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International minerals taxation:

experience and issues

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Taxing natural resources: new challenges, new perspectives

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The mining sector is important in a wide range of economies providing, for example, a source of export revenue as well as government revenue through minerals taxation arrangements. The aim in minerals taxation policy is to enable governments to collect a reasonable return from the extraction of the community's mineral resources, while ensuring that industry outcomes remain efficient and administrative costs are not excessive. The objective in this paper is to examine the international experience and key economic issues in minerals taxation.

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1. Introduction

Minerals are an important source of export earnings and taxation revenue in a wide range of countries. For example, based on UN trade data, world exports of selected major mineral resources — including coal, iron ore, base metals, bauxite, alumina and aluminium, and tin — were valued at US$448 billion in 2006 comprising US$49 billion for coal, US$108 billion for ores and concentrates and US$291 billion for metals (see appendix 1). Developed economies accounted for 51 per cent of world exports of these commodities (40 per cent for ores and concentrates). Minerals taxation revenue accounts for a significant share of total fiscal revenue in several countries — most notably, over the period 2000-05, this share was 62.5 per cent in Botswana, 17.9 per cent in Papua New Guinea, 17.8 per cent in Guinea, 9.4 per cent in Chile, 8.2 per cent in Mongolia and 5.9 per cent in Namibia (IMF 2007).

From an economic perspective, mineral deposits are a natural form of wealth that generate a resource rent (or economic rent) following mineral extraction. The resource rent represents a return to the mineral resource. This resource rent provides the economic justification for governments to consider introducing some form of minerals taxation. While specific arrangements vary between countries, mineral resources in the ground may be considered to be owned by the community and the government, on behalf of the community, transfers exploration and production rights to companies in the mining sector in return for a minerals taxation payment (or resource royalty payment).

The objective in this paper is to examine the international experience and key economic issues in minerals taxation. An efficient minerals taxation system has the potential to facilitate mineral exploration, development and production while also providing the community with a reasonable, or fair, return on the use of its mineral resources. The approach taken in this paper is based on an ABARE study of minerals taxation arrangements in Australia that was released in January 2007 (see Hogan 2007).

The structure of the paper is as follows. In the next section, a brief overview of international minerals taxation arrangements is provided. The research method used to analyse minerals taxation options is presented in section 3 — the economic framework for analysing policy options is presented and hypothetical mining projects used to illustrate economic impacts are described. An important focus in the economic framework is to distinguish the impact of risk on the investor's assessment of the profitability of mining projects. In section 4, key economic issues in minerals taxation are examined drawing on the simulation results for the hypothetical projects. Some concluding comments are provided in the final section.

2. International minerals taxation arrangements

In broad terms, minerals taxation arrangements may be classified according to whether they are profit based or output based:

- **profit based royalties** are levied on the net cash flow or some measure of the profit of a mining project.

- **an ad valorem royalty** is an output based royalty that is levied as a percentage of the value of production of a mining project.

- **a specific, or unit based, royalty** is an output based royalty that is levied as a set charge per physical unit of production of a mining project.

Minerals taxation arrangements vary widely between countries and minerals. Minerals include coal, metallic minerals and non-metallic minerals — industrial minerals include coal and non-metallic minerals (that is, nonindustrial minerals are metallic minerals). A summary of minerals taxation arrangements, mainly for coal and metallic minerals, is provided in table 1 for selected developed economies and table 2 for selected other countries. In some cases, information is provided for nonindustrial minerals and gemstones (a non-metallic mineral), or non-construction minerals.

In all countries, specific royalties tend to apply to low value high volume non-metallic minerals, particularly construction materials. In general, for coal, metallic minerals and gemstones:

- **in the selected developed economies**, minerals taxation arrangements are mainly profit based or ad valorem royalties — the most consistent application of profit based royalties is in Canada.

- **in the selected other countries**, minerals taxation arrangements are mainly ad valorem royalties in Africa and Latin America, and some combination of specific and ad valorem royalties in Asia and Pacific countries — none of these countries has adopted a profit based royalty to date.

Under profit based royalties, measures of profit vary, the royalty rate is sometimes applied as a sliding scale and, in some cases, no tax applies if the income from mines falls below some threshold level. Although the profit based royalties vary between jurisdictions, in broad terms, Canada is likely to currently represent world's best practice in minerals taxation arrangements.

Table 1: Summary of mineral taxation arrangements in selected developed economies [a]

		Royalty rate		
	Royalty type	Ad valorem %	Profit %	Comment
Australia [b]				
Western Australia	specific/ad valorem	1.25-7.5		Mainly ad valorem - in general, ores 7.5%, concentrates 5%, metals 2.5%; gold 1.25-2.5% based on price; export coal 7.5%; specific royalty on coal not exported
Queensland	ad valorem	1.5-7		Coal 7%, other minerals - fixed rate option 2.7%, variable rate option 1.5-4.5% based on price
New South Wales	ad valorem	4-7		Coal - deep underground 5%, other underground 6%, open cut 7%; other minerals 4%; exception is profit royalty for specified Broken Hill mines
Northern Territory	profit		18	Based on net value of production where the first A$50,000 is not liable to royalty
Canada [c]				
British Columbia	ad valorem/profit	2	13	Ad valorem is minimum tax (fully deductible against profit royalty); losses can be carried forward under profit royalty
Northwest Territories	profit		5-14	Sliding scale; no tax if income below Can$10,000
Ontario	profit		10	No tax if income below Can$500,000; tax reductions for mines in remote regions
Saskatchewan	ad valorem/profit		5-10	Mainly profit royalty - 5% rate increases to 10% when production threshold is exceeded, capital recovery based on 150% of expenditures; exceptions are ad valorem on coal (15% less 1% resource credit) and uranium (5% less 1% resources allowance)
United States [c]				
Arizona	ad valorem	at least 2		Commissioner to set rate
Michigan	ad valorem	2-7		Sliding scale
Nevada	profit		2-5	Sliding scale

a Information is from Otto et al (2006) unless otherwise specified; see Otto et al (2006) for further details. Mineral taxation arrangements vary between jurisdictions in each country - information on selected jurisdictions is included in the table.
b From Hogan (2007). Includes coal and metallic minerals. **c** Mainly nonindustrial minerals.
Sources: Otto et al (2006), Hogan (2007).

Table 2: Summary of mineral taxation arrangements in selected other countries [a]

		Royalty rate		
	Royalty type	Ad valorem %	Profit %	Comment
Africa [b]				
Botswana	ad valorem	3-10		Precious stones 10%, precious metals 5%, other 3%
Ghana	ad valorem	3-12		Rate graduated on operating profit
Mozambique	ad valorem	3-12		Diamonds 10-12%, other 3-8%; rate negotiable; artisanal miners exempt
Namibia	ad valorem	5-10		Uncut precious stones 10%, other max 5%
South Africa [c]	ad valorem	1.5-4		Lower rates apply to refined product
Tanzania	ad valorem	0-5		Diamonds 5%, cut and polished gemstones 0%, other 3%
Zambia	ad valorem	2		Small miners exempt; no royalty for local processing
Asia and Pacific [d]				
China	specific+ad valorem	1-4		Combined royalty; specific rates vary
India	specific/ad valorem	0.4-20		Specific rates vary
Indonesia	specific/ad valorem	2.5-13.5		Specific royalty mainly applies and rates vary; ad valorem applies to gold at 2.5% (placer gold 7.5%) and coal at 13.5%
Mongolia	ad valorem	2.5		Exception is placer gold at 7.5%
Papua New Guinea	ad valorem	2		
Philippines	specific/ad valorem	2		Ad valorem generally applies with specific royalty on coal; small miners exempt
Latin America [d]				
Argentina	none or ad valorem	0 or 3		Most jurisdictions do not apply a royalty; federal government imposes a maximum rate of 3%
Bolivia	ad valorem	1-6		Sliding scale based on price; rate is 60% lower for domestic use
Brazil	ad valorem	0.2-3		
Chile [c]	ad valorem	0-5		Rates for copper with sliding scale based on annual sales; other rates not available
Mexico	none			
Peru	ad valorem	1-3		Sliding scale based on annual sales in US dollars; 1% if no international price; small miners exempt
Venezuela	ad valorem	3-4		

a Information is from Otto et al (2006) unless otherwise specified; see Otto et al (2006) for further details.

b Nonindustrial minerals and gemstones. **c** From Conrad (2008). **d** Most non-construction minerals.

Sources: Otto et al (2006), Conrad (2008).

Under ad valorem royalties, the basis of mineral valuation may be market price, netback price or some specified reference price — Otto et al (2006) presents a list of options for calculating the ad valorem royalty (see table 3.1, p. 56). Higher ad valorem royalty rates tend to be applied to coal, ores and higher value minerals such as diamonds — for example, Western Australia distinguishes between ores (7.5 per cent), concentrates (5 per cent) and metals (2.5 per cent), and African countries consistently apply higher rates to diamonds and other gemstones.

The ad valorem royalty is most often applied at a constant rate for a specified mineral, although there are several examples of sliding scales based on price, production, sales or profit. A sliding scale may also apply to different cost categories within an industry — for example, in New South Wales in Australia, the ad valorem rate for coal varies for deep underground (5 per cent and assessed to be the highest cost category), other underground (6 per cent) and open cut (7 per cent). Special arrangements may apply for specific mines, although details may not be publicly available (that is, information may be classified as commercial-in-confidence for these mines) — in Australia, Olympic Dam (South Australia; 3.5 per cent ad valorem royalty, but a surplus royalty may apply) and the Argyle Diamond mine (Western Australia; 5 per cent ad valorem royalty, lower than the 7.5 per cent royalty that generally applies to diamonds) are two examples of significant mining operations where special arrangements apply. Lower ad valorem rates sometimes apply to minerals that are used in the domestic market — for example, Bolivia provides a 60 per cent discount on minerals used in the domestic market and Zambia provides a tax exemption for minerals used in local processing.

Some important trends in global minerals taxation arrangements, discussed in Otto et al (2006), include:

- **shift toward profit based royalties in developed economies** — nearly all provinces in Canada have adopted profit based royalties; the Northern Territory in Australia and Nevada in the United States have also adopted profit based royalties.

- **shift toward lower rates and/or sliding scales under ad valorem royalties** — Otto et al (2006) note that most ad valorem royalty rates generally do not exceed 3 or 4 per cent.

- **increased application and coverage of minerals taxation arrangements** — for example, Chile, Peru and South Africa have only introduced minerals taxation arrangements in recent years, and Western Australia applied an ad valorem royalty to gold production just prior to 2000; some countries (for

example, Mexico) and jurisdictions within a country (for example, Argentina) still do not apply minerals taxation arrangements.

- **increased emphasis on transparency of minerals taxation systems** — for example, the Extractive Industries Transparency Initiative is an approach to revenue reporting that is gaining adherents among developing countries and mining companies operating within them; it is standard practice in most African countries to include minerals taxation arrangements as part of the legal framework.

Related to the transparency issue, IMF (2007) provides a guide on resource revenue transparency that recommends practices based on the experience of developed economies, as well as some emerging market and developing economies that are improving their transparency standards. Further, Otto et al (2006) report that the practice of setting a royalty on a mine-by-mine basis is becoming increasingly rare.

The information presented in tables 1 and 2 mainly refers to systems in practice in 2006, but it should be noted that minerals taxation arrangements can be subject to frequent change. Conrad (2008) provides more recent information for selected countries and minerals.

3. Economic framework for assessing minerals taxation options

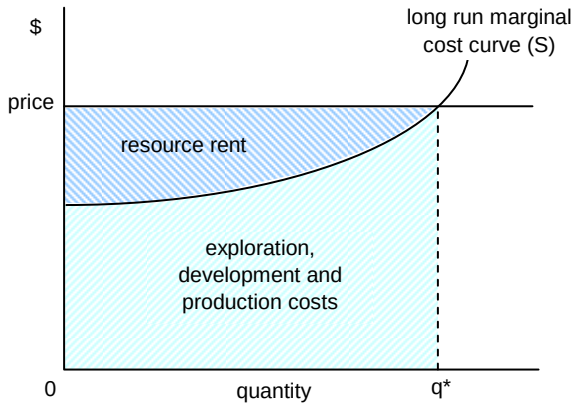
In this section, an economic framework for assessing minerals taxation options is presented. This economic framework forms the basis for the later discussion of economic issues relating to minerals taxation arrangements.

Resource rent

The economic justification for minerals taxation policy is based on the presence of resource rent or a return to the mineral resource. Resource rent is the supernormal or excess profit that would be earned in the exploration, development and extraction of mineral deposits. That is, resource rent is the profit after private investors have received a normal rate of return on their exploration and capital expenditures, including an appropriate risk allowance. Resource rent exists, for example, through the quality differential of mining projects — profitability increases with the quality of the mineral deposit, everything else remaining constant.

The concept of resource rent is illustrated in figure 1 where, for simplicity, price is assumed to be determined on world markets. The long run industry supply curve, S, represents the long run marginal cost of exploration, development and production (including abandonment). The equilibrium level of industry output is given by q* since it would not be profitable for the industry to incur any additional costs by increasing activity beyond this level — in addition, there would be unexploited profit opportunities if activity stopped at a lower level. The resource rent, assumed to be equal to the industry's economic rent is given by total revenue less the industry's exploration, development and production costs (including a normal return to capital).

Figure 1: Resource rent



Key minerals taxation options

The key minerals taxation options discussed in this paper include profit based royalties and output based royalties based on a constant royalty rate. Economic issues relating to ad valorem royalty arrangements where royalty rates are based on some form of sliding scale are also discussed, given the importance of these arrangements in a number of developed and developing economies.

The industry impacts of three minerals taxation options are illustrated in figure 2, including a neutral profit based royalty (panel a), an ad valorem (panel b) and a specific or unit based royalty (panel c). The economic framework is consistent with the simplified approach given in figure 1.

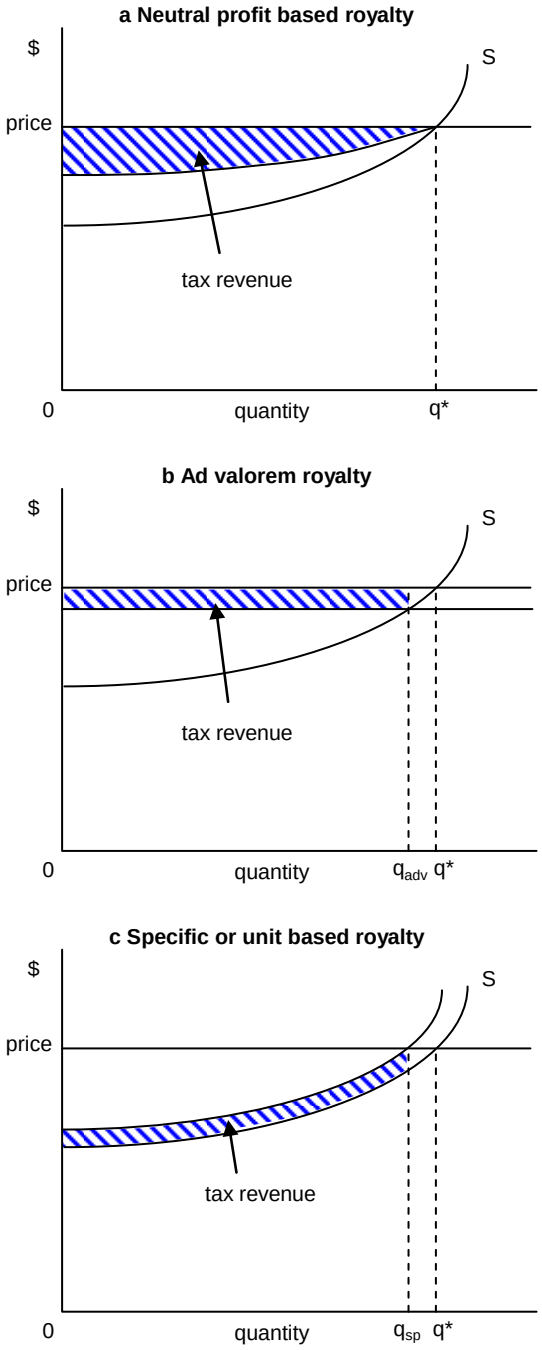
Profit based royalties are levied on the net cash flow or profit of a mining project. The profit based royalty presented in panel a is neutral because industry output is unchanged under this (theoretical) minerals taxation option — the government is assumed to obtain a constant share of the resource rent under this arrangement. Economic issues in the design of a profit based royalty are discussed further in the next section, but two important options are:

- **the Brown tax**, a profit based royalty that provides a useful benchmark against which other policy options may be assessed — under the Brown tax, the government collects a constant percentage of a project's net cash flow in years in which profits are earned and provides cash rebates to private investors in years of negative net cash flow.

- **the resource rent tax**, a profit based royalty that provides governments with an approximation to the Brown tax but avoids cash rebates in years in which losses are incurred — under a resource rent tax, the government collects a constant percentage of a project's net cash flow where losses (negative net cash flow) are accumulated at a threshold rate and offset against future profit.

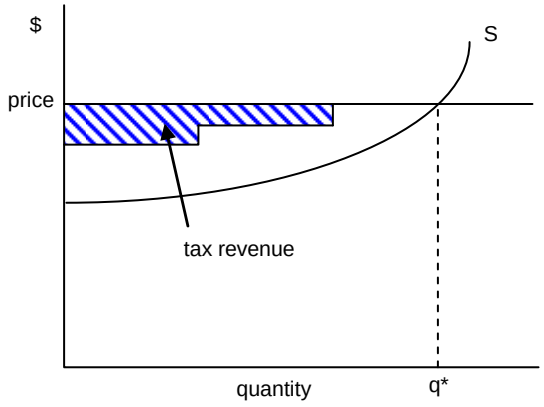
Under both output based royalties, marginal projects become unprofitable and the equilibrium level of industry output is reduced. The ad valorem royalty in panel b is an output based royalty whereby the government is assumed to collect a constant percentage of the value of production. The specific or unit based royalty in panel c is an output based royalty whereby the government is assumed to collect a constant charge per physical unit of production, increasing industry production costs.

Figure 2: Key mineral taxation options
(constant rate)



Some countries have adopted output based royalties that incorporate a sliding scale that may take into account, at least to some extent, the profitability of different segments of the mining industry. An ad valorem royalty with a sliding scale based on profit is illustrated in figure 3 where lower profit mining projects are assumed to be exempt from the royalty. In principle, an ad valorem royalty with a sliding scale may be adopted to approximate a profit based royalty, but there are significant practical issues that governments should consider (see the next section for a discussion).

Figure 3: Ad valorem royalty with sliding scale based on profit



Risky investment decisions in mining

Risk is an important feature of mining projects. The graphical analysis presented above represents a traditional approach to considering the industry impacts of minerals taxation options. The economic framework used in this paper, referred to as the certainty equivalent approach, includes an explicit risk premium in the profitability assessments of risky mining projects. The impact of minerals taxation options on the investor's risk assessment may be analysed explicitly in this framework.

Certainty equivalent approach

The assessment of the profitability of a prospective mining project following successful exploration activity depends on the expected geological, economic and policy setting over the life of the mining project, risks in the outlook and the attitude (or preferences) of private investors to incurring those risks. In the assessment of risky projects, it is assumed that investors are able to identify a range of possible outcomes reflecting significant sources of risk and assign (objective or subjective) probabilities to each of these outcomes.

Table 3: Decision criteria for profitability assessments of mining projects

Risk/ attitude toward risk	Profitability measure	Profitability assessment		
		Uneconomic	Marginal	Economic
Risk free project	Net present value (NPV)	< 0	= 0	> 0
Risky project				
Risk neutral investor	Expected net present value (ENPV)	< 0	= 0	> 0
Risk averse investor	Certainty equivalent value (CEV)	< 0	= 0	> 0

The main decision criteria used in the profitability assessments for mining projects are summarised in table 3. Risk free projects may be ranked according to the net present value since it is a measure of the return to the investment — a project with a net present value that is greater or equal to zero is assessed to be profitable since it indicates that the investment will achieve a return that is greater or equal to the risk free interest rate. In the presence of risk, investors are assumed to summarise the profitability of a potential mining project by calculating the expected net present value if they are risk neutral, or the certainty equivalent value if they are either risk averse or risk preferring. These decision rules are summarised as follows:

- **net present value (NPV) applies to a risk free investment** — NPV is the sum of the annual net cash flow over the duration of the project discounted at the risk free interest rate (assumed to be the long term government bond rate or LTBR).

- **expected net present value (ENPV) applies to a risky investment and risk neutral investors** — risk neutral investors are indifferent to the risk that an outcome may be either worse or better than expected; the expected net present value is the probability weighted sum of the net present value of each possible outcome.

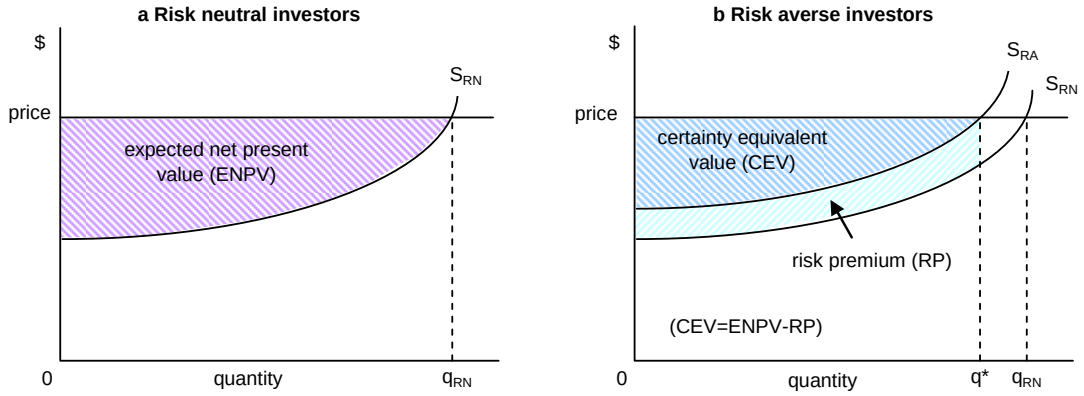
- **certainty equivalent value (CEV) applies to a risky investment and risk averse investors** — risk averse investors are relatively more concerned about the risk of unexpected losses than the risk of unexpected gains; the certainty equivalent value is the expected net present value less a risk premium (RP) that provides adequate compensation for the risks associated with the project (that is, CEV = ENPV – RP).

For risk averse investors, a mining project is assessed to be profitable if the certainty equivalent value is non-negative (zero or positive). The certainty equivalent value of a project may be interpreted as the amount where the investor would be indifferent to investing in the risky project or accepting a risk free investment with a certain return.

The valuation of the risk premium may have an important influence on the assessment of project profitability.

This economic framework is presented in figure 4 at the industry level for risk neutral investors (panel a) and risk averse investors (panel b) — the industry supply curves are given by S_{RN} and S_{RA}, respectively. In practice, investors are assumed to be risk averse and hence the economic framework presented in panel b is most relevant to the assessment of policy options. From an economic perspective, an important issue in assessing minerals taxation options is the extent to which the industry's supply curve may shift in response to changes in the risk premium.

Figure 4: Economic framework for risky investment decisions



Hypothetical mining projects

In this paper, five hypothetical mining projects are used to illustrate the impact of key minerals taxation options on project profitability and government tax revenue. The assumptions underlying these projects are given in appendix 2 (see table 6). For simplicity, all projects are assumed to produce a single ore that is sold at the same market price, $1000 a tonne. The projects vary widely in terms of size with the value of production assumed to range from $5 million for project 1 to $250 million for project 5. The cost structure reflects the presence of economies of scale, whereby average operating costs are lower for larger projects. Production and operating costs are assumed to be constant during the production phase of each project. The mine life is assumed to be twenty years for project 5 and ten years for the other projects.

The assumptions for other relevant variables and the policy settings in the minerals taxation options are given in appendix 2 (see table 7). The tax rate in the Brown tax, included as a benchmark royalty, and the resource rent tax is assumed to be 40 per cent. Two options are considered for the threshold rate in the resource rent tax — 5 per cent (that is, no risk premium in the threshold rate) and 10 per cent (that is, a risk premium of 5 per cent in the threshold rate). The royalty rate in the ad valorem

royalty is assumed to be either 10 per cent or 5 per cent. The royalty rate for the specific royalty is assumed to be either $100/t or $50/t.

For simplicity, the resource price is the only variable that is considered by private investors to be risky in the outlook. Price is usually considered to be a major source of risk in resource development projects. Price risk is introduced into the project simulations in a relatively simple way. There are assumed to be seven possible price outcomes over the development and production stages of the mining projects. The probability distribution for the mineral price that is assumed to be relevant to the outlook is given in appendix 2 (see table 8). Thus, for example, the probability that a price of $1000 a tonne will occur is assumed to be 30 per cent, while the price outcomes of $650 a tonne or $1350 a tonne are each assumed to occur with a probability of 1 per cent.

In the profitability assessments, risk averse private investors need to estimate the risk premium for each hypothetical mining project. In this study, the risk premium is assumed to be equal to the variance of the distribution of the net present values divided by the expected net present value — this is consistent with the approach used in other economic studies and discussed in Newbery and Stiglitz (1981). (In particular, the coefficient of relative risk aversion, R, is assumed to be 2; a higher value would indicate a higher degree of risk aversion and a lower value would indicate a lower degree of risk aversion.)

4. Economic issues in minerals taxation

There are several important stages in the policy assessment process:

- **identify policy objectives** — the objective in minerals taxation is to enable the government to collect a reasonable or fair return from the extraction of the community's mineral resources at least cost.

- **identify policy options** — these include profit based and output based royalties.

- **identify criteria for assessing policy options** — key criteria used in assessing the benefits, costs and risks of policy options include economic efficiency (that is, the extent to which a policy may have a negative impact on mineral exploration, development and production) and administrative costs (including administrative feasibility). Dependence on minerals taxation revenue and stability of the revenue stream are significant issues, particularly in several developing economies.

- **assess policy options** — in practice, it may be difficult to identify and quantify all significant economic effects and some aspects of the assessment will rely on the subjective judgment of policy makers.

- **rank policy options** — in principle, the policy option with the highest assessed net economic benefits (or lowest assessed net economic cost for a given level of tax revenue) is preferred to the alternatives.

In this section, a range of economic issues that merit consideration by governments in their policy assessments are discussed. Issues relating to administrative costs, the timing and magnitude of tax revenues, and the impact on project profitability (or economic efficiency) are discussed first for key policy options based on a constant royalty rate. Issues relating to policy options that incorporate a sliding scale in the royalty rate are then discussed.

Administrative costs

Administrative costs are the costs associated with revenue collection under the minerals taxation policy, including monitoring the compliance of investors in meeting their obligations under the policy. Costs are incurred by both investors and government. The administrative costs of a minerals taxation policy tend to be higher if the information requirements of the policy are higher. In general, the information requirements of profit based royalties are higher than those for output based

royalties. Hence, the administrative costs tend to be higher for profit based royalties than for output based royalties.

However, the increase in sovereign risk and administrative costs associated with the potential for governments to adjust fiscal settings over time (as occurs with output based royalties) also needs to be taken into account in the economic assessment of policy options. An assessment of the costs associated with the transition to any change in minerals taxation arrangements is also an issue for policy makers.

Otto et al (2006) and IMF (2007) examine issues associated with administrative feasibility and resource revenue management in developing economies. Increasing transparency and ensuring that minerals taxation arrangements are part of the legal framework are important in increasing the efficiency of administrative processes and the effectiveness of policy assessments and outcomes.

Tax revenue (constant royalty rates)

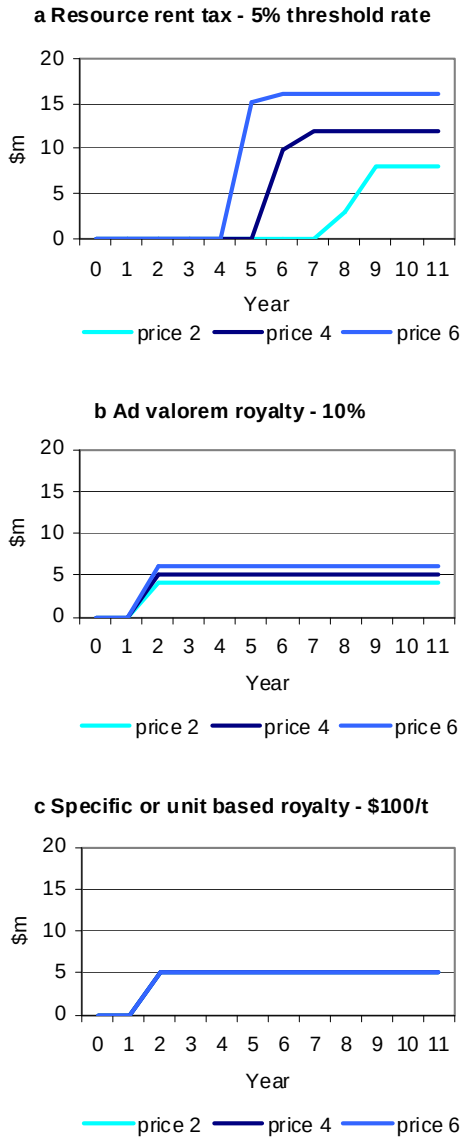
Timing of tax revenue

Under a profit based royalty, the government aims to collect a constant percentage of the resource rent (excess or supernormal profit) of each mining project. The government tax take is responsive to changes in project profitability, although the timing and magnitude of the government return will depend on the particular design of the profit based royalty. Under a resource rent tax, exploration and capital costs are accumulated at a specified threshold rate and offset against future revenue, and the tax is levied as a constant percentage of a project's net cash flow — that is, the government collects a percentage (the tax rate) of annual profits in excess of the threshold return to the investment in mineral exploration and development.

Under an ad valorem royalty, the government collects a constant percentage of the value of production irrespective of the net cash flow position of the project — tax revenue is responsive to changes in price and production, but not project costs. Under a specific or unit based royalty, the government collects a set charge per physical unit of production — tax revenue is responsive to changes in production, but not price or project costs. Under both output based royalties, the government receives royalty payments in all years in which production from the mining project is positive, including any years in which losses may unexpectedly occur.

In figure 5 the timing and responsiveness of tax revenue is illustrated for hypothetical project 3 under three price assumptions — $800/t (price 2), $1000/t (price 4) and $1200/t (price 6) — for selected minerals taxation options (see appendix 2 for further information on the underlying assumptions).

Figure 5: Hypothetical project 3 - tax revenue under three price assumptions
(Source: Hogan 2007)



The three minerals taxation options illustrated in figure 5 are the resource rent tax based on a 5 per cent threshold rate (40 per cent tax rate; panel a), the 10 per cent ad valorem royalty (panel b) and the $100/t specific royalty (panel c). The ad valorem and specific royalty rates have been calibrated to collect the same tax revenue for the expected price of $1000/t (a similar approach applies to the 5 per cent ad valorem royalty and the $50/t specific royalty). Figure 5 highlights two important features of the policy options:

- **timing of the tax revenue varies** — under the resource rent tax, tax revenue is delayed but, after investors receive their threshold return, tax revenue is higher than under the output based royalties.

- **responsiveness to unexpected price outcomes varies** — under the resource rent tax and ad valorem royalty, tax revenue is reduced if the price is lower than expected and increased if the price is higher than expected (assuming production is unchanged); tax revenue is unchanged under the specific royalty.

Many governments that maintain ad valorem royalties appear to have particular issues with two aspects of the tax revenue profile under profit based royalties. First, tax revenue is not collected in the initial years of the mining project (unlike output based royalties). Second, there is a risk that tax revenue will be lower than expected — that is, the government bears significant risks in terms of future adverse market outcomes. For countries with a diversified revenue base and a capacity to manage fluctuations in revenue flows, such an approach appears to be highly risk averse. Consideration of the expected tax revenue, the risks to the tax revenue stream and the capacity of the country (or jurisdiction) to manage these risks is an important part of any assessment of alternative policy options.

Total tax revenue in present value terms

The total tax revenue collected by the government depends on the available resource rent, the policy approach and the policy settings. The available resource rent or excess profits will vary in mining industries where there is a mix of low and high quality mine sites. The mix of mining projects will also change over time as ore deposits are exhausted and new ore deposits are discovered and brought into production. The tax revenue under profit based royalties is designed to vary with resource rent or project profitability.

Under an output based royalty, an important problem facing policy makers is to set a royalty rate that is expected to collect sufficient royalty revenue to justify the imposition of the royalty but to make a subjective judgment about the negative impact on the profitability of low profit or marginal mining projects and the possible shortfall in returns from high profit projects (compared with the outcome under profit based royalties).

Provided there exists a range of low profit and high profit mining projects, output based royalties with a constant royalty rate tend to overtax low profit projects and to undertax high profit projects. Compared with profit based royalties, the government tax take will be too high for low profit projects with some becoming uneconomic as a consequence (and the government tax take reduced to zero for these projects), and too low for high profit projects.

Table 4: Key results for hypothetical mining projects [a]
(in present value terms)

		Profit based royalties			Output based royalties			
			Resource rent tax		Ad valorem royalty		Specific royalty	
	Before tax	Brown tax	5% [b]	10% [c]	10%	5%	$100/t	$50/t
	$m	$m	$m	$m	$m	$m	$m	$m
Tax revenue								
Project 1	-	3.5	2.8	2.0	3.7	1.8	3.7	1.8
Project 2	-	18	16	12	18	9	18	9
Project 3	-	50	46	40	37	18	37	18
Project 4	-	130	124	113	74	37	74	37
Project 5	-	398	386	364	184	92	184	92
	-							
Project profitability assessments								
Risk neutral investors - expected net present value (ENPV)								
Project 1	8.9	5.3	6.1	6.9	5.2	7.0	5.2	7.0
Project 2	44	27	28	32	26	35	26	35
Project 3	125	75	79	85	89	107	89	107
Project 4	324	195	201	211	251	288	251	288
Project 5	995	597	609	631	811	903	811	903
Risk averse investors								
Risk premium (RP)								
Project 1	2.3	1.4	1.3	1.2	3.2	2.6	4.0	2.9
Project 2	12	7	7	6	16	13	20	15
Project 3	16	10	9	8	19	17	23	19
Project 4	25	15	15	13	27	26	33	29
Project 5	52	31	30	28	51	52	64	57
Certainty equivalent value (CEV)								
Project 1	6.5	3.9	4.8	5.7	2.0	4.4	1.2	4.1
Project 2	33	20	22	26	10	22	6	20
Project 3	109	65	70	77	70	90	65	88
Project 4	299	179	186	198	224	262	218	259
Project 5	943	566	578	603	759	851	747	846
Certainty equivalent value under higher capital costs								
Project 1	3.3	2.0	2.5	3.3	-3.2	0.6	-4.6	0.2
Project 2	16	10	11	15	-16	3	-23	1
Project 3	81	49	53	64	39	61	33	58
Project 4	247	148	155	173	170	209	163	206
Project 5	817	490	503	540	631	724	617	718

a Profitability measure is expected net present value for risk neutral investors and certainty equivalent value for risk averse investors (where CEV=ENPV-RP). See section 3 for further information.
b No risk premium in the threshold rate. **c** 5% risk premium in the threshold rate.
Source: Hogan (2007).

The total tax revenue collected by governments may be summarised in present value terms — that is, the sum of the discounted value of future tax revenue. Key results for tax revenue and the project profitability assessments for the five hypothetical mining projects are given in table 4. These results highlight the extent to which larger high profit projects may be undertaxed under an ad valorem royalty compared with the outcome under profit based royalties. Most notably, for project 5, the

government tax take under the 10 per cent ad valorem royalty is around half of the government tax take under the resource rent tax with a 10 per cent threshold rate (that is, a 5 per cent risk premium in the threshold rate).

Project profitability assessments (constant royalty rates)

Risk premium

An important feature of profit based royalties is that investors share part of the risk of mining projects with governments. The extent of risk sharing depends on the design of the profit based royalty. A resource rent tax with full loss offset is similar to the Brown tax where the government is essentially a silent partner in the project (contributing the tax rate, for example 40 per cent, to the investment costs and receiving the tax rate applied to profits as a return on this investment). Under a resource rent tax, full loss offset is achieved when the net losses from failed mining projects are deductible against the profits from successful mining projects (this may occur through cash rebates, trade in losses between companies and/or companywide deductibility of losses).

In practice, profit based royalties do not provide full loss offset — for example, mining companies tend to incur the risk of failed development projects. These risks may be accounted for, to some extent, by incorporating a risk premium in the fiscal settings (the threshold rate and/or the accelerated rate of deduction for different expenditure categories). A resource rent tax with less than full loss offset still provides significant risk sharing between the government and investors since the resource rent tax is not triggered until investors achieve the threshold rate of return. The government then collects a percentage (the tax rate) of annual profits in excess of the threshold return to exploration and capital expenditure.

By contrast, the government collects ad valorem and specific royalty payments in all years when mineral production is positive. Since project profitability may be significantly lower than expected, the risk premium for any given project tends to be increased under both ad valorem and specific royalties (compared with the risk premium before the resource tax is applied).

The impact of the key policy options on the investor's risk premium for the five hypothetical mining projects under price risk is given in table 4. Under the profit based royalties, the risk premium is consistently less than the risk premium before tax. By contrast, the risk premium tends to be increased under each ad valorem and specific royalty option. However, the risk premium is similar before and after the ad valorem royalty for the larger projects 4 and 5 indicating the relatively low

government tax take has a negligible impact on the risk assessment of these highly profitable projects.

Risk adjusted profitability measure — certainty equivalent value

Compared with the outcome under profit based royalties, project profitability under an ad valorem or specific royalty tends to be lower for low profit projects (since these tend to be overtaxed) and higher for high profit projects (since these tend to be undertaxed). As a consequence, a mining project is more likely to switch from being economic before tax (CEV≥0) to uneconomic after tax (CEV<0) under an ad valorem or specific royalty than under any of the profit based royalties.

These results reflect the net outcome of the government tax take and the risk assessment:

- **under profit based royalties**, the government tax take varies with project profitability and the risk premium is reduced compared with the before tax outcome (reflecting the risk sharing characteristics of profit based royalties).

- **under output based royalties**, the government tax take varies with the value or volume of production but not with project profitability, and the risk premium tends to be higher than the before tax outcome — there is some tendency, depending on the royalty rate, for ad valorem and specific royalties to overtax low profit projects and undertax high profit projects.

The profitability results for the hypothetical projects illustrate these features (see table 4). Notably, for the larger projects 4 and 5, the certainty equivalent value is higher under the ad valorem and specific royalties than under the profit based royalties, reflecting the relatively low government tax take under the output based royalties.

With higher capital costs, each of the five hypothetical mining projects remains profitable before tax, although project profitability is reduced. While all projects are still assessed to be profitable under the profit based royalties, projects 1 and 2 are unprofitable under the 10 per cent ad valorem royalty and $100 a tonne specific royalty — that is, these projects switch from being economic before tax to uneconomic after tax, and tax revenue is zero under these options. Under the 5 per cent ad valorem royalty and $50 a tonne specific royalty, the certainty equivalent value of projects 1 and 2 is reduced significantly, but remains positive in each case.

Royalties with sliding scales (variable royalty rates)

In assessing minerals taxation options, governments compare the major advantages of ad valorem royalties — administrative simplicity and revenue stability — with the major advantages of profit based royalties — economic efficiency (for example, small mines are less likely to become uneconomic) and an expected larger government tax take (in present value terms).

A compromise approach, discussed briefly in section 3, is to adopt an ad valorem royalty with a sliding scale in the royalty rates based on profit (see figure 3). One difficulty with this approach is that information on profit is required to set the royalty rates. In practice, ad valorem royalty options have been adopted in various countries or jurisdictions with sliding scales based on price, production, sales or profit (see section 2). There are several issues that merit consideration by governments.

An ad valorem royalty will be more efficient (less distorting to mineral investment decisions) if the lower ad valorem royalty rate applies to lower profit mining projects. Sliding scales based on production or sales will reflect project profitability in the presence of economies of scale, although some smaller mines may also be relatively profitable.

An ad valorem royalty will result in a higher government tax take if the higher ad valorem royalty rate applies to higher profit mining projects. There will be efficiency losses, however, if the higher royalty rate also applies to lower profit mining projects that become uneconomic under the royalty arrangement.

Two further issues relate to the additional boundaries that are established in the policy framework through variable royalty rates. The sliding scale is set, increasing the likelihood that governments will adjust the fiscal settings over time in response to market changes. In addition, a sliding scale (or any boundary that has royalty implications) provides an economic incentive for mining companies to adopt strategies to avoid moving into a higher royalty bracket — thus, for example, transfer pricing may become a more significant issue under a sliding scale arrangement.

5. Concluding comments

A complex system of minerals taxation arrangements apply in the world economy. Royalty arrangements vary between countries, between jurisdictions in the one country and between minerals. Progress has been achieved in several areas, enabling governments to obtain a return to the community from mineral extraction while reducing negative industry impacts. For coal, metallic minerals and gemstones, profit based royalties have been adopted in some developed economies, including most jurisdictions in Canada and a single jurisdiction in Australia (the Northern Territory) and the United States (Nevada). Ad valorem royalties apply in Africa, Latin America and Asia/Pacific countries, although specific royalties still form an important part of the minerals taxation arrangements in China, India and Indonesia. Specific royalties mainly apply to high volume low value non-metallic minerals, particularly construction materials.

In this paper, several economic issues have been discussed that merit consideration by governments in assessing minerals taxation options. There appears to be significant scope for countries to achieve further progress in rationalising minerals taxation arrangements. It should be emphasised that the information presented in this paper is intended to inform policy makers about some major economic implications of key policy options. Some aspects of the assessment will rely on the subjective judgment of policy makers and the circumstances of the individual country or jurisdiction.

Appendix 1 World exports for selected major mineral commodities in 2006

Table 5: World exports for selected mineral commodities, 2006

		Developed economies		Other economies		
	UN code	Exports	Share of world	Exports	Share of world	World
		US$b	%	US$b	%	US$b
Coal	321	27.3	55.4	22.0	44.6	49.3
Ores and concentrates						
Iron ore and concentrates	281	14.8	45.1	18.0	54.9	32.8
Copper ores and concentrates	283	6.3	19.7	25.6	80.3	31.8
Nickel ores and concentrates	284	4.0	52.6	3.6	47.4	7.5
Aluminium ores and concentrates **a**	285	7.6	60.6	4.9	39.4	12.6
Ores and concentrates of base metals, nes	287	10.6	46.2	12.3	53.8	22.9
Total of above	-	43.2	40.1	64.4	59.9	107.6
Metals						
Silver, platinum **b**	681	19.8	55.7	15.7	44.3	35.5
Copper	682	46.7	42.1	64.1	57.9	110.8
Nickel	683	13.8	62.9	8.1	37.1	21.9
Aluminium	684	65.2	65.2	34.9	34.8	100.1
Lead	685	2.0	53.9	1.7	46.1	3.8
Zinc	686	8.6	54.7	7.1	45.3	15.7
Tin	687	0.7	19.1	2.7	80.9	3.4
Total of above	-	156.7	53.8	134.5	46.2	291.2
Total of above	-	227.2	50.7	220.9	49.3	448.1

a Including alumina. **b** Includes other metals of the platinum group.

Source: United Nations Commodity Trade Statistics, *Yearbook 2006* (available at http://comtrade.un.org/pb/).

Appendix 2 Assumptions for the hypothetical mining projects

Table 6: Production and cost assumptions for hypothetical resource projects

	Unit	Project 1	Project 2	Project 3	Project 4	Project 5
Value of production	$m	5	25	50	100	250
Price	$/t	1000	1000	1000	1000	1000
Resource size	kt	50	250	500	1000	5000
Mine life	no. years	10	10	10	10	20
Production	kt	5	25	50	100	250
Costs						
Exploration costs	$m	2	5	10	15	30
Capital costs a						
Lower capital costs	$m	10	50	100	200	500
Higher capital costs	$m	12.5	62.5	125	250	625
Operating costs	$m	2.5	12.5	20	30	50
Average operating costs	$/t	500	500	400	300	200

a Hypothetical resource projects are defined under two alternative assumptions for capital costs. The main simulation results are based on the assumption of lower capital costs.

Table 7: Assumptions for other variables and policy settings

	Unit	Assumption
Risk free interest rate	%	5
Inflation rate	%	3
Brown tax		
Tax rate	%	40
Resource rent tax		
Tax rate	%	40
Threshold rate		
Option 1 No risk premium	%	5
Option 2 With risk premium	%	10
Ad valorem royalty rate		
Option 1	%	10
Option 2	%	5
Specific royalty rate		
Option 1	$/t	100
Option 2	$/t	50

Table 8: Assumed probability distribution for the mineral price [a]

Price outcome	Probability	Price	Percentage change from price in year 0
	no.	$/t	%
Price 1	0.01	650	-35
Price 2	0.10	800	-20
Price 3	0.24	900	-10
Price 4	0.30	1000	0
Price 5	0.24	1100	10
Price 6	0.10	1200	20
Price 7	0.01	1350	35
Price in year 0		1000	
Expected price	-	1000	-

a For example, a price outcome of $1000 a tonne is assumed to have a probability of occurring of 0.3, or 30 per cent.

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