

Gold Mining Taxation in South Africa: a discussion of the MPRDA, its amendments and whether internal inconsistencies exist in the mining legislation

Prepared in partial fulfillment of the requirements for a Masters in Commerce
(Economics)

Karen Dowe

Supervisor: Anthony Leiman

Abstract

The purpose of this paper is to add to the current debate regarding the royalty imposition by discussing the Mineral and Petroleum Resource Development Act No. 28 of 2002 and the three amendments that have been made to it. The effect on investment, production, exploration and government taxation revenue of the MPRDA, specifically on gold mining taxation in South Africa, is discussed. An important objective of the Act is to deal with past injustices. The Act results in a change in the ownership of minerals, where all mineral rights will vest in the state. The paper analyses whether internal inconsistencies in the mining legislation exist, by comparing the effects of the introduction of royalties, ring-fencing and the 'use-it or lose-it' clause. It is found that certain inconsistencies do exist.

Key words: *non-renewable resources, gold mining, Hotelling, taxation, royalties, Mineral and Petroleum Resource Development Act, South Africa, internal inconsistencies.*

- I would like to thank Tony Leiman for his contributions to this paper



School of Economics
UNIVERSITY OF CAPE TOWN

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

Table of Contents

| | |
|--|-------|
| Section 1: Introduction | pg 1 |
| Section 2: Taxation of Non-Renewable Resources | |
| 2.1 Introduction | pg 4 |
| 2.2 The Gold Mining Taxation Formula | pg 7 |
| 2.3 Aims of the MPRDA | pg 9 |
| 2.4 Revision of the Taxation Formula – Draft 1 of the MPRB | pg 11 |
| 2.5 Revision of the Taxation Formula – Draft 2 of the MPRB..... | pg 12 |
| 2.6 Revision of the Taxation Formula – Draft 3 of the MPRB | pg 14 |
| Section 3: Basic Literature | |
| 3.1 Hotelling and Gray | pg 16 |
| 3.2 The Model | |
| 3.2.1 The Model of Optimal Depletion | pg 22 |
| 3.2.2 The Social Planner | pg 24 |
| 3.2.3 The Mining Company | pg 26 |
| 3.2.4 Comparison of the optimal inter- temporal extraction policies | pg 27 |
| Section 4: Taxation | |
| 4.1 Reasons for taxation | pg 29 |
| 4.2 Key Aspects of a Tax | |
| 4.2.1 Equity | pg 31 |
| 4.2.2 Efficiency | pg 32 |
| 4.2.3 Administrative Simplicity | pg 33 |
| 4.3 Types of Taxes | |
| 4.3.1 Profit-based Royalty | pg 34 |

| | |
|---|-------|
| 4.3.2 Revenue-based Royalty | pg 37 |
| Section 5: Analysis | |
| 5.1 First Draft | pg 40 |
| 5.2 Second Draft | pg 45 |
| 5.3 Third Draft | pg 48 |
| 5.4 Ring-fencing | pg 50 |
| 5.5 The 'use-it or lose-it' Principle | pg 53 |
| 5.6 Property Rights | pg 54 |
| 5.7 Internal Inconsistencies | pg 57 |
| Section 6: Conclusion | |
| Section 6: Conclusion | pg 59 |
| Tables | pg 62 |
| References | pg 68 |
| Appendix A | pg 75 |

List of Tables

Table 1: Percentage of Tax Revenue from Mining

Table 2: Cross-Country Analysis of Royalty Regimes for gold

Table 3: Royalty Rates for the first draft

Table 4: Royalty Rates and Classification for second draft

Table 5: Tax Rates for Third Draft

Table 6: Qualifying Deductible Expenditure as a percentage of Gross Sales or Revenue

University of Cape Town



School of Economics

PLAGIARISM DECLARATION

1. I know that plagiarism is wrong. Plagiarism is to use another's work and pretend that it is my own.
2. I have used the Harvard referencing guide for citation and referencing. Each contribution to, and quotation in this thesis from the work(s) of other people has been contributed, and has been cited and referenced.
3. This thesis is my own work.
4. I have not allowed, and will not allow, anyone to copy my work.

Signature: _____

Date: _____

1. Introduction

South Africa is a country endowed with an abundance of renewable and non-renewable natural resources. It is one of the world's most important mining countries and has a large variety of minerals. It has the world's largest reserves of gold and platinum-group metals (PGMs) and is one of the world's leading producers of base metals and coal. The mining industry is recognised as the cornerstone of the economy. It contributes significantly, both directly and indirectly, to the country's economy. Direct contributions are to GDP, economic growth, investment, employment, export earnings and government taxation revenue. Between 1996 and 2005 mining and quarrying contributed R676 billion in real rand terms; mining investment contributed 8.9% of total investment of R1621.8 billion and contributed 32% to total exports (R2380.3 billion). Employment in the mining sector in 2005 stood at 443 300 and 41% of total miners were employed in the gold mining industry. Indirect benefits include skills development through education and training, provision of infrastructure for mine social facilities and contribution to local economic development. It is important to note that, although mining is a fundamental part of the South African economy, in recent years its importance has diminished, mostly due to the growth of the secondary and tertiary sectors of the economy and as a result of the reduction in production (Phale, 2007: 5-6).

The essential theory is that natural resources are gifts of nature and that all citizens of the mineral rich country should benefit from extraction and transfer of the minerals. The secondary hypothesis is that multinational companies, known as mining houses, generally

have control of the mines, which otherwise make little contribution to the development of the country. In the presence of uncontrolled private access to the mining houses the resource may be exploited at too rapid a rate and the country may not benefit from extraction of its minerals. The mining houses could take the revenue earned from mining activities and invest it back home. The mining houses earn the benefits from mining resources that belong to the mineral rich country and its citizens. For this reason state intervention is necessary to ensure that the benefits accrue to the rightful owner of the resource (Dore, 1990). The policy emerging from the two hypotheses above requires that a taxation system be established (on the basis of equity or efficiency) in order for the mineral-abundant country to reap some of the benefits from mining.

The issue of optimal resource extraction and mining taxation began as early as the twentieth century. In recent years it has resurfaced as an important point of discussion, especially in South Africa with the introduction of the Mineral and Petroleum Resources Development Act (MPDRA) no. 28 of 2002. Royalty payments for the right to explore and mine resources are a common practice in many developing countries. The royalties are used as a means of compensation for the opportunity cost of the extracted resource. The revenue earned is used to fund development projects or to change the extraction behaviour of mining companies. The development projects will assist with the alleviation of poverty. The redistribution of property rights resulting from the MPRDA will assist in alleviating inequality in distributions of wealth. This is important for South Africa as a

large percentage of the population lives below the poverty line and inequality¹ is so rife. If these issues are left unresolved, a threat may be posed to future social and economic stability. Rent generation and rent distribution is therefore a crucial aspect for South Africa's future social and economic outlook (Figueroa B, 1999: 81). Although still important to the government, the importance of revenue from mining tax has diminished with personal income tax and value added tax becoming larger revenue earners for the government (See Table 1). Mines paid a total of R6.9 billion in direct taxes and R4.1 billion in other taxes in 2003 (Coetzee and Horn, 2007:1).

The objective of the paper is to contribute to the current debate in South Africa regarding the proposed MPRDA and its amendments. It contributes to existing literature by including the recent changes made in the third draft of the MPRDA and by analysing whether internal inconsistencies exist within the new mining legislation. Section 2 discusses the foundation literature (Kotzé, 1933) of gold mining taxation, the gold mining taxation formula and each draft of the MPRDA. Section 3 and 4 discuss the foundation literature (namely, Hotelling and Gray) on optimal extraction and taxation of non-renewable natural resources and can therefore be omitted by a reader familiar with this literature, without the analysis losing meaning. Section 5 analyses the change in the system by discussing concerns with each draft, the change in property rights and assesses whether internal inconsistencies arise from the new legislation. Section 6 concludes the paper.

¹ 61% of the people are living below the poverty line in 2007 and the Gini Coefficient was 0.65 in 2005.

2. Taxation of Non-Renewable Minerals

2.1 Introduction

Two seminal papers written by Kotzé (1933) discuss the implications of the introduction of a tax, how taxes change miner behaviour and the decision of which ore grade is mined. A tax on profits was thought not to deter low-grade mining and affect higher-grade miners and higher producing mines more than lower-grade miners or mines with lower production levels. The lower the grade mined, the lower the profit, and therefore the lower the amount of tax paid. Kotzé (1933) regarded mining tax as an incentive for bad mining practice, with government losing and mining companies gaining. The companies gain, as the lifespan of the mines would be lengthened by the mining of lower grade ore. This tax was therefore not viewed as favourable by government. However, it was suggested that the increased life of the mines and the benefits that this would have on the economy compensated for the loss in profit.

The excess profits duty that was introduced was a tax paid on the premium², the portion of the gold which was in excess of the former standard gold price. This resulted in lower-grade mines paying a higher percentage of profits to tax than higher grade mines. Mines that made profits below standard profit did not pay taxes. Kotzé (1933) did not agree with this tax, as it was thought a great injustice that a lower grade mine is charged more in taxes than a higher grade mine. It was thought that the tax suffered from many anomalies, which resulted in opposing state and shareholder interests, instead of being

² Rather than the profits

beneficial to both. The justification for taxation should be the need for revenue. And the state should tax those that can best afford it and “do it in such a manner that the least injury to the taxed industry and to the country results” (Kotzé, 1933: 318).

Capital value taxes and severance taxes were first discussed by Hotelling (1931). It was recognised that a regulation system should be put in place so as to deal with the world's disappearing resources. The benefit of a capital value tax is that it will not have an effect on the value of the mine, if anticipated, other than transferring income to the state. A severance tax is a tax of a constant certain rate per unit of mineral extracted. This type of tax results in a lower price of the resource and lengthens the life of the mine (Hotelling, 1931: 164-169).

There have been many more recent studies involving taxation of mineral resources. The effects of taxes under different technologies at different rates of production have been discussed (Slade, 1986). The responses to tax policy can differ drastically to responses in the model when stages of production are included. The effect that taxation has on the environment has also been studied (Muzondo, 1993). It is found that a combination of a neutral tax and a dynamic Pigovian tax is the most appropriate corrective tax for environmental problems. There have also been a number of studies discussing the impacts that royalties and other types of taxes have on mines (Osmundsen, 1998; Conrad and Hool, 1984; Gamponia and Mendelsohn, 1985, Otto, 2000). Osmundsen develops a dynamic resource taxation model for a non-renewable resource taking informational

asymmetries into account. It was found that the extraction level is distorted by royalties and that the pace of extraction is distorted through royalties that differ between each period. Conrad and Hool (1984) discuss extraction rates of natural resources under variable tax rates. It is found that severance taxes result in a reallocation of production from the present to the future. Whereas if the tax is variable, production is shifted into the present and the conclusion is drawn that more progressive taxes result in higher total extraction. Gamponia and Mendelsohn (1985) discuss four different types of taxes (unit, yield, property and windfall profit) and find that the most efficient tax is the yield tax and the most inefficient taxes are the unit and property taxes. Otto (2000) discusses different types of taxes and the effects the taxes have, specifically in developing countries. Cairns (1985) discusses the reform of resource taxation and the efficiency of various revenue raising instruments and concludes that a variety should be used in order to collect revenues from mines. The general results of these papers have been that a short-term goal of maximising revenues from royalties should be avoided and that investment is negatively affected by the imposition of turnover royalties.

During the 1970s and 80s the most important discussion regarding taxation was to find effective ways in which to split the economic rent between the investor and the host state ensuring that both parties' interests were satisfied. The attraction of foreign investment was considered to be extremely important (Garnaut and Clunies-Ross, 1983). More recently there has been a reform in the mining sector with "new legislation and mining codes, revised fiscal terms, the removal of formal barriers to foreign investment, a

reduction in the role of the state in foreign investments, and the complete or partial privatisation of state mining companies” (Andrews-Speed and Rogers, 2000: 221). The side-effects of this are that the state is receiving a share of revenue that is too low and are being exposed to an unacceptable level of political risk.

The rest of this section discusses how the tax system has changed since its introduction. It specifically focuses on the current debate regarding mineral taxation in South Africa by discussing the gold mining taxation formula, the introduction of the MPRDA and the proposed amendments to it.

2.2 The Gold Mining Taxation Formula

The gold tax formula was introduced in 1926, at a time when gold mining was the dominant industry in the country. Previously, taxation of mines was a flat rate tax that changed between periods. The formula used was

$$\%taxpayable = A - \frac{AB}{X}$$

where A and B are policy constants and X is the profit expressed as a percentage³.

This formula allows the mining companies to compensate for losses and/or capital investments. It makes use of a sliding tax system, where in times of low mining revenue lower taxes are paid. More profitable mines pay higher taxes than less profitable mines.

³ The values of A and B depend on whether the company pays secondary taxes or not. If secondary taxes are paid on declared dividends at 12.5% A=37 and B=5. This results in the %tax rate = $37 - 185/X$. If no secondary taxes are paid A=46 and B=5. The %tax rate becomes $46 - 230/X$. When X=38 the tax paid is equivalent to that of normal companies.

In times of large industry revenues taxes can be extremely high (sometimes up to 46%). The tax for each mine is calculated separately and is ring-fenced⁴ to that mine. This is important as it ensures that the industry is preserved (the mines lives are prolonged) and valuable jobs are not lost. This is extremely important in a country, such as South Africa, with such a large rate of unemployment. A positive aspect of the gold taxation formula is that it encourages the mining of marginal ores, thereby prolonging the life of mines. The marginal ore will be mined when the dollar price of gold is low and when the mining companies are paying little in tax to the government (Mangondo, 2006: 85). The mining tax formula allows for income tax exemption and secondary tax relief (Davis, 2005: 34). The AB in the formula is the portion of revenue that is tax free and is commonly known as the 'tax tunnel'. This encourages deep mining and the mining of low grade ore, thereby lengthening the life of mines.

There have been numerous criticisms of the gold formula. It introduces a distortion effect and a misallocation of resources by encouraging wasteful expenditure and could lead to a reduction in efficiency. There has also been the criticism that it is unlikely that this tax formula results in marginal ores being mined. Deep-level mines, like those in South Africa, are not able to mine selectively so that the formula can be taken advantage of. It is rather the marginal cost that determines whether marginal ore is mined or not. The formula also results in unequal returns of investment for the government and the shareholders (Mangondo, 2006: 85).

⁴ Ring-fencing will be discussed further in Section 5.

2.3 Aims of the MPRDA

The MPRDA recognizes the need to “create an internationally competitive and efficient mineral resource royalty regime that contains rules seeking: (i) maximum certainty for the investor community in support of sustainable economic growth, and (ii) royalty rate stability within the foreseeable future” (National Treasury, 2006: 2).

The MPRDA discusses its objectives. These are to

- “Recognise the internationally accepted right of the State to exercise sovereignty over all the mineral and petroleum resources within the Republic;
- Give effect to the principle of the State’s custodianship of the nation’s mineral and petroleum resources;
- Promote equitable access to the nation’s mineral and petroleum resources to all the people of South Africa;
- substantially and meaningfully expand opportunities for historically disadvantaged persons, including women to enter the mineral and petroleum industries and to benefit from the exploitation of the nation’s mineral and petroleum resources;
- Promote economic growth and mineral and petroleum resources development in the Republic;
- Promote employment and advance the social and economic welfare of all South Africans;
- Provide for security of tenure in respect of prospecting exploration, mining and production operations;

- Give effect to Section 24 of the Constitution by ensuring that the nation's mineral and Petroleum resources are developed in an orderly and ecologically sustainable manner while promoting justifiable social and economic development;
- Ensure that holders of mining and production rights contribute towards the socio-economic development of areas in which they are operating" (Government Gazette no. 23922, 2002: 18).

The aim of the government is an attempt to reconcile the objectives of the MPRDA and the broader economic objectives of the mining sector. This includes stimulating investment and ensuring investor certainty (National Treasury, 2006: 1). And there is an overriding emphasis being placed on socio-economic development. The introduction of the MPRDA will introduce the principle of sustainable development, resulting in a balance of the social, economic and environmental spheres of mining within a framework of good governance. The tax is used to compensate the state for past, present and future costs for the loss of valuable irreplaceable assets (Mining Information Sheet, 1997: 1).

The MPRDA ensures that mines contribute to the development of skills and physical infrastructure and provide services and business opportunities in mining communities. The mining companies have to ensure that contribution is made to these developments in order to gain mining rights (Cawood, 2005: 4). Mining companies must also contribute to HIV/AIDS care and prevention.

The MPRDA introduces a scorecard system to ensure that mines are complying with the objectives of the MPRDA and whether or not a mine is achieving the objectives is assessed. The objectives are human resource development, employment equity, migrant labour, mine community and rural development, housing and living conditions, procurement, ownership and joint ventures, beneficiation and reporting. Companies are required to score in each category (BEE Charter for the South African Mining Industry).

2.4 Revision of the Taxation Formula – Draft 1 the MPRDA

The first draft of the MPRDA was released in March 2003 and is scheduled to take effect in 2009. It proposed that the gold taxation formula be updated by introducing a royalty⁵ system, whereby an ad valorem charge on the gross sales of the ore extracted be used. There are to be no deduction of costs from revenues before tax is calculated and is payable regardless of company profits. The royalty rates range from 1% to 8% and depend on the type of mineral (see Table 2 for classification). The proposed royalty for gold is 3% of gross sales payable quarterly. The royalty will be payable on top of company income tax. This is in line with taxation systems in most other developing countries (Press Statement notes, 2003: 2). A country-by-country analysis of the different types of mineral taxes was undertaken by Grote (2007). Only Canada and the Northern Territories of the USA (from 31 countries) made use of a profit-based system whereas 22 countries made use of revenue based royalty taxes (see Table 2). The royalty rates proposed in the MPRDA are within international competitive margins.

⁵ Defined as “payment due to the sovereign owner in exchange for the right to extract the mineral substance” (Cawood, 2006: 3)

2.5 Revision of taxation formula – Draft 2 of the MPRDA

The second draft was released in October 2006. It was released as a result of the major complaints arising from the first draft. Different royalty rates were still applicable for different types of minerals but were significantly reduced. A dual rate system with a lower rate for refined minerals was introduced. The royalty for refined gold was lowered to 1.5% and for unrefined gold remained at 3%. Royalty payments would now be tax deductible as it is a deductible expense in the production of income. Capital expenditure is allowed as a deduction from mining tax. It is 10% for post-1973 gold mines and is 12% for post-1990 gold mines. There was still no provision for cross-subsidisation of loss making mines within a group of mines (ring-fencing is further discussed in section 5). The request that profits rather than revenues are used to calculate the taxes was not accepted by government; with the tax base still calculated on gross sales. There has generally been a positive reception regarding the changes from the first draft. It has been described as in line with international practice. The draft has been described as reasonable but with caveats. The concerns will be further discussed in section 5.

Exemptions and Reductions

The second draft allows for provisions for marginal mines⁶. These mines are exempt from the royalty payment or only partially pay it. Loss making mines and marginal mines may receive relief of up to 75% of royalties paid. Small mines receive a tax reduction of 15% on the first R100 000 of taxable income and 30% thereafter (Cawood, 2005: 8). The

⁶ A marginal mine is a one that produces at a rate barely covering costs of production.

reason for this is to prevent the closure of low-grade mines, resulting in a shorter lifespan of the mines and a rise in unemployment. Others exempt from royalty payment are those miners extracting for analysis, bulk sampling or other similar testing. This exemption, however, does not apply to diamonds and other gemstones. Minerals used for domestic brick-laying, public infrastructure construction and cement manufacturing, and agriculture are also exempt from the royalties. The reason for these exemptions is that these minerals have relatively low values, resulting in limited revenue-raising potential.

The MPRDA assists the small scale sector, as it makes a few provisions for these mines. Small scale mines receive technical and financial assistance, access to historic classified information and a special permit system. In the case that there are two or more applications for mineral rights on the same day, the government must first consider the application from the Historically Disadvantaged South Africans (HDSA) mines. The marginal mines may make use of contract mining to larger companies (Cawood, 2005: 8). Small scale mines also receive assistance for training and education of workers and special interest rates on capital loans, which increase job opportunities (Cawood, 2005: 9).

Reductions on the royalty rate pertain to bituminous coal intended for domestic use⁷ (levied at 1%). The royalty rate is halved (to between 0.5% and 1.5%) for oil and natural gas in the case that the rights holder discovers an economically exploitable deposit within the area that the rights are owned (Press Statement, 2003). Capital expenditure allowance

⁷ Generally has a lower grade than coal that is used internationally

results in expenditures on capital being written off before taxes are deducted. This type of tax rebate encourages investment in capital and new mines when prices are high. Capital allowance is similar to capital expenditure allowance. Firms can deduct capital expenditure and interest before being taxed.

In this draft of the MPRDA there is a fiscal stabilization provision. This provision ensures maximum certainty for investors, as it minimises administrative discretion and maximises clarity of administration. “In order to allay uncertainty concerning rates in a material way, the MPRDA contains rates that are sustainable for the foreseeable future” (South African Government website, 2003). The stabilization provision also acts as a contractual guarantee that rates will be stable in the case that miners pay a premium. The initial tax price that is used will be guaranteed if the miner pays a premium “equal the lesser of 2 per cent or 50 percent of the initial royalty rate” (South African Government website, 2003). A miner with a 2% royalty would pay an extra percentage on the tax rate for this guarantee. This provision will only hold for 30 years from its starting date.

2.5 Revision of the Taxation Formula – Draft 3 of the MPRDA

The third and final draft was released in December 2007 giving effect to the MPRDA. It moved away from the dual system suggested in the second draft. It still made use of gross sales to calculate taxes but included an allowance for deductions of beneficiation-related expenses such as smelting, refining, processing and sorting in the case of diamonds, and also allowed for transport expenses between the seller and buyer of the product. The

qualifying deductible expenditure as a percentage of gross sales and revenue can be seen in Table 5. The rate now is based on a formula that also takes the profitability of a company into account. The formula is:

$$Y (\%) = \frac{EBITDA}{\text{grosssales} \times 12.5} \times 100$$

where EBITDA⁸ is earnings before interest, taxes, depreciation and amortisation

For the change in the tax rates see Table 3. The rates using the formula are between 1% and 3.7%. This is a narrower base than in the previous two drafts. Most mineral rates have been reduced but the rate for manganese has increased slightly and there has been an introduction of royalties for minerals such as lime and sandstone that previously were exempt from royalty payments. This new draft has been welcomed by mining companies and the government. It has been seen as easier to administer and more investor friendly, than the previous two drafts, whilst ensuring that the government receives a fair share of revenue (Olivier, 2007).

Beneficiation of gold in South Africa is low. 97% of the gold mined in South Africa in 2004 went into the production of gold bars. South Africa produces 15% of the world gold supply but only produces about a percent of the world's gold jewellery supply. The country should be promoting the beneficiation of minerals so that the manufacturing sector expands and the country becomes less dependent on its mining activities. This will

⁸ In the case that a company has a negative EBITDA, it is set equal to zero in the formula.

result in a stronger, more diversified economy. With this a higher standard of living can be realised for all South Africans and competition with other countries will be on more equal terms (Sonjica, 2006: 7). The average for developing countries in the gold-jewellery manufacturing sector is 3.9% (Mining Weekly, 2006). Both the second and the third drafts attempt to promote the beneficiation of minerals.

The exemption that marginal mines were granted in the second draft was removed. This was done as the new formula based system was already providing relief for these mines. In this draft smaller mines (those earning less than R10 million a year) are to be granted a credit of R100000 a year that can be offset against royalty payments.

3. Basic Literature

The following section sets up the relevant natural resource literature which is important for the analysis of recent changes in the South African mining legislation. Readers familiar with the basic Hotelling literature could omit this section without losing any value from the analysis.

3.1 Hotelling and Gray

In 1931, Harold Hotelling determined the conditions under which a given resource could be optimally extracted in a competitive industry by building on previous work by Jevons (1871), Menger (1871) and Walras (1874) by introducing the concept of time. The fundamental result of Hotelling is extremely important, as it is the point of departure for

all analysis of non-renewable resources in a dynamic framework. In showing that perfect competition gives the same actual rates of extraction in a dynamic model as it does in a static model (Hotelling, 1931: 143); it was also found that the present value of rents should be the same in all periods. And that under pure competition, the market extracts the amount of ore that is both socially and privately optimal. In other words, the undiscounted royalty should rise at the rate of interest. Hotelling recognised that the marginal cost of extraction depends on both current and cumulative production. The logic behind Hotelling's rule is this; if the net price rises at a rate slower than the interest rate then it is preferable to decrease extraction in this period and invest the money in financial instruments that grow at the rate of interest. Alternatively, if the net price rises slower than the interest rate, it is beneficial to increase extraction rather than investing in financial instruments.

In symbols the Hotelling rule is $p_t = p_0 e^{rt}$ where p_t is the net price in the current period, p_0 is the price in the previous period and r is the interest rate (Hotelling, 1931: 141; Devarajan and Fisher, 1981: 66). The discount rate is used to measure the present value of future consumption (Harris, 2002: 73). The logic that Hotelling used was that as a non-renewable resource is depleted less will be available for future consumption. This creates a scarcity rent resulting in an increase in the price of the resource. An increase in the price results in decreased demand for the resource and leaves more of the resource for future consumption. For the case of competitive markets this results in an efficient allocation over time. The mining company should therefore be indifferent between

extracting the resource and leaving the resource in the ground at every point in time. The production of the resource will equal the demand at the current price, the market will clear and extraction will be at the socially optimal rate (Solow, 1974: 3). The optimal depletion of non-renewable resources is based on the principle that the resources and capital are equivalent assets. A recent extension of Hotelling is the case in which the marginal extraction costs tend to rise as the resource is depleted.

The simple version of Hotelling makes a number of assumptions. The marginal benefits of extracting the resource must be equal to the marginal costs of extracting the resource. The resource stock should be viewed as an asset and its returns should be compared to that of other assets. The return to assets is measured using the interest rate. Both the fixed costs and the entry costs are assumed to be zero, marginal extraction rates are constant, all deposits are of the same quality, there is a special component to the extraction of the resource, the firms average costs are a function of variable costs and the firm will mine until the ore is completely depleted (Brazee and Cloutier, 2006: 831).

Changing any of these assumptions affects the natural extraction path of the mineral. Thus where the ore grade is non-homogenous in quality the higher grade ores should be extracted before the lower grade ores. When taxes are included into the model there is no equilibrium in the market, as mining companies are no longer indifferent about production periods. Some types of taxes, particularly revenue taxes and severance taxes, which result in a change in production costs, result in a deferral of production into the

future so that the tax burden can also be shifted into the future. This results in an extension in the life of the mine and the resource. The higher the discount rate the faster the resource will be extracted, as the owner will receive a higher profit by extracting today rather than waiting for future higher prices (Harris, 2002: 73).

Social and private rates of interest are equal in a Hotelling model with no taxation. But when distortions, such as a tax, occur in the economy a wedge is driven between the two interest rates. Most cases in reality result in different social and private rates of interest. If the social discount is below the private discount, which is generally the case, the resource will be used up quicker than is socially optimal. Optimality implies that the resource should be depleted at the rate that maximises the net present value of benefits from the resource (Fischer, 1981: 20-22). Sustainability of the resource requires that the present generation meet its needs without compromising the needs of future generations. When social and private discount rates differ or if extraction creates an externality, unregulated extraction may not be optimal. Extraction may be too fast if there are common-pool problems in exploration or extraction. Extraction may be too slow if the industry is characterized by a monopoly. Monopolists produce less, so as to ensure that prices are higher which will result in higher profits (Slade, 1984: 133). When the private rate is greater than the social rate the rents and prices will increase resulting in increased production and too rapid a rate of exploitation of the resource (Solow, 1974: 8). There is no reason why future generations should be valued differently to the current or past generations, as we have a social obligation to conserve resources for future generations.

The choice of the social discount rate is therefore about the choice of intergenerational distribution (Solow, 1974: 9-10).

A natural resource is exhaustible if it is not reproducible and limited in quantity; the size of the available stock cannot increase over time and the resource is therefore subject to ultimate exhaustion with any positive rate of use (Solow, 1974: 2). This limitation is one of the reasons for government intervention and is also the real problem with Hotelling. The Rule is not likely to hold for extremely abundant minerals unlikely to be depleted completely over time, such as iron ore and bauxite. There is an opportunity cost (the non-extractive economic cost of current depletion) involved in the production of an exhaustible resource, as extracting one unit of the resource today will result in it being unavailable for extraction tomorrow, depriving future generations of use of that resource (Fischer, 1981: 13). This includes the forgone future use of the non-renewable resource. The decision on how much to extract should take this opportunity cost into account. The price of the resource becomes the marginal production cost plus the opportunity cost rather than merely the marginal production cost (i.e.: $P = C_q + \lambda$, where P is the extracted resource price, C_q is the marginal extraction cost and λ is the opportunity cost) (Simpson *et al*, 2005: 59). This implies that less of the resource should be extracted than if the resource were a renewable resource, as a renewable resource is able to replenish itself. For abundant metals there is no opportunity cost involved in extraction and mines will extract where marginal revenues are equal to marginal costs.

There have been numerous critiques of Hotelling's theory. Hotelling refers to an abstract theoretical state and many of the assumptions used do not extend to reality. The assumption that the firm produces up to the point where the resource is completely exhausted has been viewed as unnecessarily restrictive. Extraction does not necessarily occur until the resource is completely exhausted; it is possible for terminal output to be positive (Levhari and Liviatan, 1977: 178). This occurs when the demand for the resource is stationary but costs are an increasing function of ore already mined. Mining companies will discontinue mining if costs become too high. This could occur while there are still reserves in the ground. In this case there would be some changes in the results. The total and marginal profits would no longer be positive but would both be zero at the terminal point. The marginal cost also no longer includes the extra term that accounts for the alternative cost of producing an extra unit.

The assumption that the extraction cost of any small amount of the resource is independent from the general path of extraction is problematic (Cremer, 1979). This assumption fails for two reasons. Firstly, for "a single deposit it is a well known fact that a faster recovery rate may reduce the total quantity which can be extracted" (Cremer, 1979: 317) and secondly, "the exploration of a deposit necessitates the use of rented equipment. When the rate of exploration increases permanent equipment will be in short supply and its rental rate will go up" (Cremer, 1979: 317).

Earlier work on the same issue was written by L.C Gray (1914). Optimal extraction paths were determined from the perspective of an individual mine owner rather than from the industry as a whole (Figueroa B, 1999: 98). Several simplifying assumptions were made. “Firstly, he assumed that the market price of a unit of the mineral remained constant (in real terms) over the life of the mine” (Hartwick and Olewiler, 1998: 269). Secondly, the exact amount of reserves in the mine was assumed known by the producer and all the ore in the mine was assumed to be of uniform quality. Thirdly, it was assumed that the extraction costs were an increasing function of the quantity of the mineral extracted in each period. Gray’s paper dealt with the heterogeneity of deposits and the spatial dimensions of these deposits. It suggests that mining companies will be subject to costs carried between periods. It is focused on quantity or output and incorporates the fact that a firm can possibly change its rate of production. This would result in a difference between anticipated price and marginal cost. As a result, assuming that the cost curve is U-shaped, the marginal cost would rise at the rate of interest (Brazee and Cloutier, 2006: 829).

3.2 The Model

3.2.1 The model of optimal depletion

A critical question that needs to be answered is “how much of the resource should be extracted today and how much should be left in the ground for tomorrow?” or in other words “how fast should we be consuming our resources?” The answer to how much

should be mined in each period is best found with the use of a dynamic optimization problem.

Several simplifying assumptions have been used for the model in this paper. It is assumed that there are n identical firms that all produce gold; that there is no exploration for gold to ensure that the gold reserves are constant over time; and the gold reserves are known by the agents in the model. Prices are assumed to be exogenous and firms have perfect information about prices in all periods. The tax policy is assumed to have no effect on prices, as the resource is sold globally but taxes are levied locally. A tax that is levied locally should not affect the price at which the firm can sell its output (Slade, 1986: 282).⁹ It is also assumed that the costs are borne entirely by the mining company and that costs are negatively related to the stock of the resource. That is, the lower the remaining stocks of the resource the higher the cost of extracting. The input costs are assumed to be constant over time and the demand functions are assumed to be linear. The firm has a finite planning horizon of length T and the firm has production possibilities that are described by a single-period technology set such as $N = \{Q, X, S_0, S_1\}$ where Q is the vector of outputs, X is the vector of variable inputs, S_0 is the beginning of the period stock and S_1 is the end of period stock (Slade, 1984: 134). It is also assumed that there are no agreements between the government and the mining company that the mining company will rehabilitate the mined area. If this assumption is not made the company would have

⁹ This would hold in the case of a mineral such as gold, as only small quantities are actually mined. There is already a large amount of gold in reserves. However, this assumption is not likely to hold in the case of a mineral such as platinum. Large amounts of this mineral are mined in South Africa (monopolistic market). South Africa has 90% of the worlds platinum group metal reserves. The firm is not a pure price taker and therefore a tax that affects the quantity that is extracted will affect the price of the resource.

to set aside a certain amount of income each year (decreased from company profits in the model) in order to rehabilitate the area once it has been mined.

It is important to note that these assumptions are unrealistic. In reality, mines are required to rehabilitate the mined areas. A provision for this expense should therefore be taken into account over the life of the mine. Costs are also generally rising over time and not fixed as is assumed. The lower the grade of mineral mined and the deeper the mines become the higher the costs. Mining companies do also invest in the exploration for new minerals, as it is generally financially beneficial for them to do so. However, with the current uncertainty in the mining legislation this may be a valid assumption to make as mines have decreased exploration as a result of the uncertainty.

There are two agents in the model, the mining company and the government of the country abundant in natural resources, the social planner (South Africa in this case study).

3.2.2 The social planner

When mining of gold takes place the total surplus that accrues to the country is the total tax revenue (θpy) where θ is the tax rate, p is the exogenous price of gold and y is the quantity of gold mined.

The social planner or the government chooses a time path that will maximise the total stream of tax revenue receivable from the mining company over time

$$\text{Max}_{\theta, y} \int_0^T (\theta py) e^{-rt} dt \quad (1)$$

$$\text{Subject to } \dot{x} = y \quad (2)$$

The equation of motion (equation 2) states that the change in the stock of gold over time is equal to the rate of extraction of the resources and therefore the rate of depletion of gold. This is the case because of the assumption of no exploration. The rate of depletion is therefore the flow without backstop¹⁰.

There are the following constraints:

$$x_0 = \bar{x}_0 \text{ initial stock} \quad (3)$$

$$\text{and } x_T = \bar{x}_T \text{ terminal stock} \quad (4)$$

$$\int_0^T ((1-\theta)(py - c(y))) e^{-rt} dt \geq 0 \quad \text{for the profits tax} \quad (5)$$

$$\text{And } \int_0^T ((1-\theta)py - c(y)) e^{-rt} dt \geq 0 \quad \text{for the revenue tax} \quad (6)$$

$$x \geq 0, y \geq 0 \quad (7)$$

Equation (5) and (6) state that the discounted net revenue must be non-negative over the mining period. This constraint must hold because if the mining firm does not make a

¹⁰ Nordhaus explained a backstop as a substitute that will emerge at a future date for a non-renewable resource (Hartwick and Olewiler, 1998: 49).

profit it will not be able to pay taxes to the government. The capital for mining generally comes as foreign direct investment (FDI). The direct cost of mining has no opportunity cost to the country. It is therefore not included in the objective function. The choice variable is the tax rate (θ) and the flow variable is y .

3.2.3 The Mining Company

The mining company wishes to maximise its net present value of profits and therefore chooses its extraction path accordingly.

Before taxation the firm's profit function is

$$\text{Max}_{\{y\}} \int_0^T (py - c(y))e^{-rt} dt \quad (8)$$

where p is the exogenous world price of gold, y is the quantity of gold extracted by the firm within a particular year, $c(y)$ is the cost of production of the harvest of gold (costs depend only on the harvest of gold), r is the discount rate, 0 is the initial time period and T is the terminal time period.

The mining firm is constrained by the same equation of motion as the mining company (equation (2)) and the same constraints (equation (3), (4) and (7)).

When a royalty tax is included in the model the profit function becomes

$$\text{Max}_{\{Y\}} \int_0^T ((1 - \theta)(pY - c(Y)))e^{-rt} dt \quad (9)$$

And when the tax is based on revenues the profit function becomes

$$\text{max}_{\{Y\}} \int_0^T ((1 - \theta)pY - c(Y))e^{-rt} dt \quad (10)$$

Where θ is the royalty tax rate and the other variables remain the same, as does the equation of motion and the other constraints. The tax decreases the revenue that the firm receives, as some of the revenue must be used to pay the tax. The firm only receives a fraction of the profit that it would have received in the absence of the tax.

The formal analysis of the mine behaviour is carried out in Appendix A, as the results are well known.

3.2.4 Comparison of the optimal inter-temporal extraction policies

The planning horizon of the mining firm is finite with finite time equal to T ($0 < T < \infty$). However, the terminal time is free, as infinity could be any length of time. Therefore, the transversality condition is $H^c(T) = 0$. That is, the current value Hamiltonian must equal zero at the terminal time, indicating that at the final period (the end of the

planning horizon) the mine closes down and extraction ceases to exist (Akpulu and Parks, 2005: 15).

The optimal inter-temporal extraction policy in the presence of a profits tax is

$$(1 - \theta)(p - c'(y)) = \lambda(T)e^{r(T-t)} \quad \text{for all } t \leq T \quad (11)$$

And in the presence of a revenue tax the optimal inter-temporal extraction policy is

$$(1 - \theta)p - c'(y) = \lambda(T)e^{r(T-t)} \quad \text{for all } t \leq T \quad (12)$$

Whereas, in the absence of a tax it is

$$p - c'(y) = \lambda(T)e^{r(T-t)} \quad \text{for all } t \leq T \quad (13)$$

The comparison of equation (11) and (12) with equation (13) show that the quantity of gold extracted will be lower in the presence of a royalty. This shows the distortionary effect that the tax has on the extraction path of the resource. A tax based on revenue will ensure that the government earns more in taxes than from a royalty based on profits.

This shows an important result. Any positive tax rate value will be distortionary because the inter-temporal efficiency conditions of the social planner and of the firm do not equate. A tax is therefore “not a desirable economic policy instrument for raising revenue without decreasing the optimal path levels of extraction for all $t \leq T$: a condition that is well established in the literature” (Akpulu and Parks, 2005: 16).

4. Taxation

The next questions that need to be addressed are which type of tax system should be used, the optimal level that the tax should be set at and the implications of each tax type. The tax system chosen should promote the optimal utilization of non-renewable resources. The objective that the government wishes to achieve by instituting the tax (revenue maximisation or preservation of the mines) should be decided and the appropriate tax type should be instituted with minimal informational asymmetries. Each different type of tax influences decisions on extraction rates, revenue that government receives and investment into the mining industry in different ways. The discussion of which tax is the best one to implement is an ongoing one.

4.1 Reasons for Taxation

There are a number of reasons why governments tax mining companies. Firstly, the government wishes to obtain a share of the economic rent that the companies earn. This revenue is then used for the social and economic development of the country. Secondly, certain taxes induce companies to slow production thereby conserving¹¹ the resource and preventing overexploitation. This results in the lengthening of the life of the mines. A potential short term payoff will be lower revenues received by government as a result of decreased production, but the government will be able to collect the taxes over a longer period of time. This also ensures employment in the mining sector for longer periods of time (Otto, 2000: 16).

¹¹ Where conservation is defined as preservation, restoration, use and management of the resource for the benefit of long-term society

There are three crucial aspects that need to be taken into account in the formulation of a taxation system (Conrad and Hool, 1984; O'Faircheallaigh, 1986). Developing countries generally face a dilemma in the decision of formulating a tax, as objectives may be conflicting making it difficult to obtain all three objectives simultaneously. On the one hand the tax revenues are needed to finance development initiatives but on the other hand investment into the mining industries is heavily depended on. These may be conflicting as investment may be adversely affected by the imposition of a tax rate that is too high. And government would receive lower tax revenues. Firstly, a taxation system should be designed so as to attract investment to fund exploration, the modernization of mines, and the development of new ones. Secondly, the system should "not discourage exploration of low-grade ores in existing mines or the development of new marginal mines" (O'Faircheallaigh, 1986:63). And thirdly, the system should provide a stable flow of revenue for the government and should allow the government to accrue a share of the windfall profits that would accrue to mining companies as a result of changes in the economic environment.

The characteristics that impact tax policy design are the "potential for huge rents, volatility of commodity prices-structural change surprises, enclave status of mines, potential for over-investment into supporting infrastructure, politically motivated downstream beneficiation of minerals domestically extracted versus creating functional markets, ad hoc changes to fiscal regime if windfall profits arise, creating power base for elite thereby encouraging corruption, what preventative measures exist in expectation of

deposit depletion, lack of transparency and accountability regarding tax proceeds, tendency to prescribe price controls for domestically produced mineral resources, trend to introduce state enterprises versus leaving it to the market and environmental degradation” (Grote, 2007: 1).

4.2 Key Aspects of a Tax

There are three key aspects regarding a tax. These are equity, efficiency and administrative simplicity. Although, no matter how careful the government is with imposing taxes, distortions are likely to occur. These distortions should be kept to a minimum. Governments may fail in achieving optimal outcomes, as there is incentive to increase the budget by trying to receive as much money as possible, by rent-seeking or by interest groups affecting political decisions (Mangondo, 2006: 41). Equity and efficiency are generally conflicting objectives and work in opposite directions.

4.2.1 Equity

Equity is defined as follows: “the subjects of every state ought to contribute towards the support of government, as nearly as possible, in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state” (Mangondo, 2006: 29). All mining companies should be taxed equally under this objective. The gold mining taxation formula used is against the equity principle, as each tax is charged taxes at a different rate. The royalty system with a dual taxation also does not meet this objective as refined and unrefined minerals are taxed differently.

4.2.2 Efficiency

Dynamic Efficiency is defined as follows: “an allocation of resources across n time periods is dynamically efficient if it maximizes the present value of net benefits that could be received from all the possible ways of allocating these resources over n periods” (Asher, 1999: 33). Efficiency occurs when society’s benefit from the last marginal resource unit exploited is equal to the social cost of extracting that unit. It is important to employ a tax system that is efficient, as an efficient system maximizes the value of rent that the company will receive and hence the revenue that the government will earn.

There are five conditions that efficiency is based on. Firstly, “the free market will set input and output prices such that private and societal interests will converge, under conditions of perfect information, competition and secure property rights” (Asher, 1999:37). Secondly, “the government must take actions to ensure competition, good information, and secure property rights, as long as these actions are not more societally costly than the additional net benefits they provide”(Asher, 1999: 37). Thirdly, “the government must take actions to make private resource exploiters bear the indirect costs to society and reward private resource exploiters for providing benefits to society” (Asher, 1999: 37). Fourthly, “government must ensure that state resource exploiters are kept accountable for the quality of their resource management and the damages they cause” (Asher, 1999: 38) and lastly, “government must ensure that directives to state resource exploiters call for appropriate rates and methods of resource exploitation” (Asher, 1999: 38).

An efficient tax system should provide as little distortion in the economy as possible and should not disturb economic behaviour, i.e. it should be neutral. However, in reality this is rarely ever the case. The taxation system should be administered efficiently. An administratively inefficient system would result in poor collection of taxes, result in uncertainty and could result in a drop in investor confidence.

4.2.3 Administrative Simplicity

The administrative costs of a tax system should be kept to a minimum, should be simple and the taxes should also be flexible and adjust to the business cycle. A poorly administered system results in investor uncertainty (Mangondo, 2006: 35). “The most stable, equitable and flexible system in the world has no value if the government cannot collect the tax revenue which is due” (Andrews-Speed and Rogers, 2000: 224). An important administrative requirement is the formulation of clear definitions from the tax base. The collection of taxes by government is a big job for the government. In order to ensure that the actual tax rate collected is the same as the expected tax earnings there needs to be an effective administrative system in place which ensures that there is no fraudulent bookkeeping, under-reporting of mine output and income or bribery of state officials (Andrews-Speed and Rogers, 2000: 225).

Governments and investors have differing views regarding resource taxation. Investors prefer taxes that minimise risk and taxes that are easily administered so as to ensure easy

collection. The taxes should allow recovery of initial capital costs over the shortest possible time period and should allow maximisation of long-run post-tax returns. The mining companies would like the government to ensure that the taxation system is stable and does not introduce windfall profit taxes when the prices of resources increase. The governments, on the other hand, prefer taxes that secure a substantial share of the resource rent with minimal tax-induced inefficiencies by the most simple tax administration process (Grote, 2007).

4.3 Types of Taxes

Many different types of taxes have been implemented by governments; some include royalties (profit or revenue based), severance taxes, lump-sum taxes, excess profit taxes and export taxes. This paper will, however, primarily discuss the two types of royalty taxes. It will also touch on other relevant, more general policy/legislation issues such as ring-fencing, the 'use-it-or-lose-it' principle and property rights of the mineral in Section 5 of the paper.

4.3.1 Profit-based Royalty

A profit-based royalty is a flat rate charged on mining profits. It does not change the extraction decision of the mining firm. It changes "the present value of the resource extracted but there can be no change in the rate of extraction over time that can offset that decline in the present value" (Perman *et al*, 2003: 525). Extraction rates will therefore remain unaltered but the government will gain some of the revenue from the

mining companies' activities. The effect of this tax follows from the Hotelling rule of efficient resource depletion. The mining company should be indifferent between post tax profits in any two periods. This is the only tax that the static theory (Garnaut and Ross, 1983) and the Hotelling-based dynamic theory (Burness, 1976) agree upon; where both schools of thought favour this type of tax (Dore, 1990: 462).

Mathematically,

$$(p_t - c(y))(1 - \theta) = \frac{(p_{t+1} - c(y))(1 - \theta)}{1 + r}$$

where t is the current period and $t+1$ is the next period, $(1-\theta)$ is the royalty rate percentage, p is the price of the resource, $c(y)$ is the cost of extracting the resource and r is the interest rate (discount rate).

The tax rate is the same in the two periods and can be cancelled from both sides of the equation, leaving:

$$(p_t - c(y)) = \frac{(p_{t+1} - c(y))}{1 + r}$$

This shows that post-tax profits cannot be increased by shifting production of the resource into the next period, resulting in no change in the extraction path. This type of tax results in lower investment into the mining industry and reduces exploration, as the expected payoff from investing or finding new deposits is reduced with the imposition of

the tax. This is potentially problematic, especially in South Africa, where the country's economy (employment, foreign exchange, investment) is so reliant on mining. Also from Hotelling's rule, the post-tax royalty must increase at the discount rate if the resource is to be exploited efficiently (i.e. $(1-\theta)p_t = (1-\theta)p_{t+1}e^{-r}$ \Rightarrow canceling $(1-\theta)$ from both sides gives the same Hotelling rule as without the tax, $p_t = p_{t+1}e^{-r}$) (Perman *et al*, 2003: 525).

Despite the theoretical features of the tax there have been suggestions that royalty taxes result in inefficient production. With collection of taxes from the mining companies many informational constraints arise. The problem that government faces is that the multinational companies possess private knowledge about the reserves in the mine and existing operating costs. These may be overstated or misrepresented using any number of accounting methods (Osmundsen, 1998: 934). Companies have an incentive to exaggerate costs. A system to avoid this will need to be put into place adding to the tax implementation costs of government. Accounting rules that calculate allowable costs and more monitoring and enforcement are needed (Figueroa B, 1999: 176). There is also a high collection risk for the government, as there is incentive for mining companies to misrepresent profits. The Treasury has disregarded this as a concern as most of South Africa's mines are listed on various stock exchanges requiring transparent reporting (Seccombe, 2007). Another negative aspect is that there may be faster extraction than is optimal as the tax does not result in reduced extraction. This type of tax may result in the government foregoing revenue or earning little revenue if mines are running at a loss.

A positive of this type of tax is that costs are taken into account resulting in risks being shared symmetrically between government and firms. If costs are not taken into account, the company may not make a profit after taxes have been deducted and may have to close. This would not be beneficial to a country such as South Africa, as there would be a major loss in jobs and foreign investment. Another positive aspect is that government and mining companies share in the risk of a downturn in the commodity cycle symmetrically therefore having minimal impact on investment into the industry.

4.3.2 Revenue-based Royalty

A royalty tax based on revenues (or an ad valorem royalty) is a payment charged on revenues. The government receives a fixed share of the sales revenue made by the mining company.

The mining company should be indifferent between post-tax profits in any two periods.

Mathematically:

$$(1-\theta)p_t - c(Y) = \frac{(1-\theta)p_{t-1} - c(Y)}{1+r}$$

$(1-\theta)$ cannot be cancelled from both sides.

The Hotelling rule becomes:

$$(1-\theta)p_t - c(Y) = [(1-\theta)p_0 - c(Y)]e^{rt} \Rightarrow p_t - \frac{c(Y)}{1-\theta} = \left[p_0 - \frac{c(Y)}{1-\theta} \right] e^{rt}$$

$$\text{with } \frac{c(y)}{1-\theta} > c \text{ as } 0 < \theta < 1$$

This shows that the imposition of a revenue tax is equivalent to an increase in extraction costs and therefore has a distortionary property. It increases costs by a fixed amount, and results in decreased resource extraction and therefore decreased revenue to the firm. The marginal revenue function has been shifted downward, thereby lengthening the life of the mine leaving more ore for use by future generations. By postponing extraction the tax bill is also postponed. This will allow the government to collect taxes for a longer period of time. More (less) ore is extracted in earlier time periods, which is offset by lower (higher) extraction rates in later periods (Slade, 1984:139). This is known as time-tilting. It also results in reduced investment into the industry. It can be interpreted as a decline in price or demand for the non-renewable resource.

The tax also results in higher grade ore being extracted (as it is less costly to extract). Lower grades will not be extracted if the tax results in a value of extraction less than the cost of extraction. The cut-off grade of the mineral mined has therefore been raised by the introduction of the tax, as it is no longer financially beneficial for them to extract the lower grade ore (Nellor, 1987: 369). The tax determines the lowest grade ore that will be mined. This is known as 'high-grading' (Dore, 1990: 460-462). This describes the South African gold tax. If there is an increase in the price of gold, a mine can keep its marginal tax down by mining a lower grade of ore. This lengthens the life of the mine but to the expense of the taxpayers. Governments will have to increase taxation in other sectors of

the economy in the case of a reduction in taxation revenue from the mining sector. Royalties based on revenues are thought to weaken the ability of mines to mine economically.

A negative aspect of a revenue tax is that after-tax profits may be negative, as the costs of production are not taken into account. Another downside is that it increases the cut-off grade of the ore resulting in ore not being mined, as it will be too expensive to mine it, shortening the life of the ore. It encourages the mining of high-grade minerals, which results in a requirement for command and control measures to deal with this problem and enforce the mining of average grade ores (Grote, 2007). This tax has been regarded as not being socially optimal, as extraction costs are not deductible, resulting in a disincentive for extraction. This creates a social loss, as too much of the ore is left in the ground (Osmundsen, 1998: 942). If the tax rate is set too high investor confidence may be eroded as the profits that the companies will earn will decrease (Grote, 2007).

A positive aspect of this type of tax is that there is no incentive for the company to overstate costs or to incur unnecessary costs in order to lower the amount of taxable profit. A royalty based on gross revenue is relatively simple and easy and inexpensive to administer. The only information required is the revenues that firms earn or the production levels and the price of gold. Royalties based on gross revenues are more attractive to governments as there is less risk for the government, as a share of the revenues is received before any surplus is determined. With this tax there is a smaller

risk to government regarding tax collection, the tax adjusts itself automatically with changes in the commodity price, payment is non-negotiable resulting in the government always earning money from mining activities, and administration is straight forward and predictable (Grote, 2007). This type of tax ensures that the government receives a share of earnings faster and is a more stable system (Figueroa B, 1999: 177) and is consistent with international best practice (Press Statement notes, 2003: 2). See Table 2.

5. Analysis

This section discusses the concerns regarding the imposition of the MPRDA. It will discuss statements made by industry, government's responses to them and what has been done to rectify these concerns; the general effects that the imposition of royalties have, the effect that ring-fencing and the 'use-it or lose-it' clause has on government revenues, investment and the length of mineral life. In addition the effects of the change in property rights and whether internal inconsistencies in the mining legislation exist will also be assessed.

5.1 First Draft

The concerns regarding the first draft are many. The rates are seen as too high. This is likely to have some negative effects, such as premature closure of mines, retrenchment of workers, reduction in export earnings and therefore foreign exchange earnings, a reduction in investment and exploration, the international competitiveness of the mining sector and a reduction in the underlying value of gold mining. Another major concern is

that the royalties are based on revenues rather than on profits. The suggestion is that the base of the royalties be changed. This was not welcomed by government (Davis, 2005: 33).

With the imposition of a royalty there is likely to be premature closure of mines, as the introduction of a royalty system contributes significantly to mining costs. With a gold royalty of 3% the estimated increase in costs is 3.7%. This would negatively affect the productivity of the mining companies. 427 tonnes were mined in 2000 whereas approximately 300 tonnes were mined in 2005. The last time that production was this low was in 1925 (Davis, 2005: 36). This is problematic for a country such as South Africa, as the mining sector provides many direct benefits and has major induced and multiplier effects, discussed in Section 1 of the paper.

The increase in costs would result in a significant shortening of the mine's life, as the reserve base would decrease from 16 250 to 15 650 tonnes, as lower grade minerals would not be mined because it would be too costly to do so. There would be an increase in grade of ore from 4 to 4.2%¹². The 'high-grading' of minerals that arises due to the royalty will sterilise large amounts of the mineral, as lower grade ore is left in the ground and not mined. And the introduction of royalty payments will result in a decrease in the value of production. 46 284 kg of gold would not have been mined between 1996 and

¹² The percentage refers to the percentage of gold in the soil.

2005 because the mining of this ore would not have been economic. This amounts to a loss of between 1 and 2% of total reserves (Cawood, 2006: 11, 15).

With a 3% royalty on gold there will be a reduction of R1.6 billion in production over the next 40 years, whilst it will only result in a revenue for government of R1 billion (Cawood, 2006: 9). With respect to the underlying value of gold mining, it has been calculated that R33 billion worth of revenue could be lost over the economic life of South Africa's mines as a result of the imposition of the royalty tax (McKay, 2004). With the imposition of a 3% royalty it is possible that the underlying value of gold mining could decrease by up to 6% (Davis, 2005: 33).

The introduction of royalties will result in the retrenchment of a large number of workers, as a result of decreased production and closure of mines from the increase in costs imposed by the royalty. A study by Cawood (2006) found that if the MPRDA had been introduced in 1986, 30 700 miners would have been retrenched over a 10 year period. This effect may seem small but it accounts for retrenchment of 6.5% per annum of the total miners employed in the mining sector. Labour Unions are extremely concerned with this effect. This stresses the argument that a royalty based on revenue is not the best decision for a country, such as South Africa, attempting to decrease unemployment and fight poverty.

Export earnings would also be affected by the imposition of the royalty. The average price per kilogram of gold over the 10 year period from 1986 to 1996 was R72 280. This would result in a cost to South Africa of R3.3 billion in export earnings whilst only R3.2 billion would have been earned in royalties resulting in a loss amounting to R100 million. The loss in revenue earned and the resulting unemployment would be greater than the benefits from the government revenue.

The change in the taxation is likely to alienate international investors, as South Africa may become less business-friendly in the future, resulting in reduced investment into the country (Williams, 2006). The aim of government is to ensure that it remains significantly capitalistic in order to attract foreign investment, whilst ensuring that past inequalities are dealt with at home (Wachman, 2005). The government has, however, argued that the introduction of the MPRDA is likely to protect investors, as it creates more opportunities on a more level playing field. A Report completed by the Fraser Institute in 2004/5 asked mining explorative investors to state whether it was believed that the current regulatory regime for mining in African countries encouraged investment. The general consensus regarding South Africa was that the regime was not conducive to attracting new foreign investment. It ranked 58th out of the 64 surveyed countries. And only 8% of investors reported that investment was encouraged by the South African mining taxation regime. This figure falls significantly short when compared to other African countries. It was 24% for Ghana and 23% for Tanzania (Leon, 2006).

The poor implementation and management of the legislation has resulted in investors investing elsewhere in Africa. Fixed investment in real terms into the mining industry declined by 32.7% between 2004 and 2006 (OECD/AfDB, 2007: 488). However, there has been a large increase in investment into the mining industry from BEE companies. In order to increase investor confidence “South Africa will need to address investor perceptions of open ended discretion regarding BEE-compliance; uncertainty concerning the MPRDA’s implementation; and moves towards an apparently punitive royalty regime” (Leon, 2006).

The uncertainty and unpredictability of the introduction of the MPRDA has resulted in a reduction in exploration for minerals. This has occurred as the mining houses are unsure of the future of mining in South Africa and do not want to spend money on exploration if minerals may not be able to be mined in the future. The costs spent on exploration may be unnecessary if the company finding the ore is not able to mine the ore found.

The competitiveness of the mining sector (both national and international) could be negatively affected, as investment into the mining sector could be discouraged. The increased cost of extracting the resource results in a reduction in international competitiveness, as companies may relocate to countries with more favourable taxation systems or choose to invest in new mines in other countries rather than in South Africa. This could have detrimental effects to the economy, such as a reduction in the number of mining jobs, reduced revenue from taxes on mining activities, and reduced foreign money

flowing into South Africa. Royalties are generally opposed by industry. The reason is that the royalties may cause mining companies in South Africa to diversify its geographical exposure if the imposition of the royalties renders the industry unprofitable (Competition Commission: 2003: 4).

A positive aspect of the royalties would be that the world supply of gold would be reduced. This is likely to increase the price of gold, thereby restoring the profitability of the mines. However, the actual beneficiaries of the reduction in supply from South Africa would be the developed world's central banks. These banks have a large supply of gold reserves that was built up in the years when gold was a monetary asset and an opportunity to sell these reserves would arise.

Some suggestions regarding changes to this draft are the need to address the issue of marginal mines and double royalties, to introduce ring-fencing provisions and to impose royalties on profits rather than on revenues.

5.2 Second Draft

The reduction in the rates, introduction of the dual system and the provision for marginal mines was welcomed. AngloGold Ashanti was "pleased to note that the proposed royalty on gold is likely to have a less severe impact on the industry than was the case with the previous draft" (Rose, 2006). The reduction in rates will positively affect the economy by increasing mining companies' profits and providing a better incentive for investment

when compared to the rates of the first draft. The IMF has, however, pointed out that by reducing the tax rate the immediate result would be government forgoing revenue. The government should therefore only reduce tax rates if the investment benefits induced by the tax cut outweigh the cost of foregoing the revenue. If the benefits do not outweigh the costs from the reduction in taxes, the system will be inefficient (Curry, 1984: 38). However, the long-term effects that the investment into new mines (more mines to tax and creation of employment) would have are likely to offset this loss in revenue.

There are a number of concerns with the MPRDA revision. Firstly there is the concern that the imposition of such a taxation system will discourage new mining ventures, as the tax is payable on gross sales irrespective of profit margins. This will have a significant impact on costs to the mining company. Mining companies will have less money to use for exploration and opening up new mines, as the amount of tax paid will be higher. This reduction in profitability also negatively impacts the marginal mines, as it makes them uneconomical. Larger mines may stop production if it is uneconomical to mine whereas marginal mines do not have this luxury.

The general effects from the second draft on output, employment, and foreign exchange earnings will be similar to the effects from the first draft. However, with the reduction in the rates, the effects will be less severe. With lower royalty payments the costs of the companies will not increase to such a large extent as with royalty rates in the first draft. The royalty payments still have the same negative effects on the balance of payments,

with fewer payments being received from foreigners, and on the exchange rate, with potential exchange rate depreciation.

The Chamber of Mines believes that the MPRDA (both the first and second drafts) merely penalise mining companies rather than addressing the underlying manufacturing weaknesses in the economy. It is also suggested that the revenue generated by the taxation of mines be ring-fenced for developing communities around the mines and that there is the creation of sustainable industries in the event of mine closure. The concern is that the revenues earned from taxing the mines may end up supplementing current government expenditure rather than being spent on achieving sustainable development goals. Like the Competition Commission, the Chamber of Mines would like to see the taxes being levied on revenues rather than on profits. The reason given is that mines in South Africa are already at a competitive disadvantage internationally. This is due to the high railway and port tariffs and rising steel prices. There are many structural problems in gold mining in South Africa; costs have been rising at a rapid rate (largely due to increasing energy costs, the current loss in energy supply from Eskom which is costing the mining companies billions of dollars, the loss in productivity of workers, increased absenteeism and early death due to HIV/AIDS and increased investment in social development for mine-based communities) resulting in a less impressive increase in profits.

Investment and growth into the manufacturing sector should be promoted, due to the depletable nature of minerals. There should be a change from a commodity-based economy to a knowledge-based economy. This change is, however, not happening in South Africa. The manufacturing industry has also been declining (Cawood, 2005: 9). There should be incentives that promote the beneficiation of minerals. The MPRDA does provide these incentives. With allowance for beneficiation mining companies will add value to the mineral before it is exported, as it makes business sense for them to do so (Cawood, 2005: 11).

The mining companies are still concerned that the royalties are based on revenues rather than profits, but have welcomed the other changes.

5.3 Third draft

The changes made to the third draft of the MPRDA have been welcomed by the mining industry. The change to the formula that allows for the deduction of beneficiation costs will benefit the companies that beneficiate minerals. This partially deals with the concern of mining companies that royalties are based on revenues rather than on profits, even though taxes are still revenue-based, as it allows for the reduction of some costs before the calculation of taxes. This change will assist in dealing with the weaknesses in the manufacturing industry. The tax rate reduction and the imposition of lower tax rates for newly established mines have also been welcomed. The lower taxes for newly established mines means that the government will share some of the risk in the case of

downward falls in the commodity market. This will assist new mines in establishing themselves in the industry. The main problem with this draft is that it still does not deal with the issue of double royalties. Mines obliged to pay royalties to communities will also be required to pay taxes according to the new formula. The concern is that on top of paying the royalties to the government the mining companies will have to pay for the development of the areas around the mines. The mining companies argue that the revenue made by the government from the mining royalties should be used for this.

The third draft is closer in line with international standards, as there has been a trend over the last century to de-emphasise royalty taxes and make use of profit-based taxes that work on 'ability-to-pay'. A large number of countries have abandoned the use of royalties and many have reduced the importance of these royalties. There are, however, still a large number of countries making use of royalties. The benefit of royalties is their ability to raise revenues for the state. When royalties are based on revenues the state will always receive a nominal payment even if the mining companies are running at a loss (Otto, 2000: 6). When royalties are used it is important to set the rates at an internationally competitive rate so as to ensure that there is no decrease in investment to the mining industry. The rates in this draft are competitive internationally and do take some of the costs of extraction into account. This draft is therefore more along the lines of international standards than the first and second drafts.

An important contribution that the third draft makes is that by allowing the deduction of beneficiation costs before taxes are paid, the mining companies will have an incentive to add value to the raw mineral, resulting in a reduction in the tax paid.

The benefits to the economy of beneficiation will be immense and may outweigh the effects of the loss in revenue to government (Cawood, 2005). The manufacturing sector will be developed as a result. This will create jobs and ensure that the economy is sustainable in the future. Mining has decreased in importance in recent years and has continued to decrease, thereby making it important to develop other sectors of the economy. Gold is a non-renewable resource that will run out in the future. The development of other sectors in the economy will result in the country being buffered against the effects that this would have.

5.4 Ring-Fencing

South Africa is one of the few mining countries that makes use of ring-fencing. It requires that the various taxable projects of a company are separated for tax payments and that each mine is treated as an isolated unit. In the case of large mining houses, each mine within the house is deemed a taxable project and must pay taxes separately. Costs and incomes may not be grouped together and one tax paid. More profitable mines also may not subsidise less profitable mines. This ensures that the government's tax base is not eroded by mining companies deferring tax payments. Therefore, a positive of ring-fencing is that it prevents the erosion of the tax base. The profits from an existing mine

are also not to be used to develop new mines, ensuring that the government receives a share of profits from all profitable companies. If ring-fencing is not imposed costs and incomes from all operations within the mining house, including non-mining ones, can be grouped. Taxes will then be calculated on this figure rather than calculating the taxes separately for each mine within the mining house. Although, even when ring-fencing is used, mining companies may write off all capital expenditure, such as shaft sinking and mining equipment, immediately against current or future profits¹³. However, this practice is restricted and there is a limit that can be offset against tax.

Cases where imposing ring-fencing makes sense is when a unique tax regime is applied to each mine, when a tax stabilisation policy is put into place or when a resource rent tax or excess profits tax is used. In the first instance allowing companies to combine costs and incomes would result in an administrative mess for government as there more than one tax regime is used. In the last case it would undermine the purpose of the tax, as the excess profit or rent from each operation should be attained by the government (Otto, 2000: 15). The use of ring-fencing has been cited as one of the reasons why the gold price is persistently low (Hughes, 2006: 6).

There are several types of ring-fencing used in the mining industry. These are a Mining Activity Ring-Fence, a Tax-Payer Ring-Fence, a Capital Expenditure “General” Ring-Fence and a Capital Expenditure per mine Ring-Fence. The Mining Activity ring-fence

¹³ Other companies are unable to do this. Their assets are depreciated over time.

ensures that income from mining and non-mining income (such as interest, rental and other trading activities) are taxed separately. Under the gold tax formula mining income was taxed according to the formula and non-mining income was taxed at the ordinary rate applicable to other companies.

The tax-payer ring-fence results in each tax payer being tax separately. The third type results in mines being unable to offset mining expenditure against non-mining income. The fourth type results in companies that run a number of mines being unable to offset costs of one mine against incomes of another mine within the company. A 25% breach of this ring-fence was allowed in 1990, where up to 25% of income from an existing mine could be used for a new mining development. This is only, however, allowed if both of the mines are the property of the same taxpayer (Leger and Nicol, 1992).

A disadvantage of ring-fencing is the introduction of inefficiency in long-run resource allocation, as if a ring-fence is used there may be capital-deepening¹⁴ within the ring-fence affecting other firms not part of the ring-fence. Ring-fencing reduces investment into new mining adventures, as the new mine cannot use income from other mines to assist with the payment of taxes from the new mine. This makes it more difficult to open new mines as they are more likely to run at a loss. Recommendations regarding ring-fencing are that it should be removed in the case of failing mines.

¹⁴ Increasing capital per worker and therefore productivity per worker

The mining companies support the removal of ring-fencing. The reason is that the industry has reached maturity and so ring-fences are no longer needed. However, government does not support this suggestion. The removal would result in the government receiving less revenue from taxation. However, with the removal of ring-fencing exploration is likely to increase and result in mine development. The mining houses argue that the effects of this will outweigh the costs of the foregone revenue to government (Hughes, 2006: 6). The removal of ring-fencing will mean that a mining company will be able to offset mining expenditure against non-mining income and offset costs from one mine against costs from another mine. This will result in an increase in the life of mines, as marginal mines would not be forced to close. The marginal mines would be able to pay the royalties without running at a loss. If there is no ring-fence a company running for example 10 mines would be able to run all 10. However, in the case of ring-fencing say 2 out of the 10 mines may not be profitable to mine and would have to close. With ring-fencing in place the life of the mine is decreased, as marginal mines may have to close prematurely and new mines will not be developed. This would be the case, as marginal mines within the mining house cannot offset their costs against more profitable mines and would therefore have to close.

5.5 The 'use-it or lose-it' Principle

Mineral rights are administered according to the 'use-it-or-lose-it' principle. This principle requires that if mineral rights are owned, the mineral must be mined. The owner of the rights cannot just leave the resource in the ground and mine it at a date in

the future. If the resources are not being mined, the rights will be revoked and will be sold to another party. There have been many applications received for mineral rights since the development of the MPRDA. This shows that the industry has responded positively to the introduction of this principle (Sonjica, 2006: 4). The principle has been welcomed as it will open up areas for mining that were previously 'locked-up' as they were not being mined, resulting in an increase in production. This will, however, reduce the lifespan of the ore, as production in the present period will increase.

5.6 Property Rights

The change in the MPRDA will transfer mineral rights to the state, also in line with international standards. The mining sector has been identified as an area that requires more participation by black South Africans. The MPRDA ensures that this increase will occur as the minerals are vested in the state and there is a greater access to HDSAs. South Africa and the USA have been the only two countries that make use of dual property rights in the mining sector; the mineral rights are owed by both the government and private shareholders. In South Africa, one-third is owned by government and two-thirds are owned by private shareholders. This system is not entirely accepted by the government. Its long term objective is to have all the mineral rights vested in the state to ensure that the benefits from mining the minerals can be used for the people of South Africa (Northern Cape Province-Mineral sector Strategy, 2005). This is the aim of the MPRDA.

The South African property rights were developed from Roman-Dutch law where property rights were privately owned. Mineral rights could be leased out to third parties for the financial gain of the private owners. The principles of private enterprise and the free market mechanism determined the development of the mining industry resulting in market distortions as black ownership was excluded. The change in ownership will take place over 5 years from 2004. The MPRDA will change this system to mineral rights that are state owned. The target is 15% ownership by HDSAs within 5 years. This will be increased gradually to a minimum of 26% by 2014. For new rights allocated, 51% ownership by HDSAs is required¹⁵ (Cawood, 2005: 3). BEE companies get preference of supplier status. By paying royalties to the government, the government owns the resources and receives revenue from extraction of the resources. With the introduction of royalties the ownership will be placed solely in the hands of the state. The mining companies will only be able to exploit the resources under license giving the government the decision of who mines where and what (Cauvin, 2002). The mineral rights will be given to the mining companies for a period of 30 years and another 30 year period once the rights are renewed. The new MPRDA has been welcomed by black business groups and unions. It is believed that it is likely to end the racist exploitation that began with Apartheid. The mining companies again have argued against this change, as it is believed that it will result in an undermining of property rights.

¹⁵ Unit Trust Schemes have been put into place to assist the HSDAs with funds.

The change in mineral rights now means that former owners of rights have mining rights extinguished and replaced with less valuable transitional rights by being required to pay royalties for what was previously owned (Booyesen *et al*, 2007). There is a divide regarding the effect that this change in ownership rights will have. This has been seen as the most controversial of all the aspects of the MPRDA. There is the concern that the change in ownership will only benefit politically connected individuals (Cawood, 2005: 3). But the government argues that it is not the intention of government to nationalise the mining industry, but is rather the desire for the transfer of ownership rights so that the mining industry benefits all South Africans equally. The transfer of rights is to be done in a transparent manner via the change in legislation and the Black Socio-Economic Employment Charter¹⁶. This has resulted in BEE ownership being “used in conjunction with FDI to attract high-risk exploration investment thorough joint-venture arrangements” (Cawood, 2005: 4). BEE initiatives have been effective in the services and construction sector. However, there has been underperformance in the mining sector due to structural bottlenecks and diminishing prospects (OECD/AfDB, 2007: 487). The only aspect of BEE initiatives that has seen any improvement in the mining sector is ownership. There has not been a significant improvement in the benefits flowing to miners and mining communities. This is an area that still needs to be addressed (Sonjica, 2006: 6).

¹⁶ The Black Socio-Economic Empowerment Charter was introduced to develop a mining industry that was globally competitive that ensures real benefits to all South Africans. The goal is to reflect an industry that will reflect a non-racial South Africa. It aims to encourage black empowerment and transformation with regards to ownership, management, skills development, employment equity, procurement and rural development by addressing past social inequalities (ESIPP, 2006: 7).

The introduction of the MPRDA and the subsequent changes to property rights has resulted in a large amount of investment into the mining industry by BEE enterprises. Three major new BEE companies that have entered the market and invested billions of rand are Mvelaphanda Resources, African Rainbow Minerals and Eyesizwe Coal. This increase in investment has impacted significantly on employment in the industry (Sonjica, 2006: 5).

5.7 Internal Inconsistencies

The three objectives of the change in the mining legislation are to extend the life of the mines, to provide equitable distribution of resources and enable profitable complementary economic activity (Sonjica, 2006: 9). There seems to be some internal inconsistencies in the legislation regarding these objectives.

The general consensus regarding the introduction of royalties based on revenues is that the life of the mine will be extended, as discussed above. However, in the mining legislation ring-fencing and the 'use-it-or-lose-it' principle are also suggested, which has resulted in a decrease in the life of the mines. This is inconsistent with the introduction of royalties to promote conservation of the resource. One part of the legislation is slowing mining down so that resources are conserved for use in the future, whilst other parts of the legislation are resulting in the minerals being mined faster. The effect of this is that the effects may cancel each other out and no difference is made to the lifespan of the mine.

With regard to the creation of revenue for the government, the royalties imposed will create more revenue for the government. The existence of ring-fencing ensures that the tax base of the government is not eroded. And the 'use-it or lose-it' clause ensures that mines are mined and thus generates taxable revenues. This would also result in more revenue for the government. With respect to revenue generation there is no inconsistency in the mining legislation.

The goal of equitable distribution is assisted by the imposition of the MPRDA. It changes property rights to vest in the state, resulting in the state having the say as to who receive the rights to mine. The provision for marginal mines allows those mines starting out a partial exemption from royalties. This will assist new BEE companies in establishing themselves into the industry. The 'use-it or lose-it' clause also results in new companies establishing themselves in the industry. Ring-fencing, however, decreases the ability for new mines to establish themselves in the industry, contradicting the use of 'use-it-or-lose-it'.

However, conservation of the resource is not the major short-term objective that the government in South Africa is trying to achieve. But rather it is the social inequalities that arose during Apartheid that need to be addressed. This is being achieved via the change in property rights proposed in the act and BEE initiatives. Another important aspect to address is the large number of people living below the poverty line. This will be addressed through development initiatives funded by taxation revenue and also

through the opportunities arising from the changes to the property rights. It is therefore important that government maximise its revenues and one way in which this can be achieved is through ring-fencing. A concern with this, however, is that the goal is short-term. The long-term goal should be to conserve resources so that the benefits from mining can be realised for as long a time period as possible.

6. Conclusion

This paper discussed the Mining Taxation Policy in South Africa, especially in relation to gold mining. It discusses the change in the policy from the use of a gold mining taxation formula, which has been in place since 1926. In 2002, the MPRDA was passed. It proposed the introduction of a royalty based on the gross sales of mining companies. The first draft of the MPRDA proposed royalties that were between 1% and 8% depending on mineral type. This was criticised by the mining companies and hence a second draft was released in 2006. This draft reduced royalty rates and introduced a dual taxation system for refined and unrefined minerals but was still based on mineral type. The proposed royalty for refined gold was 1.5% but the royalty for unrefined gold remained at 3%. This change was welcomed by the mining companies. However, the government still insisted that the royalties be paid on revenues and not profits. There were still some criticism regarding the second draft and so in 2007 a third and final draft was released. The third draft proposed the royalty be based on a formula that takes the profitability of the companies into account. This was welcomed by the mining companies, as this draft

partially allowed for the deduction of costs. The criticisms regarding each draft were discussed.

A number of inconsistencies arose with the imposition new mining legislation. Ring-fencing, the 'use-it or lose-it' clause and the imposition of royalties seem to result in conflicting results. There is an inconsistency regarding the conservation of resources, whereas the objectives are consistent for government revenue earnings. The MPRDAs main objective is to deal with past injustices that arose during Apartheid. The change to property rights that will come into effect with the imposition of the MPRDA will deal effectively with righting past wrongs and encouraging BEE investment.

There is no ideal universal tax system. The choice of the system should take the unique factors of the country into account. The basic tools of taxation are, however, becoming more similar for each nation with the introduction of a more global economy (Otto, 2000: 18). Companies can invest into any country in the world, so in order to ensure that investment into your country is more appealing, it is important to have a tax rate that is internationally competitive. The chosen tax regime should, however, be "responsive to low metal prices without the need for either ad hoc modifications or the creation of special funds" (Andrews-Speed and Rogers, 2000: 222). The stability of a tax lies in its flexibility and this flexibility can be achieved by directing taxes at profits. The risk of reduced profits is shared equally between the mining company and the government and there is an incentive for companies to look for ways to reduce costs, so that lower tax is

paid (Garnaut and Clunies-Ross, 1983). Taxation is universally disliked as it is believed that it does not contribute to the value of a business. However, there is still the consensus that it is necessary.

The change from the gold taxation formula, discussed in Section 2.2 of the paper, to a royalty based tax seems to be consistent with international taxation systems. Furthermore, the rates that have been set by government are competitive with royalty rates worldwide. McKay believes that “Warts and all, the Royalty Bill is good lawmaking. And since its first draft, other emerging markets have called for escalation of royalties to recompense for use of their national patrimony. Like South Africa, they perhaps recognize an opportunity to cash in on the strong commodity market” (McKay, 2006). The gold mining industry in South Africa is mature and has proven its flexibility, and as a result it is believed that it will adapt and change with the suggested changes (Davis, 2005: 38).

Tables

Table 1: Percentage of Tax Revenue from Mining

| Year | Net Revenue Collections R1000 | % of Revenue Collections from mining | % of Revenue Collection From Gold Mining |
|------|----------------------------------|---|---|
| 1985 | 24, 963 262 | 9.4 | 7.9 |
| 1986 | 31, 559 978 | 11.8 | 9.7 |
| 1987 | 36, 488 915 | 12.2 | 8.7 |
| 1988 | 40, 846 692 | 9.5 | 6.4 |
| 1989 | 52, 069 533 | 7 | 4.2 |
| 1990 | 69, 312 515 | 4.8 | 1.9 |
| 1991 | 72, 450 471 | 4.6 | 1.1 |
| 1992 | 78, 962 588 | 2.4 | 0.9 |
| 1993 | 84, 155 104 | 1.4 | 0.6 |
| 1994 | 98, 358 058 | 1.5 | 0.8 |
| 1995 | 113, 709 825 | 1.7 | 1.2 |
| 1996 | 127, 567 163 | 1.4 | 0.8 |
| 1997 | 122, 964 153 | 1.6 | 0.4 |

** Hughes, 2000: 7

Table 2: Cross-Country Analysis of Royalty Regimes for gold

| Country | Gross sales (value) | Profit-based | Net-smelter Return | Specific Royalty | Negotiated Contract | None |
|-----------|------------------------|-------------------------------------|-----------------------|---------------------|------------------------|------|
| Canada | | 20% Quebec 15% BC 18% Ontario | | | | |
| Greenland | | | | | X | |
| Sweden | | | | | | X |
| USA | Severance taxes | X Northern Territory | | X | | |

| | | | | | |
|---------------------|-------|--|---|--|---|
| Australia | 2.5% | | X | | |
| China | 4 | | | | |
| Mexico | 1.5% | | | | |
| Poland | 10% | | | | |
| Argentina | 0-3% | | X | | X |
| Bolivia | 1-7% | | | | |
| Brazil | X | | | | |
| Peru | 1-3% | | | | |
| Chile | 3% | | | | |
| Indonesia | 2% | | | | |
| Kazakhstan | | | | | X |
| Uzbekistan | 4% | | | | |
| Russia | 6% | | | | |
| Papua New Guinea | 2% | | X | | |
| Philippines | 23% | | | | |
| Angola | 2-5% | | | | |
| Botswana | | | X | | |
| Ghana | 3-12% | | | | |
| Ivory Coast | | | X | | |
| Lesotho | 5-10% | | | | |
| Malawi | 5-10% | | | | |
| Mozambique | 3-10% | | | | |
| Namibia | 4-10% | | | | |
| Swaziland | | | X | | |
| Tanzania | 3% | | | | |
| Zambia | | | X | | |
| Zimbabwe | 2-10% | | | | |

**Grote, 2007

Table 3: Royalty Rates for the first draft

| Group | Minerals | Royalty Rate % |
|-------|--|----------------|
| 1 | Salt, sand, stone, sandstone, late, gravel, clay, concrete, mortar, plastar, brick, dolorite, limestone, shale, gypsum, limestone, perlite, and phosphate | 1 |
| 2 | Oil and gas: natural gas and natural gas condensate petroleum crude offshore production where the water depths are deeper than 500 meters | 1 |
| 3 | Alumino-silicates (andalusite, sillimanite, kyanite), asbestos, ammonium sulphate, barytes, zirconium oxide uranium oxide, kaolin, talk, magnesite, mica, silica, sulphur, sodium sulphite, mineral pigment, pyrophyllite, dimension stone (granite norite), and perlite | 1 |
| 4 | Anthracite and bituminous coal (low ash and steam) | 2 |
| 5 | Antimony, copper, iron, manganese, lead, zinc, cobalt, nickel, silicon, tin, and vermiculite | 2 |
| 6 | Oil and gas: natural gas and natural gas condensate petroleum crude onshore and offshore production where the water depths are shallower than 500 metres | 3 |
| 7 | Gold, silver, vanadium, chromite, and titanium dioxide (Ilmenite, rutile) | 3 |
| 8 | Platinum group metals: platinum, palladium, rhodium, iridium, ruthenium, and osmium | 4 |
| 9 | Amethyst, quartz (smoky quartz, citrine, rose quartz), cryptocrystalline quartz (jasper, opal), or chalcedony (blue lace agate, moss agate, onyx, rainbow chalcedony), tigers' eye, blue asbestos (crocidolite), beryl, (emeralds, aquamarine, morganite, heliodor), | 5 |

| | | |
|----|---|---|
| | chrysoberyl (cat's eye, alexandrite), corundum (rubies, sapphires), garnet (jade, hydrogrossular, spessartine), lolite, kyanite, sodalite, sugilite (royal lavulite or royal azel), tourmaline, verdite (serpentine), and topaz | |
| 10 | Unpolished natural diamonds | 8 |

** Davis, 2005: 35

Table 4: Royalty Rates and Classification for second draft

Minerals with Single Rates

| Group | Minerals | Rate % |
|-------|--|--------|
| 1 | Unpolished natural diamond (gem and industrial), crystalline quartz (smoky quartz, citrine, rose quartz, amethyst, rock crystal), cryptocrystalline quartz (jasper, opal), chalcedony (blue lace agate, moss agate, onyx, rainbow chalcedony), chalcedonic replacements (silicified wood, tigers-eye), blue asbestos (crocodolite), beryl (emeralds, aquamarine, morganite, heliodor, goshenite, bixbite), chrysoberyl (cats-eyes, alexandrite), corundum (rubies, sapphires), garnet (almandine, pyrope, almandine-pyrope, grossular, spessartine, uvarovite), lolite, kyanite, sodalite, sugilite (royal lavulite, royal azel), tourmaline, verdite (serpentine), topaz, copper minerals (azurite, malachite, chrysocolla), enstatite, epidote, feldspar group (moonstone, amazonite) and spinel | 5 |
| 2 | Andalusite, asbestos, vermiculite, silliminite, kieselguhr, calcite, granite, marble and siltstone | 1 |
| 3 | Feldspar, fluorspar, barytes, gypsum, magnesite, mineral pigment, sulphur, silica, sillimanite, talc, slate, shale, attapulgite, bentonite, flint clays, kaolin and fire clay | 0.5 |

| | | |
|---|---|---|
| 4 | Limestone, lime and dolomite, phosphate rock, salt, quartzite, schist, Plastic clays, fire clay (construction grades), kaolin (construction grades) aggregate and sand | 0 |
|---|---|---|

Minerals with Unrefined and Refined Rates

| Group | Minerals | Unrefined rate % | Refined Rate % |
|-------|--|------------------|----------------|
| 5 | Platinum Group Metals (platinum, palladium, rhodium, ruthenium and osmium) | 6 | 3 |
| 6 | Chrome, manganese, silicon, vanadium, iron, cobalt, copper, nickel, lead, zinc, antimony and tin | 4 | 2 |
| 7 | Illmenite, rutile and zircon | 3 | 2 |
| 8 | Gold and silver | 3 | 1.5 |

Energy

| Group | Mineral | Specification | Rate % |
|-------|--------------------------------|--|--------|
| 9 | Coal | Above 15% ash content | 1 |
| | | Below 15% ash content | 3 |
| 10 | Hydrocarbon fuel (oil and gas) | Mining in water deeper than 500m | 1.5 |
| | | Mining in water shallower than 500m | 3 |
| 11 | Uranium | Oxide (yellow cake) and Uranium Hexafluoride | 1.5 |
| | | Uranium Concentrate | 3 |

**Table from Mineral and Petroleum Royalty Bill, (2006), National Treasury, p 23

Table 5: Tax Rates for Third Draft

| Mineral | Refined Rate | Unrefined Rate | Average | New Average rates Formula |
|-----------------------|--------------|----------------|---------|---------------------------|
| Diamonds | N/A | 5% | 5% | 3.7% |
| Manganese | 2% | 4% | 3% | 3.3% |
| Iron Ore | 2% | 4% | 3% | 3% |
| Mineral Sands | 2% | 4% | 3% | 3% |
| Platinum Group Metals | 3% | 6% | 4.5% | 2.7% |
| Gold | 1.5% | 3 | 2.25% | 2.1% |
| Chrome | 2% | 4% | 3% | 1% |
| Base Metals | 2% | 4% | 3% | 1% |

** South African Government Website

Table 6: Qualifying Deductible Expenditure as a percentage of Gross Sales or Revenue

| Mineral | % |
|-----------------------|------|
| Gold | 0.4 |
| Diamonds | 7.4 |
| Platinum Group Metals | 8 |
| Manganese | 19.5 |
| Mineral Sands | 21.4 |
| Coal | 21.6 |
| Chrome | 23.4 |
| Iron Ore | 27.9 |

**Table from SA Government Information, 2007

References

Akpula, W and Parks, P.J, (2006). Natural Resource Use Conflict: Gold Mining in Tropical Rainforest in Ghana. Forthcoming in Environment and Development Economics, EDE

Asher, W, (1999). Why Governments Waste Natural Resources: Policy Failures in Developing Countries. The John Hopkins University Press, Baltimore and London

Andrews-Speed, P and Rogers, C. D, (2000). "Mining Taxation issues for the Future" in *Resources Policy*, Vol. 25, Issue 4, pp. 221-227

Broad-Based Socio-Economic Empowerment Charter for the South African Mining Industry, DTI. URL: <http://www.dti.gov.za/bee-beecharters/MiningCharter.pdf>

Booyesen, M, van der Walt, A and Classen, R, (2007). Mining and Mineral Law.

Brazeel, R. J, and Cloutier, L. M, (2006). "Reconciling Gray and Hotelling" in *American Journal of Economics and Sociology* Vol. 65, No. 3, pp 827-856

Cairns, R. D, (1985). "Reform of Exhaustible Resource Taxation" in *Canadian Public Policy*, Vol. 11, No. 4, pp. 649-658

Cauvin, H. E, (2002). A Radical Overhaul for South African Mining
URL:<http://query.nytimes.com/gst/fullpage.html?res=9B02E6D7133AF937A35755C0A9649C8B63&sec=&spon=&pagewanted=all> Last Updated: 4 June 2002

Cawood, F, (2005). Social Change through Mineral Law in South Africa, Annual Mining Seminar in London.

Cawood, F, (2006). The Impact of the Draft Mineral and Petroleum Resources Royalty Bill on Gold Mine Revenues, WITS University

Coetzee, B and Horn, R, (2007). Theft of Precious Metals from South African Mines and Refineries, Chapter 1, Monograph number 133. Institute for Security Studies

Competition Commission, 2003. Comments by the Competition Commission on the Mineral and Petroleum Royalty Bill.

Conrad, R. F and Hool, R. B, (1984). "Intertemporal Extraction of Mineral Resources under Variable Rate Taxes" in *Land Economics*, Vol. 60, No. 4, pp 319-327

Cremer, J, (1979). "On Hotelling's Formula and the Use of Permanent Equipment in the Extraction of Natural Resources" in *International Economic Review*, Vol. 20, No. 2, pp. 317-324

Curry, R. L, Jr, (1984). "Problems in Acquiring Mineral Revenues for Financing Economic Development: A case study of Zambia during 1970-78" in *American Journal of Economics and Sociology*, Vol. 23, No.1, pp 37-52

Davis, D, (2005). Royalties and Costs, The LBMA Precious Metals Conference 2005, Johannesburg

Devarajan, S and Fisher, A. C, (1981). "Hotelling's "Economics of Exhaustible Resources": Fifty Years Later" in *Journal of Economic Literature*, Vol. 19, No. 1, pp. 65-73

Dore, M. H. I, (1990). "On Market Structure and the Taxation of Exhaustible Resources: A Sales Tax, it is argued, will capture the rents and lower the grade of the ore mined" in *American Journal of Economics and Sociology*, Vol. 49, No. 4, pp 459-468

ESIPP: Mines 2006. Country Profile: South Africa.

Figueroa B, E, (1999). Economic Rents and Environmental Management in Mining and Natural Resource Sectors, University of Chile and University of Alberta

Fischer, A. C, (1981). Resource and Environmental Economics, Chapter 2: Exhaustible Resources: the theory of optimal depletion. Cambridge University Press, UK.

Gamponia, V and Mendelsohn, R, (1985). "The Taxation of Exhaustible Resources" in *The Quarterly Journal of Economics*, Vol. 100, No. 1, pp. 165-181

Garnaut, R and Clunies-Ross, A, 1983. *Taxation of Mineral Rents* Clarendon Press, Oxford.

Government Gazette No. 23922, (2002). Republic of South Africa

Gray, L. C, (1914). "Rent under the Assumption of Exhaustibility" in *The Quarterly Journal of Economics*, Vol. 28, No. 3, pp. 466-489

Grote, M. (2007). Tax Aspects of Domestic Resource Mobilisation- a discussion of enduring and emerging conditions. Taxation of Natural Resources. UN Financing for Development Office and IFAD. National Treasury, South Africa

Harris, J.M., (2002). Environmental and Natural Resource Economics: A Contemporary Approach. Global Development and Environmental Institute, Tufts University, Houghton Mifflin Company, Boston, New York

Hartwick, J. M, Olewiler, N. D, (1998). *The Economics of Natural Resource Use*, Second Edition, Addison-Wesley Educational Publishers, Inc

Hotelling, H, (1931). "The Economics of Exhaustible Resources" in *Journal of Political Economy*; Vol. 39, No. 2, pp. 137-175

Hughes, N, (2000). *Mining in South Africa: Key Issues Relating to the Distribution of Resource Rents*. Mining and Energy Research Network, Corporate Citizenship Unit, Warwick Business School, University of Warwick, Coventry

Kotzé, R, N, (1933). "The Gold Mining Position: Report of the Low Grade Ore Commission, The Gold Premium and Gold Mining Taxation" in *The South African Journal of Economics*, Vol.1, No. 2, pp. 133-146

Kotzé, R, N, (1933). "The Excess Profits Tax on Gold and some of its Implications" in *The South African Journal of Economics*, Vol.1, No. 2, pp. 300-319

Leger, J and Nicol, M, (1992). *South Africa's Gold Mining Crisis: Challenges for Restructuring*. Article, Transformation 20.

Leon, P, (2006). "Creating a best-practice legal regime – A catalyst for Mining Investment in Africa" in Legal City, Webber Wentzel Bowens

Levhari, D and Liviatan, N, (1977). "Notes on Hotelling's Economics of Exhaustible Resources" in *The Canadian Journal of Economics*, Vol. 10, No. 2, pp. 177-192

Mackenzie, B. W, (1998). *Competitive Mining Tax Positions in South Africa*. Department of Geological Sciences, Queen's University, Kingston, Ontario, Canada. Invited Paper presented in the Third International Gold Symposium, Lima, Peru

Mangondo, K, (2006). The Economics of Gold Mining Taxation, University of South Africa

McKay, D, (2004). Royalty versus Tax Payoff, MiningMx. URL: http://www.miningmx.com/mining_fin/387958.htm last updated: 25 February 2004

McKay, D, (2006). Unpicking the Royalty Bill, MiningMx. URL: <http://www.miningmx.com/commentary/277800.htm> last updated: 12 October 2006

Muzondo, T, (1993). "Mineral Taxation, Market Failure, and the Environment" in *Staff Papers-International Monetary Fund*, Vol. 40, No. 1, pp. 152-177

National Treasury, (2006). Media Statement, Mineral and Petroleum Resources Royalty Bill

Nellor, D. C. L, (1987). "Sovereignty and Natural Resource Taxation in Developing Countries" in *Economic Development and Cultural Change*, Vol. 35, No.2, pp. 367-392

Northern Cape Province-Mineral Sector Strategy, (2005). Taxes Applicable to Mining in South Africa

OECD/AfDB, 2007. "African Economic Outlook: South Africa". Pp 485-500

O'Faircheallaigh, C, (1986). Mineral Taxation, Mineral Revenues and Mine Investment in Zambia, 1964-83. *American Journal of Economics and Sociology*, Vol. 45, No. 1, pp 53-67

Olivier, M, (2007). Final Draft Royalty Bill revises Tax Rates, Cuts Royalties.

URL: http://www.miningweekly.co.za/article.php?a_id=123171 Last Updated: 14 December 2007

Osmundsen, P, (1998). "Dynamic Taxation of Non-Renewable Natural Resources under Asymmetric Information" in *The Canadian Journal of Economics*, Vol. 31, No. 4, pp 933-951

Otto, J. M, (2000). "Mining Taxation in Developing Countries", UNCTAD

Perman, R, Ma, Y, Mc Gilvray, J and Common, M, (2003). *Natural Resource and Environmental Economics: 3rd Edition*. Pearson Education Limited, Essex

Phale, M, (2007). Mining Contribution to the National Economy 1996-2005, DME Report R59/2007

Rose, R (2006). Rejigged Royalties Bill pleases Miners, Business Day.

URL: <http://www.businessday.co.za/Articles/TarkArticle.aspx?ID=2284681> Last updated: October 2006

Solow, R, (1974). "Richard T. Ely Lecture: The Economics of Resource or the Resource of Economics" in *American Economic Association*, Vol. 64, No. 2, pp. 1-14

Sonjica, B, (2006). Department of Minerals and Energy: Speech at Mining Summit, NASREC, Johannesburg.

South African Government Website, (2003).

URL: http://www.info.gov.za/speeches/2003_03032011461013.htm Last Updated: March 2003

Seccombe, A, (2007). SA Miners Demand Royalty Bill Changes, MiningMx. URL: http://www.miningmx.com/mining_fin/630421.htm last updated: 16 February 2007

Simpson, R.D., Toman, M.A, and Ayres, R.U., (2005). Scarcity and Growth Revisited: Natural Resources and the Environment in the New Millennium. Resources For the Future Press, Washington DC, USA

Slade, M, (1986). "Taxation of Non-Renewable Resources at Different Stages of Production" in *The Canadian Journal of Economics*, Vol. 19, No. 2, pp. 281-297.

Slade, M, (1984). "Tax Policy and the Supply of Exhaustible Resources: Theory and Practice" in *Land Economics*, Vol. 60, No. 2, pp. 133-147

Wachman, R, (2005). De Beers Forced to face Modern Black Reality. URL: <http://www.guardian.co.uk/business/2005/nov/13-southafrica.theobserver> Last updated: November 2005

Williams, L (2006). Mining – Revised Drafts Out, Business Day. URL: http://transcripts.businessday.co.za/cgi-bin/transcripts_t-showtranscript.pl?1160604550
Last Updated: October 2006

Appendix A

1. Government

The principle current value Hamiltonian for the profits-based royalty is:

$$H^c(y, \lambda, \theta, t) = \theta p y - \lambda y + \eta((1 - \theta)(p y - c(y))) \quad (14)$$

Assuming that some quantity of gold is extracted at each point in time, the static efficiency condition (found using the Pontryagin Maximum Principle by taking first order derivative of equation (20) with respect to y) is:

$$\frac{\partial H^c}{\partial y} = \theta p - \lambda + (1 - \theta)p - (1 - \theta)c'(y) = 0$$

where $\eta = 1$

$$\theta p - \lambda + p - \theta p - (1 - \theta)c'(y) = 0 \quad (15)$$

η is the “multiplier associated with a constraint that is measured in the unit of price” (Akpalu and Parks, 2005: 12). It is equal to one along the optimal path, which indicates that the constraint will hold for all mining companies throughout the entire period. This shows that if a firm does not break-even it will close or relocate to areas with friendlier policies.

Rearranging Equation (15):

$$\lambda = p - c'(y)(1 - \theta)$$

For the revenue-based royalty the Current Value Hamiltonian becomes:

$$H^c(y, \lambda, \theta, t) = \theta py - \lambda y + \eta((1 - \theta)py - c(y)) \quad (16)$$

Taking the first order derivative with respect to y (using the Pontryagin Maximum Principle):

$$\frac{\partial H^c}{\partial y} = \theta p - \lambda + (1 - \theta)p - c'(y)$$

Where $\eta=1$

$$\theta p - \lambda + p - (\theta p - c'(y)) = 0 \quad (17)$$

Rearranging equation (17):

$$\lambda = p - c'(y)$$

2. Mining Company with no taxation

The current value Hamiltonian is:

$$H^v(y, \lambda, t) = py - c(y) - \lambda y \quad (18)$$

where λ is the user cost of the gold stock. Or it is known as the shadow price which is the change in the optimal value of the objective function corresponding to a small change in the constraint (Fischer, 1981: 16). p is the price of the resource, y is the extraction rate and $c(y)$ is the cost of extraction.

Using the Pontryagin Maximum Principle (taking first derivatives of equation (18)):

$$\frac{\partial H^v}{\partial y} = p - c'(y) - \lambda = 0 \quad (19a)$$

where $c'(y)$ is the first order partial differentiation of $c(y)$ with respect to y (or the marginal cost).

Rearranging equation (19a):

$$p = c'(y) + \lambda \quad (19b)$$

$$\lambda = p - c'(y) \quad (19c)$$

This states that the price is equal to the marginal extraction cost plus the opportunity cost.

Taking the first derivative of Equation (2) with respect to \dot{y} :

$$\dot{x} = \frac{\partial H^*}{\partial \dot{y}} = -\dot{y} \quad (19d)$$

This just restates the equation of motion.

3. Mining company with a Royalty Tax based on Profit

The current value Hamiltonian is

$$H^*(y, \dot{y}, \lambda, \theta, t) = (1 - \theta)(py - c(y)) - \dot{\lambda}y \quad (20)$$

where λ is again the shadow price.

Using the Pontryagin maximum principle (taking first order derivatives of equation (20)):

$$\frac{\partial H^*}{\partial y} = (1 - \theta)(p - c'(y)) - \dot{\lambda} = 0 \quad (21a)$$

$$\dot{x} = \frac{\partial H^*}{\partial \dot{y}} = -\dot{y} \quad (21b)$$

where $c'(y)$ is the first order partial differentiation of $c(y)$ with respect to y (or the marginal cost).

Rearranging equation (21a):

$$(1 - \theta)(p - c'(y)) = \lambda \quad (21c)$$

4. Mining Company with a Royalty Tax based on Revenue

The current value Hamiltonian is

$$H^c(y, \lambda, \theta, t) = (1 - \theta)py - c(y) - \lambda y \quad (22)$$

where λ is once again the shadow price.

Using the Pontryagin maximum principle (taking first order derivatives of equation (22)):

$$\frac{\partial H^c}{\partial y} = (1 - \theta)p - c'(y) - \lambda = 0 \quad (23a)$$

$$x = \frac{\partial H^c}{\partial \lambda} = -y \quad (23b)$$

where $c'(y)$ is the first order partial differentiation of $c(y)$ with respect to y .

Rearranging equation (23a):

$$(1 - \theta)p - c'(y) = \dot{\lambda} \quad (24)$$

The costate equation of gold (the portfolio balance or a condition for efficiency) is¹⁷:

$$\dot{\lambda} - r\lambda = 0 \quad (25a)$$

$$\text{or} \quad \frac{\dot{\lambda}}{\lambda} = r \quad (25b)$$

This is the dynamic efficiency condition. “The decision to mine the resource depends on marginal benefit from extracting the resource and depositing the revenue at the net benefit discount rate on one hand (i.e. $r\lambda$), and the marginal benefit from the growth in the rental rate (i.e. $\dot{\lambda}$), on the other hand” (Akpalu and Parks, 2005: 14). It can be rewritten as equation (9e). This states that “the return on all other assets in the resource-rich country (i.e. r) equals the growth in the shadow price per ounce of” (Akpalu and Parks, 2005: 14) gold (i.e. $\frac{\dot{\lambda}}{\lambda}$). This is consistent with Hotelling’s Rule; the net price should rise at the rate of interest.

¹⁷ This only involves the equation of motion of the stock of gold

The profit function is concave. This can be inferred as the static efficiency condition $(1 - \theta)(p - c'(y)) = \lambda$ (equation 13) is greater than zero and the second order derivative of the current value Hamiltonian with respect to y is equal to $-c''(y)(1 - \theta)$ which is less than zero (Akpalu and Parks, 2005: 14).

Here are a brief summary of the results. Making use of a Current Value Hamiltonian and the Pontryagin Maximisation Principle the following shadow prices were found:

For the government

$$\lambda = p - c'(y) \quad (26)$$

For the no taxation model

$$\lambda = p - c'(y) \quad (27)$$

For a profit based royalty tax

$$(1 - \theta)(p - c'(y)) = \lambda \quad (28)$$

Revenue based royalty tax

$$(1 - \theta)p - c'(y) = \lambda \quad (29)$$

These results are the static efficiency conditions. Equation (28) states that at each point in time the profit minus the costs of harvesting the gold (marginal profits) multiplied by the tax rate is equal to the user cost of the remaining gold stock λ . Comparing equation (18) to equation (26) it can be seen that profits will be lower where there is a tax.

Equation (29) states that at each point in time the profit multiplied by the tax rate minus the costs of harvesting the gold (marginal profits) is equal to the user cost of the remaining gold stock λ . Comparing Equation (29) to equation (28) it can be seen that the shadow price will be larger when the taxes are based on profits than when based on revenues. The dynamic efficiency condition is the same as the profit tax dynamic efficiency condition.