or in domestic processing increase their exposure to risks in these markets and reducing the ability of the economy to diversify.[49] The decision to increase government's share should also be tempered by the fact that multinational firms generally have a more diversified portfolio than a developing economy. Multi-national mining firms have investments in a number of countries and their stockholders are able to diversify economic and political risks via the world capital market. A developing economy on the other hand is initially limited to its own resource base and access to world capital markets can be costly. The price of risk bearing may be lower for firms than for the country implying that the economy might in fact be better-off by allowing foreign operations to bear more risk. Government revenues could then be used for diversification.[50]

---

49/ See the analysis in Chapter 3.

50/ Zambia may be a case in point. Zambia purchased the foreign investor's share of the mineral operations and it appears that large debt was used to finance the purchase. Zambia thus increased its exposure to the risks in the minerals sector for which it is now paying the price.

4.48 Fourth, government ownership of minerals combined with imperfect access to capital markets may restrict the behavior of private individuals. Private individuals may not be able to diversify out of or into specific mineral investments because of government ownership. Public ownership without perfect access to capital markets may increase the risk to both individuals and society.

4.49 These factors indicate that the "permanent" relaxation of taxes on other sectors which has occurred in mineral rich economies may not be in the best interest of the economy, e.g. Nigeria. Such actions may be appropriate in economies like Saudi Arabia if sufficient cash flow is generated to facilitate diversification. Tax reductions may not serve distributional objectives since the tax base in these economies is relatively small. Tax reductions would also increase the variability of government revenue. Unexpected revenue short falls could require costly adjustments in expenditure programs.[51]

4.50 There also may be a need to separate "income" from "depletion" in computing the return from mineral investments. If perfect certainty prevailed, then this computation would be easy. Given the nature of uncertainty, such a separation is difficult to make. However, this does not imply that attempts to separate income from depletion should be foregone. Lost asset values need to be replaced for economic growth to continue. In order to generate discussion regarding a means to properly account for depletion, the following simple proposal is offered.[52]

---

51/ To the extent that private sector savings and public sector savings are substitutes, taxes could in theory be designed to increase domestic savings as the resource is depleted. However, this may imply that the economy might consider an increase in consumption taxes relative to income taxes. Such an emphasis will encourage a replacement of exhaustible capital for private sector reproducible capital as well as offset the changes in relative prices which are attributed to Dutch Disease.

52/ A complete discussion of this proposal is contained in Conrad (1987c).

4.51 The factor payments (royalties, fixed fees, shares, or resource net schemes) could be treated in a manner similar to the repayments of a loan. That is, the factor payments consist of two parts: 1. "income" and 2. payments of principal. The income component is equal to the market rate of interest times the "outstanding" principal in any time period. Thus, the separation of income from depletion will depend on the interest rate and the amortization schedule. Such a scheme could be implemented in minerals by using the following rules:

- The government obtains an estimate of the "remaining life" of any operation or operations and an estimate of the remaining reserves.[53]
- Government selects an amortization schedule which could be straight line, declining balance or unit of production.[54]
- The government obtains an estimate of the current opportunity cost of funds, 'r'.

4.52 Cash flow from minerals in any period would be related to the value of the minerals in place by:

$$R_t = (\kappa_t + r_t)\ PV$$

where: PV = value of the minerals in place

$\kappa$ = proportion of capital repaid this period

r = rate of interest

---

53/ The government could develop this procedure on either an operation or economy wide basis.

54/ Different methods will have different implications for how principal will be amortized. The unit of production method is equivalent to cost depletion. Cost depletion has a long history and it might be the most appropriate method to use in this sector.

4.53 Imposing asset market equilibrium, i.e. the present value of principal plus interest is equal to the value of minerals in place, implies that depletion in any period is equal to:

$$\text{Depletion} = \left[\frac{\kappa}{\kappa + r}\right] \cdot R$$

4.54 The measure of depletion is equal to the minimum amount that the government should invest in other forms of capital with a market rate of return in order to keep the economy's total capital stock constant.[55] The computation in practice would not even require an estimate of the present value of the minerals in place.[56] The procedure also accommodates changes in the basis and changes in interest rates. For instance, if interest rates rise (fall), then the proportion of revenues required for depletion will fall (rise). Interest rate increases (decreases) imply capital losses (gains) other things equal and thus the procedure can automatically incorporate realized gains and losses. Increases (decreases) in reserves (or changes in mine life) would also change the proportion of revenues allocated to depletion accounts since the new information would create capital gains and losses.[57]

4.55 If this method is used by government then the share of mineral revenues allocated to depletion would not be used as current revenues in the government's budgetary accounts. Rather, they would be posted to a

---

55/ This would be equal to the amount of investment necessary to keep steady state consumption constant in an economy with zero population growth.

56/ The market value of the property is implied via the computations.

57/ The period where extraction is positive and no factor payments are made then future payments must be adjusted to account for accumulated interest. Zero or negative factor payments could occur because the government has chosen to employ share or resource rent schemes. The procedure necessary to make such an adjustment is straight forward. Note that the current method serves as another justification for the separation of "factor payments" from "taxes".

capital account to be used for other investments.[58] That is, these funds would be the minimum investment necessary in order to avoid a reduction in the economy's capital stock.[59] This procedure, while an estimate, would ensure that an accounting is made for the loss of an asset. This would aid budget and investment planning. In addition, it would force decision makers (and the public) to confront the issue of replacement investment and diversification.

## V. SUMMARY

4.56 One of the insights gained from government behavior in the past few years has been lack of emphasis on the transitory nature of mineral wealth and confusion regarding the allocative function served by natural resource rent. These factors combined with lack of diversification and perhaps the relatively low effective rates of taxation on minerals may have increased the economies' dependence on one sector. This policy could have increased the effects of Dutch Disease and contributed to the current structural adjustment problems in some Sub-Saharan countries, to the extent that revenues have been used to stimulate consumption rather than replacement investment in a more diversified asset base. The solutions to these problems are not simple. The solutions may require a revamping of both mineral and general tax policy as well as rigid discipline on the part of decision makers to ensure that revenues are not inefficiently consumed. However, economic growth and diversification may be hampered further unless such discipline is developed with consistent tax signals and expenditure policies.

---

58/ The source of funding the capital account is irrelevant. The point is that provision be made for the loss of the asset.

59/ If additional mineral revenues are invested then total savings will rise.

# TAX LAWS OF SELECTED COUNTRIES IN SUB-SAHARAN AFRICA

## BOTSWANA

### Summary of Taxes

**I. Income Taxes**

| | |
|---|---|
| Rate/(s): | 35 percent |
| Allowances: | |
| Exploration: | Capital Expenditures expensed |
| Development: | Capital Expenditures expensed |
| Depreciation: | **Manufacturing:** Straight line with asset of four to ten years. |
| | **Mining:** Capital expenditures divided by number of years mine is expected to operate. Maximum depreciation period is ten years. |
| Depletion: | None |
| Losses: | |
| Carry-forward | **Manufacturing:** 5 years. |
| | **Mining:** Indefinite. |
| Carry-back | None |
| Other Incentives: | Initial allowance if 25 percent on certain industrial buildings. |
| | Tax holidays and other incentives are allowed if approved by the government. |

II. Output Taxes (Including Import and Export Taxes)

| Name | Base | Rate |
|---|---|---|
| Customs Duties | Imports | 0-70 percent a/ |

a/ Botswana is a member of the Southern Africa Customs union which includes: South Africa, Lesotho and Swaziland. Botswana's share of revenue is based on a formulary method.

III. Withholding Taxes

| Base | Rate |
|---|---|
| Interest | 15 percent |
| Dividends | 15 percent |
| Contracts | 20 percent |
| Royalties | 15 percent |

IV. Special Mining Taxes

Royalties, dividends and other standard payments.

V. Contract Form(s)

Government Participation: Owns mineral rights but foreign investors own much of the capital.

Source: IFS/GFS, World Bank and Price Waterhouse

# CAMEROON

## Summary of Taxes

### I. Income Taxes

| | |
|---|---|
| Rate(s): | Non-oil: 35% plus 3.5% local council taxes<br>Oil: 57.5% |
| Allowances: | |
| Exploration: | Expensed |
| Development: | Expensed |
| Depreciation: | Buildings 5%<br>Machinery and other inputs have rates which vary according to schedules |
| Depletion: | None |
| Losses: | |
| Other Incentives: | Tax Holidays of various lengths depending on type and location of industry<br>Reduced import duties<br>Exemptions from local sales taxes |

### II. Output Taxes Including Import and Export Taxes

| Name | Base | Rate |
|---|---|---|
| Export | Value | Average rate about 2% |
| Import | Value | Rates vary from 40 to 245% |

III. Withholding Taxes

IV. Special Mining Taxes

Production sharing believed to be:

| | |
|---|---|
| 60% | 1st 15 million barrels of cumulative production |
| 65% | 2nd 15 million barrels of cumulative production |
| 70% | excess over 30 million barrels. |

V. Contract Forms

| | |
|---|---|
| Government Participation: | 50% via State Oil Company (SNH). |
| | SNH pays half of all exploration and development. SOE paid half of book value for its share of operations for firms which operated prior to current contract form. |

---

Source: IFS/GFS and Barclays, interviews with Bank staff.

GABON

Summary of Taxes

I. Income Taxes

| | |
|---|---|
| Rate(s): | Non-oil: 45% (or 1% of turnover) with a minimum of 500,000 CFA. |
| | Oil: 73% |
| Allowances: | |
| Exploration: | Determined by contract |
| Development: | Determined by contract |
| Depreciation: | Not known |
| Depletion: | Not known |
| Losses: | Not known |
| Other Incentives: | Tax exemptions for 2-10 years for certain new enterprises |

II. Output Taxes (Including Import and Export Taxes)

| Name | Base | Rate |
|---|---|---|
| Import | Value | 2.5-15% |
| Turnover tax on Imports | Value | 10% |
| Stamp duty | Value-Exports | 5% |

III. Withholding Taxes

| Base | Rate |
|---|---|
| Dividends | 18% |
| Director's fee | 20% |

IV. Special Mining Taxes

| | |
|---|---|
| Mineral royalty | 20% of base price which is computed on average to be 90% of posted price. |

There are some special tax holidays for mineral firms.

V. Contract Form(s)

| | |
|---|---|
| Government Participation: | New contracts are production sharing. Older contracts were concession with 10% free equity |

Sources: IFS/GFS, Price-Waterhouse, Gillis and Beals (1982), and Gillis (1978).

# LIBERIA

## Summary of Taxes

### I. Income Taxes

| | |
|---|---|
| Rate(s): | 50% if taxable income is in excess of L$ 100,000 |
| Allowances: | |
| Exploration: | Not known |
| Development: | Not known |
| Depreciation: | If assets have values in excess of LS 100,000 then depreciation is subject to negotiation. In general for other items depreciation is on a straight line basis. |
| Rates: | 33.3% Vehicles and construction plants |
| | 2.5% Buildings |
| | 10-20% Machinery |
| Depletion: | Not known |
| Losses: | |
| Carry-forward: | 5 years |
| Carry-back: | none |
| Other Incentives: | Exemptions for up to 90% of import duties |
| | Profits reinvested in fixed assets are tax exempt. One-half of subsequent profits are exempt. |
| | Full rebates of duties on inputs for output which is exported. |

### II. Output Taxes (Including Import and Export Taxes)

| Name | Base | Rate |
|---|---|---|
| Import duties | Value and Volume | Varies |

III. Withholding Taxes

| Base | Rate |
|---|---|
| Interest | 15 percent |
| Dividends | 15 percent |
| Other | 30 percent |

IV. Special Mining Taxes

Original contract had provision for export tax which was equal to $0.05 US per ton exported plus 1% of excess of 115% of the ten year average price of output.

V. Contract Form(s)

Government Participation: 50% government equity

Iron ore operators work concession type contracts

Sources: Gillis (1979) and Price-Waterhouse.

# NIGERIA

## Summary of Taxes

### I. Income Taxes

Rate(s): 45%

Allowances:

Exploration:

Development:

Depreciation: Equipment: 32.3% first year allowance
12.5% declining balance

Industrial Buildings: 25% first year allowance
10% declining balance

Depletion: None

Losses:

Carry back: none

Carry forward: four years
ten years for agriculture

Other Incentives: Pioneer Industries-Tax exemption for 2-5 years

### II. Output Taxes (Including Import and Export Taxes)

### III. Withholding Taxes

| Base | Rate |
|---|---|
| Dividends | 12.5 percent |
| Interest | 45 percent |
| Management Fees | 45 percent |
| Royalties | 45 percent |

a/ After 1979 dividends are limited to 50% of post tax profits.

**IV. Special Mining Taxes**

| | |
|---|---|
| Oil Income Tax: | 65.75% until production costs are fully amortized<br>85% after amortization of production costs with deduction for all royalties |
| Royalties; | |

**V. Contract Form(s)**

Production Sharing arrangements in general.

| | |
|---|---|
| Government Participation: | Varies with contract |

---

Sources: Price-Waterhouse and Ernst and Whinny International Series.

# ZAIRE

## Summary of Taxes

**I. Income Taxes**

| | |
|---|---|
| Rate(s): | 50% |
| Allowances: | |
| Exploration: | Expensed |
| Development: | Expensed |
| Depreciation: | 3-5% Buildings<br>10-15% Equipment/Furniture<br>20-25% Machinery<br>33% Small Tools |
| Depletion: | Generally 15% of total revenue up to a maximum of 50% of taxable income |
| Losses: | |
| Carry back: | none |
| Carry forward: | 2 years |
| Other Incentives: | Export royalty is a credit for income tax. Export surtax is a deduction.<br><br>Periodic re-evaluation of assets have been allowed to account for changes in the exchange rate and for domestic inflation<br><br>Various tax holidays and tax reductions for pre-investment of profits.<br><br>5% reduction in taxes for re-investment |

II. Output Taxes (Including Import and Export Taxes)

| Name | Base | Rate |
|---|---|---|
| Base Royalty | Exports of Copper (Credited for Income) | 7% |
| Progressive | Exports of Copper when price is above 2,500 SDR/ton | 5-50% |
| Oil royalty | Value of production | 12.5% |
| Statistical Tax | Value of Exports | 1% |
| Turn-over | Value of Exports | 7% |
| Customs Duties | Value of Imports (non-luxuries) | 3% |
| Import Turnover | Value of Imports | Vary |

III. Withholding Taxes

| Base | Rate |
|---|---|
| Dividends | 20 percent |
| Interest | 20 percent |
| Royalties | 20 percent |

IV. Special Mining Taxes

V. Contract Form(s)

| | |
|---|---|
| Government Participation: | 100% of Non-fuel minerals;<br>53% Diamonds |
| | Vary by agreement in Petroleum |
| Other | Government gets 15% of annual net tax profits in petroleum. |
| | Royalty in petroleum can be taken in cash or in kind. |

---

Sources: IFS/GFS, World Bank Reports, Price Waterhouse.

# ZAMBIA

## Summary of Taxes

| | |
|---|---|
| **I. Income Taxes** | |
| Rate(s): | 50% |
| Allowances: | |
| Exploration: | Expensed |
| Development: | Depreciated |
| Depreciation: | Initial Allowance: 10% Industrial Buildings<br>Investment Allowance: 10% Industrial Buildings<br>20% Equipment<br>5-10% (straight line): Industrial Building<br>2% (straight line): Non-industrial buildings<br>30-50% (declining equipment balance): |
| Depletion: | None |
| Loses: | |
| Carry-back: | one year |
| Carry-forward: | indefinitely |
| Other Incentives: | Industrial Development Act allows tax holidays for at least five years for "approved" investments |

## II. Output Taxes (Including Import and Export Taxes)

| Name | Base | Rate |
|---|---|---|
| Mineral Export | Value of Exports<br>Copper Content | 10% plus 3% surtax |

Note: This tax is relatively new. It is allowed as a deduction for income and mining taxes. The rate has increased steadily over time.

## III. Withholding Taxes

| Base | Rate |
|---|---|
| Interest | 30% |
| Dividends | 20% |
| Royalties | 30% |
| Rents | 30% |
| Fees | 30% |

These rates are for nonresident corporations and individuals who are not citizens of a country with an operative treaty with Zambia. Treaties over-ride the base rate.

## IV. Special Mining Taxes

Mineral Tax: Rate: 51% Copper
20% Lead, Cobalt and Zinc
15% Amethyst and beryl
10% all others

Base: Same as income tax.

| | |
|---|---|
| Provisions: | 1. Companies which are formed subsequent to imposition of the tax are not liable until their initial capitalization and subsequent capital are fully recovered.<br><br>2. Firms in operation prior to imposition of the tax will have capital expenditures over the shorter of mine life or twenty years.<br><br>3. Remission of tax is made when the average after-tax return to equity over a three year period is less than 12%. Refunds are exempt from company tax. This benefit is not available for existing companies. In effect, this tax creates a variable rate profits tax which ranges from 0 to 73.05% when the company tax is included. |

V. Contract Forms

| | |
|---|---|
| Government Participation: | Government holds 100% of equity of mineral enterprises. Foreign investors were paid for their equity. Ex-patriots still work for enterprises. |

Sources: IFS/GFS, World Bank Country Reports, Price-Waterhouse, and Barclays Reports.

# ZIMBABWE

## Summary of Taxes

### I. Income Taxes

**Rate(s):** 1982/83 45% + 20% surcharge = 54%
1983/84 45% + 15% surcharge = 51.75%

**Allowances:**

**Exploration:** Expensed

**Development:** Option to expense

**Depreciation:** Self constructed assets gets special initial allowance of 100%.

| Item | Rate |
|---|---|
| Buildings | 2.5% straight line |
| Machinery | 10% declining balance |
| Vehicles | 20% declining balance |

**Depletion:** 5% of sales prior to 1982. Rules similar to U.S. percentage depletion. Abolished after 1982.

**Losses:** Carry-forward: unlimited

**Other Incentives:** 15% expensing provision for investments in rural areas

### II. Output Taxes (Including Import and Export Taxes)

| Name | Base | Rate |
|---|---|---|

III. Withholding Taxes

| Base | Rate |
|---|---|
| Dividends | 20 percent |
| Interest | 10 percent |
| Fees | 20 percent |

IV. Special Mining Taxes

Not Known

V. Contract Form(s)

Government Participation: Not Known

Sources: World Bank and Price Waterhouse.

## The Mining Process

1. From an economic perspective the objective of the mining firm is to extract and process various minerals so that the present value of the profits (measured in terms of discounted cash-flows) are at a maximum. Generally, minerals are not readily accessible and are difficult to locate and to develop. This implies that the mining firm must engage in a long and costly process if its objective is to be achieved.[1] This process can be divided into the following components:

A. Exploration

B. Development

C. Extraction

D. Processing

2. Below each of these components is described briefly.[2]

### A. Exploration

3. Exploration is divided into three general segments and can last for an average of three to five years. In the first stage, "anomalies" over wide areas are sought. This search involves airborne and even

---

1/ The description below is highly stylized. The term "minerals" will be used to mean both hard minerals and hydrocarbons. While the techniques used to explore for various minerals are different, the process itself is quite similar. It is the general structure of the process which is described in this appendix.

2/ The discussion is based in large part on Conrad (1978), Conrad and Hool (1981), and Convery and Conrad (1981).

satellite photography as well as the use of maps, surveys and other historical documents where mining activity has taken place in the past.[3]

4. On site exploration of promising areas forms the second stage. The objective of this stage is to make a preliminary determination of the size of the mineralized areas and to select the most promising areas for intensive exploration (if any). Depending on the mineral sought, testing generally proceeds by direct observation as well as a variety of geophysical and geochemical techniques.

5. The third phase consists of intensive exploration in areas of potential value. Drilling is generally used to determine the depth and extent of mineralization as well as to gather data on other aspects of the geology. Based on these studies estimates are made and divided into three groups:

**Proven Reserves**: Ores that have been both delineated and measured; tonnage (volume), and quality are known within a 5 percent error.

**Probable reserves**: Characteristics computed by measurements from widely spaced samples and from geological projections; errors are usually estimated at less than 20 percent.

---

3/ One of the benefits of foreign investment and aide for a developing country is the use of ex-patriot capital and labor in the exploration process. These techniques are capital-intensive and the capital (both human and physical) can be used in a variety of countries. Given the high fixed costs of developing internal resources for such a specialized and technical activity, developing economies have often had to seek aid for this initial stage of the mineral process.

Possible Ore

(Mineralization): No samples available; estimates based on inferences from geological structure and geographic anomalies.[4]

6. Since possible ore is a point estimate with large variance this classification is not usually included in the formulation of economic decisions at the development and initial production stages.[5] This does not imply that possible ore is immaterial. At this stage, possible ore contains the largest tonnage (volume) of mineralization and will ultimately determine the mine's value. However, mineralization in this classification will not be recovered except in the future. Also the uncertainties regarding prices, costs as well as volume and quality makes any estimate purely speculative. Given the costs of obtaining information about these reserves, the trade-off of more current exploration versus the benefits of future uncertain cash-flows requires that the firm place little current weight on these estimates in planning.

7. This stage of exploration yields additional information about the geological structure of the mineral body. The samples obtained provide estimates of:

---

4/ In most cases exploration is a continuing process. Estimates of the recoverable mineralization are constantly being revised as development and production begin. Since exploration is a costly activity the determination of "proven reserves" is itself an economic variable being related to the cost of proving reserves "today" which will mot be developed or extracted until some future date. In fact, some mineral experts believe when sufficient mineralization is present to justify proceeding to development, the measure of proven reserves is merely sufficient to convince those outside the firm (e.g., the banks) that the firm has sufficient justification for financing.

5/ See Thomas (1973).

- length, width and depth of mineralized area,
- major fault structure,
- discontinuities,
- specific gravities,
- moisture levels,
- grade and other quality characteristics,
- nature of overburden.

8. The technology employed to develop the deposit is based on these estimates. The technology includes the type of operation (open-pit vs. underground); the scale of operations; and the process necessary to spare valuable minerals from ore, if necessary. Given projections of prices and costs, estimates of "economically recoverable reserves" are made. At the pre-development level this measure of reserves is a sub-group of the three classifications described above and is restricted to those reserves which are planned for extraction, given time profiles of prices and costs.[6]

## B. Development

9. Given successful exploration, a determination of the mine's profitability must be made. This is generally a two step process. A quick assessment is first made to determine if there is a reasonable chance of success. Rules of thumb are used based on average values of quality, costs and prices. The purpose of this assessment is to determine if the

---

6/ No mine is ever exhausted in a "physical sense". Recovery from oil wells is considered good if 30 percent of the mineralization is recovered. In hard-rock mining, the recovery varies depending on the grade distribution. See Conrad and Hool (1981 and 1985).

expenditure for detailed studies is economically warranted.[7] If this assessment yields promising results, a detailed feasibility study of the project is made. Detailed studies are made to determine the technology, scale of operations, mining methods, sequence of extraction, and processing methods.[8] The engineering studies are detailed and provide a basis for a completion evaluation.[9]

10. These studies combined with various marketing and economic studies are used to generate detailed cash-flows. Estimates are changed via Monte Carlo methods as well as different scales of operation to determine the optimal scale of operations and the return on investment. Acceptable ranges for the return on investment are in the range of 15-25 percent real-net-of-tax at this stage.[10]

11. If a decision is made to proceed and financing is forthcoming the firm proceeds to construction. Before extraction begins surface facilities for storage, transportation and processing are completed in addition to the initial development areas. Not all of the mine is developed at once.

---

7/ At this stage the industry has used a form of the "Hoskold Formula".

8/ Estimates of recoverable ore are made under various mining techniques. In addition, estimates of three major factors are made. These factors are: extraction (the amount of valuable material per ton of volume); extraction either recovered or lost as a result of the chosen technique; dilution (the amount of foreign material blended with valuable material resulting from the extraction process), and recovery (the amount of valuable material per unit volume which is recovered per tone of extraction). See Thomas (1976).

9/ For examples and criticisms of this process see Thomas (1976).

10/ The "hurdle rates" used by firms vary across firms and across deposits. The estimates stated in the text are inferences from the examination of a number of projects.

Major development areas are sequenced in a manner consistent with the overall development plan for both economic and technical reasons. If too many areas relative to plant and processing capacity are developed additional costs would be incurred in the early years which increase overheads and maintenance for minerals which may not be extracted for some period of time.

### C. Extraction and Processing

12. At this stage the firm is constrained by all its previous decisions. Capacity is in place restricting the scale of operations, that is, only developed areas can be considered for extraction. The only variables the firm can control are the rate of extraction, the quantity of mineral extracted and the quality (and rate) of marketable product processed.[11]

13. The cash flows which are generated from this process are used to repay debt or returns to equity as well as to pay taxes. Reinvestment may be in the form of new exploration, development or plant expansion if economic conditions warrant. How the firm allocates these funds will depend on the expectations about the economic environment as well as the development of alternative investments.

### D. Implications for Public Policy

14. Given the above description of the problem, it is natural that mining firms have developed a sequential dynamic decision-making process which permits frequent re-evaluation of plans when new information is

---

11/ With the exception of some petroleum products (e.g., natural gas) the raw material extracted from the deposit is not marketable. The mineral is cleaned or concentrated to raise the mineral context to acceptable market levels even if no other downstream processing is done.

forthcoming. Given the long lead times necessary to develop a project and the presence of both geological and economic uncertainty a sequential process enables the firm to enhance its flexibility with respect to changes in information.

15. In this context, public policy will have differing effects on the mine's operation depending on the stage of operations in which the firm is operating. The policy will affect all future decisions as information is passed through the decision structure. Thus, a change in tax policy will have both immediate and delayed responses. An increase (decrease) in taxation could effect the level of recoverable reserves from currently developed ore bodies; affect the future level of development; and provide a disincentive (incentive) to explore. Finally, different tax policies might affect the industry in varying ways depending on where the country is with respect to its resource development. That is, countries which have had little or no exploration or development might employ different taxation methods than countries which have a mature industry which is beginning to reach geological and economic limits. It is therefore important for government to be aware of this decision structure when devising a rational tax policy.

# INCENTIVES CREATED BY TAXATION

## I. INTRODUCTION

1. This appendix contains a simple mathematical exposition of the results regarding intertemporal allocative effects created by various tax instruments. In order to highlight the basic results, a very simple model will be used. This model is based on Conrad (1978 a,b), Conrad (1982 a,b), and Conrad and Hool (1980, 1981, 1982, and 1984 a,b). It will be assumed that the mineral producer (or country) is a price-taker in the international markets for output. Given the relative shares of production and reserves in the countries under investigation this is a reasonable assumption.[1] Two production periods will be assumed. This assumption does not affect the general nature of the results. Specific assumptions employed in each section will be stated as they arise.

## II. THE BASIC MODEL

2. In this section, the model employed in the tax analysis is developed. It should be noted that if the resource constraint is not binding the tax analysis of the mining industry is identical to any other industry.[2] Given the assumption of a binding resource constraint the problem to be solved by the miner is:

$$\text{Max } \pi = P_0Q_0 - C_0(Q_0) + [P_1 (Q^* - Q_0) - C_1 (Q^* - Q_0)]/(1+r) \qquad (3.1)$$

Where: $P_t$ = Price of output in t = 0,1.

$C_t$ = Total cost function in t = 0,1.[3]

---

1/ There is the possible exception of Zaire.

2/ For instance, if a per unit sales tax is imposed on output then output in all periods will fall.

3/ Note that the cost functions in either period do not have to be the same.

$Q_o$ = Quantity produced in t = 0

Q* = Quantity of reserves measured in terms of final output.[4]

r = interest rate.

3. It is clear given the assumptions made that the only choice variable for the firm is the amount extracted in t=0, since the residual will be extracted in period 1. The first order condition which determines an extreme value is:

$$\pi' Q_o = P_o - C'_o - (P_o - C'_1)/1+r = 0. \qquad (3.2)$$

4. In words, this expression states that extraction and processing will continue in each period until the present value of marginal profit is equal in each period.[5] While discounted marginal profits are equal in each period there is no indication about the relative quantity of ore extracted.[6] The relative size of extraction will depend on both the time path of prices and costs. For instance, if discounted future prices are lower than present prices and the cost function is constant across time then more ore will be extracted in the present. However, without more specifics on the nature of prices and costs no general statement can be made about the relative size of extraction in each period.

## III. PER UNIT OUTPUT TAXES

5. These taxes are a fixed value (usually in nominal terms) of the quantity produced. This implies that the net of tax price received by

---

4/ Note that the measure of Q is not "ore"; rather the measure is in terms of final marketable output.

5/ This is one form of the familiar Hotelling rule. (Hotelling, 1932).

6/ The second order condition for a maximum is: $|H| = C''_1 - (C''_o(1+r)) < 0$.

the producer falls from $P_t$ to $P_t - T$ in each period, where T is the amount of the tax. A change in this tax will affect $Q_o$ as follows:

$$dQ_o/dT = r/|H| < 0 \qquad (3.3)$$

6. That is, this tax will induce the firm to reduce extraction in early periods and increase extraction in later periods.[7] The intuition for this result is that the "nominal" value of the tax bill is fixed because of the fixed output assumption. That is, in nominal terms the total tax is exogenous. However, the firm can reduce the present value of taxes (and increase the present value of post-tax profits) by reallocating extraction from the present to the future, i.e. more output in the future implies a lower tax bill in present value terms.

## IV. VARIABLE PER UNIT TAXES

7. Some governments have employed variable rate output taxes.[8] These taxes have been developed to preserve the "real" value of the tax revenue on account of inflation, and reflect an attempt to capture some of the rents which accrue to the mining firm. In this case, a different per unit tax is imposed each period. If $T_1$ is defined as $T_o\ (1+\beta)$ where $\beta$ is equal to the (geometric) average rate of growth in the tax, then:

$$T_o > < T_1/(1+r)$$

$$\text{as } (1+\beta) < > (1+r)$$

8. In this case, it is possible for the tax to reverse the time path of discounted gross-of-tax prices. In addition, the government must set two parameters for the tax; the base tax and its rate of growth. If the government changes the base tax ($T_o$) then the effect on $Q_o$ will be:

---

7/ $|H|$ is the value of the Hessian matrix. In effect, the above expression is a result of Cramer's Rule. Given the current assumptions, $|H|$ will always be negative.

8/ Jamaica and some states in the United States have used this type of tax.

$$dQ_o/dT_o = (r - \beta)/|H| \qquad (3.4)$$

9. The sign of this change will be positive (negative or zero) as r is less than (greater than or equal to) $\beta$. That is, if the rate of change in the tax is greater than the interest rate then extraction will be allocated to the present away from the future. The case where $r = \beta$ is a result which might serve as a basis for advocating this type of tax. However, the tax is not neutral when other decisions are included in the model (e.g. investment). Like the fixed nominal fee case the direction of change in extraction will be determined so that the firm may decrease the present value of taxes. If the rate of growth is greater than the interest rate then a reallocation from the future to the present will reduce the present value of the total tax bill and increase the present value of after tax profit.

10. The incentives created by a change in $\beta$, the rate of growth in the tax rate, can be seen by the following expression:

$$dQ_o/d\beta = - T_o/(1+r)|H| > 0 \qquad (3.5)$$

11. This expression implies that an increase in the rate of growth in the tax will induce the firm to increase output in the early periods. Since taxes will increase at a greater rate in the future the firm will decrease extraction in the future, in order to decrease the present value of total taxes.

## V. UNIFORM AD VALOREM OUTPUT TAXES

12. This tax reduces the net of tax price received by a constant fraction ($\alpha$) each period. That is the net of tax price receive by the producer in any time period is: $P_t\ (1-\alpha)$. An increase in the tax rate will induce the following comparative static effect:

$$dQ_o/d\alpha = (P_o(1+r) - P_1)/|H| \qquad (3.6)$$

13. In this case if the discounted prices are falling (rising, constant) then extraction will be reallocated to the future (present, not at all). Once again the firm will attempt to decrease the present value of the total tax bill. In this case the direction of the reallocation will be function of the time path of discounted prices.

## VI. VARIABLE RATE AD VALOREM TAXES

14. In this case the rate of taxation varies through time. This type of tax has been employed in such countries as Indonesia to capture ("wind falls") which are defined relative to some measure. Like the per unit tax the tax rate in t=1 can be defined as:

$$\alpha_1 = \alpha_o(1+\beta),$$

where $\beta$ is the (geometric) average rate of growth in the tax rate. Also like the per unit case the government must set two parameters, the base tax rate and the rate of growth. Depending on how these factors are measured the time path of discounted gross of tax prices may or may not correspond to the time path of net-of-tax discounted prices. The effects of a change in the base tax rate on current extraction is determined to be:

$$dQ_o/d\alpha = (P_o(1+r) - P_1(1+\beta))/|H| \qquad (3.7)$$

15. The direction of the reallocation, if any, will depend on the interaction of the time paths of "nominal" prices and the growth rate of the tax rate. For instance, if nominal prices are constant and the rate of growth in the tax rate is less than the interest rate then extraction will be reallocated to the future.[9]

16. A change in the growth rate of the tax will affect extraction via:

---

9/ Other cases could be examined, but it is clear that the allocative effects of this tax will depend on the relative rates of growth in nominal prices and the rate of growth of the tax rate.

$$dQ_o/d\beta = -P_1\alpha/|H| \qquad (3.8)$$

17. In this case, a change in the rate of growth of the tax will only increase taxes in the future and thus a change in this parameter will reallocate extraction from the future to the present.

## VII. PROFIT TAXES

18. It is well known that a "pure profits" tax or a cash-flow tax is neutral with respect to allocative incentives. This fact is true in the mining sector as well. Since, the tax is imposed on total economic profit the tax does not affect the marginal conditions: i.e., the tax is a tax on "pure rent". Note that this tax captures all types of rent: rent which accrues from the scare resource and rent which accrues because production is subject to decreasing returns.

19. In general, pure profits taxes do not exist. In addition to the known distortions introduced via differences between tax and economic depreciation, depletion allowances of some types are often given. In the case where the depletion allowance is determined exogenously this allowance will not have marginal incentives. However, in many cases depletion is either a function of output or the value of output. Cost depletion is a fixed nominal value for each ton (barrel) of mineral extracted. In this case, after income tax, profits in any period are:

$$\pi = (1 - k)(PQ - C(Q) - fQ), \qquad (3.9)$$

where k = income tax rate and f is the value per ton of cost depletion.[10] Some rearrangement reveals that the net of tax price receive by the firm is:

$$P^* = P + (kf/(1-k)) \qquad (3.10)$$

20. That is, the net of tax price, P*, is "increased" because of the allowance. Cost depletion is in effect a "negative" per unit tax.

---

10/ The time subscripts in this section have been suppressed for ease of notation.

Therefore, in this present case there is an incentive for the firm to reallocate extraction from the future to the present. The total nominal value of the subsidy is fixed and the firm can increase the present value of the subsidy by reallocating output from the future to the present.

21. Percentage depletion (an allowance based on value) increases the net-of-income tax price by a constant fraction in each period: i.e.,

$$P^* = [1 + (kh/1-k)]P, \qquad (3.11)$$

where k is the percentage depletion rate (measured as a proportion of the value). Thus, this type of depletion is in effect a negative ad valorem tax with the corresponding opposite effects. In particular, if discounted prices are falling then the firm will have an incentive to reallocate extraction from the future to the present.

## VIII. PROGRESSIVE PROFIT TAXES

22. Several tax systems have progressive rates. In addition, progressive profits taxes have been advocated by some economists (Garnaut and Ross (1977) and Strasma (1978)) and implemented in some countries (Indonesia, Papua New Guinea and Ecuador). The claim is made that since the tax is on profits it will not have any marginal distortions. This is true only with respect to the grade of ore extracted (the tax will not affect the cut-off grade). Ultimate recovery and the intertemporal extraction profile, however, might still be affected. In order to analyze the effects of this type of tax a quadratic approximation to the tax function will be used:

$$T_t = a\pi_t + 1/2b(\pi_t)^2 \qquad (3.12)$$

where $T_t$ denotes total taxes paid in period t and $\pi$ is gross of tax cash flow. The first order condition for the current problem under this tax regime is:

$$L'_{Qo} = (1 - a - b\pi_o)\pi'_o - \{(1 - a - b\pi_1)\pi'_1/(1+r)\} = 0 \qquad (3.13)$$

23. Like other progressive taxes the government must determine two parameters: a and b. The effect of a change in "a" (the base tax rate on current extraction is:

$$dQ_o/da = (\pi'_o(1+r) - \pi'_1)/|H^*| \qquad (3.14)$$

The effect of a change in "b" (the rate of progression) is:[11]

$$dQ_o/da = \{(1-a)/b\}dQ_o/da \qquad (3.15)$$

24. Some manipulation of the first order conditions reveals that the reallocation will be from the future (present) to the present (future) if gross of tax profits ($\pi$) in the present are higher than gross of tax profits in the future. The logic for this result is that an increase in the progressive tax rates will create an incentive for the firm to reallocate extraction to the period with the lower gross of tax profits. Such a move will reduce the marginal rate in the high profit year by more (in present value terms) than the increase in the marginal rate in the period with lower profits gross-of-tax.

---

11/ $|H^*|_2 = \{(1 - a - b\pi_1)C''_1 + b(\pi'^2)\} - (1+r)\{(1 - a - b\pi_o)C''_o + b(\pi'^2)\} < 0$

# NOTES ON RISK AND MINING TAXATION

The models used to derive the results found in Chapter 2 are contained in this appendix. This appendix is brief since extensive development is contained in Conrad (1987b).

## I. THE RECOVERY MODEL

### A. The Model

The miner must determine the quantity of economically recoverable reserves when investment and extraction decisions are made. For convenience, assume that ore qualities are continuous and range from a maximum value, $\alpha_{max}$ to zero. The choice variable is defined as, $\alpha$. With these assumptions, total output is defined as:

$$Q = \int_{\alpha_-}^{\alpha^+} \alpha \, dx \qquad \text{(A3.1)}$$

$\alpha$

where: Q = total volume of final output.

Total mineral extracted is defined as:

$$V = \int_{\alpha_-}^{\alpha^+} \alpha Q dx \qquad \text{(A3.2)}$$

Cost is assumed to be a function of extraction only. That is, extraction and processing costs are independent of the grade: i.e. C = C[V].

Profit is defined in the usual way given these definitions:

$$\pi = PQ - C[V] \qquad \text{(A3.3)}$$

where: $\pi$ = profit

P = price of output

Expected utility is assumed to be a function of profit alone; i.e. EU = EU[$\pi$]. Finally, it is assumed that the grade distribution is known and thus uncertainty will be present in all other economic and technical variables. The first order condition for this problem is:

$$EU' (P\alpha_{-} - C') = 0 \qquad \text{(A3.4)}$$

or

$$\alpha_{-} = \frac{EU'C'}{EU'P}$$

Note that an increase in $\alpha_{-}$ reduces output; i.e. an increase in the cut-off grade will reduce output.

B. Tax Incentives

Consider the following taxes: 1) an ad rem tax on output equal to 'd'; 2) an ad valorem output tax equal to '$\beta$' with $0 < \beta < 1$; and 3) an income tax rate 't'. The new cut-off grade for each case is equal to:

$$\alpha_{-}^{d} = \frac{EU'C'}{EU'(P - d)} \qquad \text{(A3.4)}$$

$$\alpha_{-}^{\beta} = \frac{EU'C'}{EU'((1-\beta)P)}$$

$$\alpha_{-}^{t} = \frac{EU'C'}{EU'P}$$

The change in the cut-off grade for a comparative static change in each rate is:

$$\alpha_{-}^{d'} = (E(R_A U'\pi' Q) - EU'\alpha)/D_d \qquad \text{(A3.5)}$$

$$= (QO_{R_A} U'\pi' - EU'\alpha)/D_d$$

$$\alpha_{-}^{\beta'} = (E(R_A U'\pi' PQ) - EU'P)/D_\beta$$

$$= (Q(O_{R_A} U'\pi' + O_{R_{A'}} P + O_{U'\pi', P}) - EU'P)/D_\beta$$

$$\alpha_{-}^{t'} = (E(R_A U'\pi'\pi))/D_a$$

$$= (O_{R_{A'}} U'\pi' + O_{R_{A'}} \pi + O_{U'\pi',\pi})/D_t$$

where: $\pi$ = profit

$\pi'$ = marginal profit

$R_A$ = $-(U''/U')$ the measure of absolute risk aversion

O = covariance

D = Denominator of second order effects which is always negative

The expression for the covariance is determined by the well known expression:

$$O_{xy} = E(_{xy}) - E(x)E(y) \qquad (A3.6)$$

The results discussed in the text can be derived from these expressions. Note first that in every case (except the income tax case) the terms which are not a function of the covariances are always negative. Second, if absolute risk aversion is constant then the covariance terms are zero for covariances which include absolute risk aversion. Third, if absolute risk aversion is falling (rising) then the covariance terms of absolute risk aversion with any other variable is negative (positive). For instance, in the case of the ad rem output tax, declining absolute or constant absolute risk aversion is sufficient for the cut-off grade to rise (i.e. for output to fall).

## II. INTERTEMPORAL EXTRACTION MODEL

### A. The Model

This model is similar to the model used in Appendix 2 for the certainty case. The major differences are the inclusion of expected utility and the assumption of homogeneous ore. The objective is:

$$\underset{X_0,X_1}{\text{Max}}\ J = EU[P_0X_0 - C_0[X_0] + (P_1X_1 - C_1[X_1])\dot{z}] \qquad (A3.7)$$

subject to: $X_0 + X_1 \leq X$

where: $z = (1+r)^{-1}$

This formulation is most general. Common special cases would include independence of prices at different points in time and perfect knowledge of t=0 prices. Since the problem is intertemporal it is reasonable to assume that once the miner gets to period 1, he will be operating with complete certainty. However, the miner must extract in t = 0 and the quantity extracted will affect the amount which can be extracted in the next period.[1]

The first order conditions for this problem are:

$$J'_{X_0} = EU'(P_0 - C') - \mu \leq 0;\ J'_{X_0}\,\mu = 0;\ X_0 \geq 0 \qquad \text{(A3.8)}$$

$$J'_{X_1} = EU'((P_1 - C')_1)\,(1+r)^{-1} \leq 0;\ J'_{X_1}\,\mu = 0;\ X_1 \geq 0$$

$$J'_{\mu} = X - X_0 - X_1 \geq 0;\ \mu \geq 0;\ J'_{\mu}\,\mu = 0.$$

where: $\mu$ = shadow price of the resource constraint.

There are two cases; one where the miner plans to extract all the resource over the two periods and the second where the resource constraint will not be binding. The crucial variable in the present analysis is first period extraction. Thus the discussion of taxes will be limited to this variable.

B. Tax Incentives

Consider the three taxes described in the previous section (ad rem, ad valorem, flat rate profits). The comparative static effects of a change in each tax when the resource constraint is not binding are:

---

1/ Note the complete analogy to the consumption/savings problem. A consumer must allocate a fixed of wealth between two periods. Thus, current consumption will affect future consumption.

$$X_{O_d}' = (-E(R_A U'\pi' X_O) + EU') + J_d'' X_O \qquad \text{(A3.8)}$$

$$= (-X_O(O_{R_{A'}} U'\pi'_O) + EU') + J_d'' X_O$$

$$X_{O_\beta}' = (-E(R_A U'\pi'_O - \pi_O P_O X_O) + EU' P_O) + J_\beta'' X_O$$

$$= (-X_O(O_{R_{A'}} U'\pi'_O + O_{R_{A'}} P_O + O_{U'\pi'_{O'}} P_O) + EU' P + J_\beta'' X_O$$

$$X_{O_t}' = (-E(R_A U'\pi_O' \pi_O)) + J_t'' X_O$$

$$= -(O_{R_{A'}} U'\pi'_O + O_{R'_{A'}} \pi_O + O_{U'\pi'_{O'}} \pi) + J_t'' X_O$$

All terms not involving covariances are positive. The denominator is negative via the necessary conditions for a maximum. All covariance terms not involving absolute risk aversion are generally negative. For instance, one would expect that output prices and profit to be positively correlated, leading to a negative correlation for the terms in the equations which do not include absolute risk aversion. Thus, the sign of the derivative will depend on the nature of absolute risk aversion. If absolute risk aversion is constant then no covariance exists between absolute risk aversion and other variables. If absolute risk aversion is decreasing (increasing), then the covariance between absolute risk aversion is negative (positive).

The comparative statics effects of a change for the three taxes when the resource constraint is binding can be determined via an examination of the following equations. Only numerators are reported here since the sign of the denominators are all positive.

$$X_{O_d}' = EU''(\pi_O' - \pi_1' z)(X_O + X_1 z) + EU'(z-1) \qquad (A3.9)$$

$$= (X_O + X_1)(O_{R_{A'}} U'\pi_O' z - O_{R_{A'}} U'\pi_1') + EU'(z-1)$$

$$X_{O_d}' = (EU''(\pi_O' - \pi_1' z)(P_O X_O + P_1 z X_1) + EU'(P_O - P_1 z)$$

$$= (X_O + X_1)(O_{R_{A'}} U'\pi_O' - O_{R_{A'}} U'\pi_1' z) + X_O (O_{U'\pi_O' P_O} - O_{U'\pi_1' z, P_O})$$

$$+ (X_1(C_{U'\pi_O' P_1 z} - C_{U'\pi_1' z, P_1 z}) + EU'(P_1 z - P_O)$$

$$X_O' = EU''(\pi_O' - \pi_1')(\pi_O + \pi_1)$$

$$= 2(O_{R_{A'}} U'\pi_O' - O_{R_{A'}} U'\pi_1' z + O_{U'\pi_O' \pi_O} - O_{U'\pi_1' z, \pi_1 z})$$

The results discussed in the text can be derived from these expressions for various assumptions regarding the nature of absolute risk aversion and certainty with respect to first period prices and costs.

## REFERENCES


Arrow, K.J. and Lind, R.C. (1970). "Uncertainty and the Evaluation of Public Investment Decisions", American Economic Review, (June).

Atkinson, A.B. and Stiglitz, J.E. (1980). Lectures on Public Economics. New York: McGraw-Hill.

Barrows, Gordon H. (1984). Worldwide Concession Contracts and Petroleum Legislation. Tulsa, Oklahoma: PennWell Books.

Benjamin, Nancy C. and Devarajan, Shantaynana (1985). "Oil Revenues and Economic Policy in Cameroon: Results from a Computable General Equilibrium Model". World Bank Staff Working Paper, Series Number 745 (August).

_____ and _____ (1985). "Oil Revenues and the Cameroonian Economy" in Zartmann, I.W. and Schatzberg, M. eds., The Political Economy of Cameroon. New York: Praeger.

_____ and _____ and Weiner, R. (1985). "Oil Revenues and the 'Dutch Disease' in a Developing Country". Unpublished.

Break, George F., Holland, Daniel and McLure, Charles E. (1986). "Private Sector Capital Investments and the Company Tax". Jamaica Tax Structure Examination Project #28, March.

Boskin, et. al. (1985). "New Estimates of the Value of Federal Mineral Rights and Land". American Economic Review, December.

Bosson, R. and Varon, Bension (1977). The Mining Industry and the Developing Countries. New York: Oxford University Press.

Burness, H.S. (1976). "On Taxation of Nonreplenishable Natural Resources". Journal of Environmental Economics and Management, December.

Conrad, Robert F. (1978). "Royalties, Cyclical Prices and the Theory of the Mine". Resources and Energy (1).

_____ (1981). "Variable Rate Severance Taxes: Impact and Incidence". Natural Resources Journal (22), July.

_____ (1980). "National Resource Taxation: A Numerical Introduction". National Tax Journal 33:4.

_____ (1983). Testimony before Subcommittee on Oversight. Committee on Ways and Means. U.S. House of Representatives, May 5.

_____ (1981). "Output Taxes and the Quality-Quantity Trade-off in the Mining Firm". Resources and Energy, 3.

_____ (1980). "Foreign Investment in the Minerals Sector and the Foreign Tax Credit". Office of Tax Analysis, U.S. Treasury, October.

_____ (1984). "Taxation of Bauxite in Jamaica". Jamaica Tax Structure Examination Project #5, December.

_____ (1987a). "Opportunity Costs, Rent and Risk Sharing in Mineral Contracts: A Defense of Royalties". Unpublished.

_____ (1987b). "Allocative Incentives of Mineral Taxes on Risk Averse Producers", (in process).

_____ (1987c). "A Proposal for Funded Depletion in Resource Rich Developing Economies", (in process).

Conrad, Robert F. and Convery, Frank (1981). Minerals Policy. Dublin: National Economic and Social Council, July.

Conrad, Robert F. and Hool, Bryce (1981). "Resource Taxation with Heterogeneous Quality and Endogenous Reserves". Journal of Public Economics, 16.

_____ (1981). Taxation of Mineral Resources. Cambridge: Ballengier.

_____ (1984a). "Intertemporal Extraction of Mineral Resources under Variable Rate Taxes". Land Economics, 60:4, November.

_____ (1984b). "Grade Variation, Endogenous Reserves and the Theory of the Mine". Resources and Energy, December.

Copeland, T.E. and Weston, J.F. (1983). Financial Theory and Corporate Policy. 2nd ed. Reading, Mass: Addison-Wesley.

Diamond, P.A. and Mirrlees, J.A. (1971). "Optimal Taxation and Public Production I and II". American Economic Review.

Feldstein, M.S. (1977). "The Surprising Incidence of a Tax on Pure Rent". Journal of Political Economy, April.

Francis, A.A. (1981). "Taxing the Transnationals in the Struggle Over Bauxite". Institute of Social Studies (The Hague): Research Report Series No. 9.

Gravelle, Jane G. (1981). "The Social Cost of Non-neutral Taxation: Estimates for Non residential Capital", in Charles R. Hulten (ed.) Depreciation, Inflation, and the Taxation of Income from Capital. Washington: The Urban Institute Press.

Garnaut, Ross and Clunies-Ross, Anthony (1975). "Uncertainty, Risk Aversion and the Taxing of Natural Resource Projects". Economic Journal, June.

_____ (1979). "The Neutrality of the Resource Rent Tax". The Economic Journal, September.

_____ (1983). Taxation of Mineral Rents. New York: Oxford.

GFS, Government Finance Statistics (Various Years), International Monetary Fund.

Gillis, S. Malcolm (1977). "Taxation, Mining and Public Ownership", in Non-Renewable Resoure Taxation in the Western States. Cambridge, Masschusetts: Lincoln Institute Monograph #77-2.

Gillis, S. Malcolm and Beals, Ralph (1980). Tax and Investment Policies for Hard Minerals: Public and Multinational Enterprises in Indonesia. Cambridge, Masschusetts: Ballinger Publishing Co.

Gillis, S. Malcolm, et. al (1978). Taxation and Mining: Nonfuel Minerals in Bolivia and Other Countries. Cambridge, Massachusetts: Ballinger Publishing Co.

Harberger, A.C. (1984). "Dutch Disease: How Much Sickness How Much Boom?". Resources and Energy.

Hawkins, Robert G. (ed) (1979). Research in International Business and Finance: Volume I. Greenwich, Connecticut: JAI Press.

Hotelling, Harold (1931). "The Economics of Exhaustible Resources". Journal of Political Economy, April.

IFS, International Finance Statistics (Various Years), International Monetary Fund

Kalter, R.T., et. al (1975). "Alternative Energy Leasing Strategies and Schedules for the Outer Continental Shelf", Department of Agricultural Economics, Cornell University, December

Leland, H.E. (1978). "Optimal Risk Sharing and Leading of Natural Resources, with Application to Oil and Gas Leasing on the OCS". Quarterly Journal of Economics, August.

Lewis, S.R. (1984). "Development Problems of Mineral Rich Countries", in Economic Structure and Performance (Academic Press).

Maximov, A. et. al. Short Course of Geological Prospecting and Exploration. Moscow: MIR Publishers.

Mikesell, Raymond F. Foreign Investment in Mining Projects. Cambridge, Massachusetts: Oelgeschlager, Guann and Hain.

Mikesell, Raymond F. Foreign Investment in Copper Mining: Case Studies of Mines in Peru and Papua New Guinea. Baltimore: John Hopkins.

Peterson, Frederick M. (1976). "The Long Run Dynamics of Minerals Taxation". University of Maryland: unpublished.

Peterson, Frederick M and Fisher, Anthony C. "The Exploitation of Extractive Resources: A Survey". Economic Journal, December.

Price-Waterhouse (Various Years). "Doing Business Series" Various Countries.

Price-Waterhouse (1980). Corporate Taxes: A Worldwide Summary.

Rybczynski, T.M. (1955). "Factor Endowment and Relative Commodity Prices". Econometrica.

Shalizi, Z., Gandhi, V. and Ehdaie, J. (1985). "Patterns of Taxation in Sub-Saharan Africa: Trends in 'Tax Effort' and Composition During the Period 1966-1981". World Bank: Country Policy Department: Resource Mobilization Division, January.

Shalizi, Z., and Lyn Squire, L. (1987). "A Framework for Tax Policy Analysis in Sub-Saharan Africa." World Bank: Country Policy Department: Resource Mobilization Division, March.

Smith, David N. and Wells, Louis T. (1975). Negotiating Third-World Mineral Agreements: Promises as Prologue. Cambridge: Ballinger.

Smith, V. Kerry (ed). Scarcity and Growth Reconsidered. Baltimore: John Hopkins.

Strasma, John A. et. al. "Mineral Taxation: Alternatives for Wisconsin". Agricultural Economics Staff Paper Series No. 93. University of Wisconsin-Madison, January.

Thomas, L.J. (1976). An Introduction to Mining. Sydney: Hicks, Smith and Sons.

Thon, Dominique (1985). "Alternative Petroleum Taxation Systems: Comparisons Under Uncertainty". Presented at American Economic Association Meetings, December.

United States Department of Interio (1984). Mineral Facts and Problems. Washington: GPO.

van Wijnbergen, Sweder (1984). "The 'Dutch Disease': A Disease After All?". The Economic Journal, March.

Virmani, Arvind (1985). "Tax and Contractual Arrangements for the Exploitation of Natural Resources". World Bank Staff Working Paper Number 752, September.

_____ (1986a). "Efficiency of Tax-Contract Policies for Natural Resource Rent Collection". DRD Report # DRD-163, World Bank, April.

_____ (1986b). "Efficiency of Practical Resource Rent Tax Systems: Threshold Rates and Income Taxes". DRD Report # DRD-164, World Bank, April.

World Bank (1984). "Toward Sustained Development in Sub-Saharan Africa: A Joint Program for Action". Washington.

World Bank Country Memoranda (Various Years), World Bank

## PPR Working Paper Series

| | Title | Author | Date | Contact |
|---|---|---|---|---|
| WPS70 | Vocational Education and Economic Environments: Conflict or Convergence? | Arvil V. Adams<br>Antoine Schwartz | August 1988 | T. Hawkins<br>33678 |
| WPS71 | School Effects on Student Achievement in Nigeria and Swaziland | Marlaine Lockheed<br>Andre Komenan | August 1988 | T. Hawkins<br>33678 |
| WPS72 | The Relative Efficiency of Public Schools in Developing Countries | Emmanuel Jimenez<br>Marlaine Lockheed<br>Vicente Paqueo | August 1988 | T. Hawkins<br>33678 |
| WPS73 | Taxation and Output Growth in Africa | Jonathan Skinner | August 1988 | A. Bhalla<br>60359 |
| WPS74 | Fiscal Stabilization and Exchange Rate Instability: A Theoretical Approach and Some Policy Conclusions Using Mexican Data | Andrew Feltenstein<br>Stephen Morris | August 1988 | A. Bhalla<br>60359 |
| WPS75 | Welfare Dominance and the Design of Excise Taxation in the Cote d'Ivoire | Shlomo Yitzhaki<br>Wayne Thirsk | August 1988 | A. Bhalla<br>60359 |
| WPS76 | On the Shadow Price of a Tax Inspector | Shlomo Yitzhaki<br>Yitzhak Vakneen | | |
| WPS77 | Incentive Policies and Agricultural Performance in Sub-Saharan Africa | Bela Balassa | August 1988 | N. Campbell<br>33769 |
| WPS78 | Economists, Institutions and Trade Restrictions: A Review Article | J. Michael Finger | | |
| WPS79 | Quantitative Appraisal of Adjustment Lending | Bela Balassa | August 1988 | N. Campbell<br>33769 |
| WPS80 | Emerging Issues of Privatization and the Public Sector | Samuel Paul | September 1988 | E. Madrona<br>61711 |

## PPR Working Paper Series

| | Title | Author | Date | Contact |
|---|---|---|---|---|
| WPS81 | Reaching People at the Periphery: Can the World Bank's Population, Health, and Nutrition Operations Do Better? | Richard Heaver | September 1988 | S. Ainsworth 31091 |
| WPS82 | Microeconomic Theory of the Household and Nutrition Programs | Dov Chernichovsky<br>Linda Zangwill | September 1988 | S. Ainsworth 31091 |
| WPS83 | Welfare Costs of U.S. Quotas in Textiles, Steel, and Autos | Jaime de Melo<br>David Tarr | September 1988 | C. Cabana 61539 |
| WPS84 | Black Markets for Foreign Exchange, Real Exchange Rates and Inflation: Overnight vs. Gradual Reform in Sub-Saharan Africa | Brian Pinto | September 1988 | R. Blade-Charest 33754 |
| WPS85 | Wage Responsiveness and Labor Market Disequilibrium: Exploring the Components of Open Unemployment | Ramon E. Lopez<br>Luis A. Riveros | | |
| WPS86 | External Balance, Fiscal Policy and Growth in Turkey | Ritu Anand<br>Ajay Chhibber<br>Sweder van Wijnbergen | | |
| WPS87 | Vocational and Technical Education in Peru | Peter R. Moock<br>Rosemary T. Bellew | | |
| WPS88 | Costs, Payments, and Incentives in Family Planning Programs | John A. Ross<br>Stephen L. Isaacs | September 1988 | S. Ainsworth 31091 |
| WPS89 | Export Quota Allocations, Export Earnings and Market Diversifications | Taeho Bark<br>Jaime de Melo | September 1988 | C. Cabana 61539 |
| WPS90 | A Framework for Analysis of Mineral Tax Policy in Sub-Saharan Africa | Robert F. Conrad<br>Zmarak M. Shalizi | September 1988 | A. Bhalla 60359 |
| WPS91 | Israel's Stabilization Program | Nissan Liviatan | September 1988 | N. Liviatan 61763 |