Income Equivalence and a Proposed Resource Rent Charge

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Abstract

We demonstrate the equivalence of various income-based charges when perfect certainty prevails, as well as deviations from equivalence under uncertainty. Some of these equivalences are known but the derivations of others, such as cases for two types of free equity, are not. These equivalences lay the foundation for a proposed Accrued Rent Charge (ARC) as an alternative to Resource Rent Taxes (RRT), both as proposed and implemented. We argue that the ARC may be preferred to the RRT because the timing of returns to investors (owners of reproducible capital) and owners of natural assets coincide. That is, returns accrue to owners of natural assets earlier in time with the ARC relative to the RRT. In addition, we argue that, while both charges are inefficient when there is uncertainty, the ARC may be relatively more administratively and economically efficient. Finally, we use simulations to compare the ARC to the RRT and to standard income charges and discuss the results.

Keywords: natural resource rents, natural resource taxation
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1. Introduction

Two objectives are served by this paper. First, we review a number of profit-based charges typically imposed on natural resource projects, and expand the number of charges that are equivalent relative to particular assumptions. This analysis is then used as the basis for a proposed "Accrued" Rent Charge (ARC) as an alternative to the Resource Rent Tax (RRT) and to other methods such as production sharing that are claimed to collect rent.¹

How governments collect revenue from natural resource projects² has been long debated.³ As well, mineral contracts between governments that own the resource base and producing entities have grown from relatively simple royalty-profit tax arrangements to complicated documents containing a range of instruments including royalties,⁴ production shares, RRTs, local employment requirements, and allocations of output for the domestic market.⁵ The increase in the complexity of contractual structures is correlated with economic criticisms about the claimed inefficiencies of royalties, which are traditionally based on either value or volume of extraction. The introduction of the Indonesian production sharing contract in the late 1970's and the RRT proposed by Garnaut and Clunies Ross (1983) that has been used in various forms since its inception (originally in Papua New Guinea and recently in Australian mining), are important markers for the change in both

¹ As Conrad, Hool and Nekipelov (2017) argue, the RRT is a poor instrument for capturing natural resource rents, however defined, because absent a royalty the RRT may distort extraction. Our purpose here is to propose a risk-sharing scheme that can be administered and that increases the likelihood that a resource-owning government is compensated for bearing a part of the risk associated with natural resource extraction projects.

² It is common to speak of taxation of rents, as in Garnaut and Clunies Ross (1983). We refrain from the use of this terminology, in part, because we believe the term has ambiguous meaning, particularly when the state owns the minerals in-situ. Some of the literature, such as Otto et. al. (2006), contains distinctions between Ricardian and Hotelling rents (or user costs). Furthermore, studies such as Adelman (1990) and Tilton (2003) provide evidence supporting the view that user costs (or the scarcity value of natural resources) are either low or zero. These claims are based on evidence about the behavior of natural resource producers who behave as if there is no forgone value from increased current extraction. Recently, however, this view has been questioned, particularly by Conrad, Hool and Nekipelov (2017) who note that such behavior by the firm is simply the result of the resource producer having no claim to the residual value of either the reserves or the real property that holds the reserves. This is not the case for the resource owner, however, who faces a tradeoff between the reduced value of the property, even absent physical exhaustion of the reserves, and increased payments for the use of the resource, including the right to extract. From this perspective, there is no economic difference between natural resources from other scarce productive factors such as capital and labor, making a "royalty" equal to the marginal value of the factor payment; effectively the wage paid for the use of the natural resource.

³ Helpful reviews of the large body of literature on this subject include Lund (2015), Otto et. al. (2006), and Daniel, Keen and McPherson (2010), among others.

⁴ See Conrad and Hool (1981) and the references cited therein for some of that literature. It should be noted that Conrad and Hool state that the distortionary effects of the royalty should be considered only after full costs, including the payment to the reserve owners, are included in the mining firm’s cost structure. Later summaries of distortionary effects of royalties include Otto et. al. (2006) and Boadway and Keen (2010) in addition to the criticisms of Garnaut and Clunies Ross (1983).

perception and application. The original Garnaut and Clunies Ross formulation was claimed to be based on risk aversion by producers and it appears that risk aversion on the part of citizens of a resource-endowed country was not considered. Economists now generally agree that the RRT is not neutral if for no other reason than the fact that the government does not engage in proportional risk sharing. The RRT and similar taxation approaches can be structured to be equivalent to a carried interest where there are incentives for the agent (the government in this case) to better align its objectives with those of the principal. By deferring compensation to later in the contract period and basing the compensation on some measure of surplus, the agent has an incentive to allow the principal to maximize the surplus. Economic rent is shared in a perfectly certain situation but there is asymmetric risk sharing because the agent’s lower bound for compensation is zero. The lack of appropriate risk sharing has led to proposals to use a more traditional Brown tax that is equivalent to an income tax with perfect loss offsets. Another concern about the RRT is that the payments to the government accrue, if at all, only after the investor has accrued a risk-adjusted return on a cash flow basis. The use of immediate expensing and full cost recovery, if undiscounted, is also a common feature of production sharing contracts. Such a result could leave the owner of a scarce productive factor, i.e., reserves, with little or no compensation in present value terms.

The ARC proposed here preserves the equivalence between economic rent and profit in a perfectly certain situation, similarly to the RRT, but payments to the government as the resource owner accure more rapidly because the ARC is essentially equivalent to the resource owner taking an equity position in the mining project. In effect, the resource owner is contributing the reserves to the project in exchange for an equity interest. Like under the RRT, an equity participant is now at risk for the value of contributed capital. Such an interpretation might be made for the RRT as well, but the essential difference between the two approaches is that the resource owner’s payments are equivalent to dividends as opposed to a carried interest. This interpretation is possible because of the equivalence between the net present value of cash flow and the net present value of “profit” measured on an accrual basis. Switching from cash flow to accrual will speed the payments to the resource owner because, like shareholders, the government will not have to wait until the investor’s (the other equity participant) capital is repaid (i.e., the adjusted basis of the assets becomes zero) before receiving a portion of income.

We begin our analysis by reviewing the equivalence between the net present values of cash flow and accrued income. We discuss the fact that the RRT in a perfectly certain situation is but one of a class of profit-based instruments – including the ARC, purchased equity, one particular type of free equity, a carried interest, and a particular type of withholding tax – that yields identical results. Although some of these equivalences are known (see, for example, Daniel et al. 2010), we believe the derivations for two types of free equity have not been previously demonstrated. We also discuss other commonly used tax instruments, such as the traditional profits taxes and withholding taxes, as well as various types of equity participation by the government. This discussion is central to our proposition that the RRT is but one of a series of instruments capable of yielding identical results, depending on the conditions. In addition, we believe it is important to separate form

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6 The government does not bear any of the downside risks with an RRT, where downside risks are defined as the part of the distribution of outcomes where the net present value of the project is non-positive. Under proportional risk sharing, risks would be borne in proportion to the share of gains (losses) between the government and the investor. See Lund (2009) for a review of this literature.

7 Traditional production sharing where costs are recovered before any surplus is shared is equivalent to an RRT with a zero discount rate (see Daniel (1995) and the discussion below).

8 Lund (2009).
(production sharing relative to the RRT or a free equity share) from economic substance. We believe that it is the economic substance that matters for the design of policy. For example, one issue raised by the equivalences is that it may not be reasonable for governments to impose two or three different charges (for example, profits tax and RRT as is done in Australia). If there is one particular instrument that yields an equivalent result at lower administrative costs, then there may be gains to all parties.

Uncertainty is what distinguishes the various instruments and so we then turn to risk sharing and our proposed Accrued Rent Charge (ARC). As noted above, payments under the ARC are equivalent to dividends, properly measured, and so is a return to the invested capital of the resource owner.\(^9\) We describe the ARC and use simulations to demonstrate the potential usefulness of the approach. It is shown that the resource owner begins to obtain revenue earlier in a mine’s life relative to the RRT, in general to coincide with the timing of income payments (dividends) to equity. In addition, holding the discount rate constant, the expected value of revenue to the government is greater with the same risk borne by the government. If the population of the resource-producing country is more risk averse relative to investors, then the ARC may be a more efficient instrument relative to the RRT. The analysis is completed by a summary and discussion.

2. Basic Accounting Identities

Define a special purpose entity (SPE) (for example, a mine) operated by one shareholder (for convenience) and financed with equity (for simplicity). The shareholder’s cash flow in any time period, \(t\) is:

\[
CF_{s,t} = -I_t + N_t + D_t
\]

Where:
- \(CF_{s,t}\) = Cash flow to shareholder
- \(I_t\) = Investment in SPE
- \(N_t\) = Repayments of capital from SPE
- \(D_t\) = Dividends paid by the SPE

In this framework, cash flow for the SPE in any time period \(t\) is zero because it is a conduit for the investor and is defined as:

\[
CF_{spe,t} = R_t - C_t - p_K K_t + I_t - N_t - D_t = R_t - C_t - p_K K_t - CF_{s,t} = 0
\]

Where:
- \(CF_{spe,t}\) = Cash flow to SPE
- \(R_t\) = Revenue
- \(C_t\) = Operating cost
- \(K_t\) = Investment in capital goods during the period
- \(p_K\) = Price of capital goods\(^{10}\)

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\(^9\) We note that although the ARC simulates equity participation by the government, actual equity participation in a particular project might be difficult to administer in the absence of highly liquid equity markets.

\(^{10}\) The price of capital goods, \(p_K\), is assumed to be constant across time for convenience. No capital gains or losses are created by the change in the relative price of capital goods.
Note that by definition:

\[ R_t - C_t - pK_t = -I_t + N_t + D_t \]  

What is not invested by the special purpose entity is distributed, or otherwise accrues, to the shareholder. The left-hand side of equation (3) will be defined as free cash flow for our purposes. In addition, \( R_t - C_t \) will be defined as operating cash flow. No assumption is made about the sign of either operating or free cash flow in any particular time period. By convention, \( N_t \) and \( D_t \) are nonnegative. Thus, when free cash flow is negative, then \( I_t \) must be positive. That is, a loss, either an operating loss or a free cash flow loss, results in additional investment.\(^{11}\)

Profit is defined on an accrual basis. For our purposes, the difference between cash and accrual has to do with how capital stocks are reflected on the shareholder's economic balance sheet, inclusive of opportunity cost, and how the resulting changes, the flows, are reflected in income.\(^{12}\) That is, investment costs are not deducted in the current period but are capitalized (as they should be) with accumulated interest. Rather, capital costs are reflected by economic depreciation (the capital gain or loss from holding the asset for one year) and the opportunity cost of capital. That is:\(^{13}\)

\[ \Pi_t = R_t - C_t - (r + \delta)S_t \]  

Where:

- \( \Pi_t \) = Economic profit of the SPE
- \( r \) = Shareholder's required return (assumed to be constant through time)
- \( \delta \) = Economic depreciation rate (assumed to be constant through time)\(^{14}\)
- \( S_t \) = Aggregate economic value (liquidation value) of the capital stock

\(^{11}\) This additional investment may take the form of additional cash outlays to keep the value of the balance sheet constant or as a type of accrued capital loss, in the case of an unanticipated operating loss. Such contributions might be construed to be shareholder loans, but the fact remains that with no third-party debt shareholders are effectively contributing equity. The amortization of the contributed equity will be the same as that assumed for capital assets more generally, or .

\(^{12}\) This is generally true. Receivables, payables, other accrued revenues (such as interest receivable), and expenses (wages payable) are assets, are reflected on the economic balance sheet, and are capital in an economic sense even though they are defined as short term.

\(^{13}\) In the general case, \( R_t \) and \( C_t \) would be measured on an accrual basis. Revenue and costs can be converted to accrual in equation (4) by having the capital stock include changes in receivables, payables, and cash. This generalization is not needed for the points developed below.

\(^{14}\) Neither the shareholder returns nor the economic depreciation rate is dependent on time. Capital gains and losses would be created if unanticipated changes in the shareholder return occurred. The exogenous depreciation rate assumes that the composition of the capital stock is the same across time.
For simplicity, assume that the SPE repays all free cash flow as either dividends or repayments of capital, which is amortized according to the depreciation schedule. Thus, assuming \( R_t - C_t \geq 0 \),

\[
(\delta + r)S_t + \Pi_t = R_t - C_t = N_t + D_t
\]

where:

\[
N_t \leq \delta S_t
\]

\[
D_t \geq r S_t + \Pi_t
\]

This implies that \( I_t = p_K K_t \) because:

\[
CF_{SPE,t} = R_t - C_t - p_K K_t + I_t - N_t - D_t = -p_K K_t + I_t = 0
\]

The above equation is a restatement of the fact that free cash flow is allocated between capital repayments and dividends. Given the convention that \( N_t \) and \( D_t \) are nonnegative, an operating cash flow loss is treated as additional investment (see above). Note that free cash flow can be positive even if economic profit is negative. In this case, a stacking rule is needed in order to determine the allocation of free cash flow between dividends and capital repayments:

\[
\begin{align*}
\text{If} & \quad r S_t > -\Pi_t \quad \text{then} \quad D_t > 0 \\
\text{If} & \quad r S_t - \Pi_t \leq 0 \quad \text{then} \quad N_t = R_t - C_t \leq S
\end{align*}
\]

Following accrual concepts, our stacking rule is that any free cash flow distributed to shareholders in periods when economic profits are negative is allocated first to capital repayments (in effect partial liquidations) and then to dividends to the extent that any free cash flow remains.\(^{15}\) Note that it is possible for dividends to be positive even in the case where economic profit is negative. Thus, dividends are defined in a more conventional sense where free cash flow is sufficient to recover economic depreciation but not sufficient to cover the net opportunity cost of capital.\(^{16}\)

\(^{15}\) In the United States, this is equivalent to the assumption that accumulated earnings and profits are zero, which would be the case if all positive cash flow were distributed to shareholders and economic depreciation were used to compute earnings and profits.

\(^{16}\) Note the importance of timing in relation to any definition of dividends. For instance, some countries define dividends to be any distribution from the entity to its shareholders in proportion to their economic interest (other than a liquidating distribution). See Hussey and Lubick (1996). Suppose the liquidation value of the SPE is zero. In this case, non-capital free equity is equivalent to true free equity because no distinction is made between repayment of capital and capital's return in any period other than the liquidation period. That is, dividends would be defined as \( (N_t + D_t) \); in effect, dividends would be defined as free cash flow before additional investment. We investigate the potential effect of different definitions below, given the importance of timing regarding the net-of-tax present value to the investor.
Given these definitions, it is easy to show that the net present value (NPV) of free cash flow is equal to the net present value of the shareholder's cash flow, which is equal to the net present value of profits, or:

\[
\begin{align*}
NPV_{spe} &= \sum_{t=1}^{T} \frac{R_t - C_t - p_k K_t}{(1 + r)^t} \\
NPV_{shareholders} &= \sum_{t=1}^{T} \frac{R_t - C_t - p_k K_t}{(1 + r)^t} \\
NPV_{fl} &= \sum_{t=1}^{T} \frac{R_t - C_t - p_k K_t}{(1 + r)^t}
\end{align*}
\]

(7)

3. Equivalences

3.1. Perfect Certainty

In a situation of perfect certainty, no investment will be made unless \( NPV \geq 0 \). In this case, some equivalences of various charges are demonstrated in this section. In particular, we show:

Result 1: In the absence of uncertainty, the following charges are equivalent:

Pure Profits Tax  
RRT  
Paid Equity  
Carried Interest (of two types, see below)  
Free Equity (of two types, see below)  
Traditional Profits Taxation  
Withholding Tax  
Production Sharing

The derivations and discussion are presented below. These equivalences are summarized in Table 1 and are discussed below.

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17 Garnaut and Clunies Ross (1983) claim that investor risk aversion is one reason for proposing the RRT. Their demonstrations reflect this concern by their assumption that a higher discount rate is applied to the present value computation. We note that, holding other things such as extraction constant, if risk is accurately reflected by simply increasing the discount rate, then the equivalences demonstrated in this section flow through to the risk-adjusted situation. This is not the forum to debate the wisdom of reflecting risk for a specific project by simply increasing the discount rate, but we note that the conditions under which such a result is correct are stringent. In particular, it implies that the risks associated with the expected cash flow in period \( t \) are \( (1 + \lambda)^t \), where \( \lambda \) is the risk-adjusted discount rate. Such a situation will not occur in cases where exploration can resolve some uncertainty about reserves in the early periods of the project, leaving relatively lower risks for later years. This example is only one of many examples that can be used to demonstrate that increasing the discount rate for risk is correct only in special cases.
3.1.1. Profits Taxes and Resource Rent Tax

In cases where $NPV \geq 0$, and this will always be the case in a world of perfect certainty if the project is undertaken, a proportional pure profits tax, imposed at rate $k$ based on accrued profits with either perfect loss carry forwards or negative taxes in periods of tax losses, is:

$$NPV_{ProfitsTax} = k \left( \sum_{t=1}^{T} \frac{R_t - C_t - (\delta + r)S_t}{(1+r)^t} \right) = kNPV$$  \hspace{1cm} (8)$$

A resource rent tax (RRT) at rate $k$ will accrue positive revenue for the government in any time period $j$ if the net present value of the cash flow up to and including the cash flow in period $j$ is positive. That is,

$$RRT_j = k(R_j - C_j - p_jK_j) > 0 \quad \text{if} \quad NPV_{j-1} = \sum_{h=0}^{j-1} \frac{R_h - C_h - p_hK_h}{(1+r)^h} \geq 0$$

and

$$RRT_j = k(R_j - C_j - p_jK_j) > 0 \quad \text{if} \quad NPV_{j-1} = \sum_{h=0}^{j-1} \frac{R_h - C_h - p_hK_h}{(1+r)^h} < 0$$  \hspace{1cm} (9)$$

If the RRT is refunded when cash flow is negative during periods after the NPV becomes positive, then:

$$PV_{RRT} = k \left( \sum_{h=M}^{T} \frac{R_h - C_h - p_hK_h}{(1+r)^h} \right) = kNPV$$

$$= k \left( \sum_{t=1}^{T} \frac{R_t - C_t - (\delta + r)S_t}{(1+r)^t} \right) = PV_{ProfitsTax} = kNPV$$  \hspace{1cm} (10)$$

where $M$ is the time period when RRT payment begins; that is, $M - 1$ is the last period where the cumulative $NPV < 0$.

3.1.2. Purchased Equity Participation

The RRT and a “pure” profits tax are also equivalent to purchased equity participation by the government in a proportion $k$, with the purchase being from government funds. By purchased equity, we mean that government pays a proportional amount of all investment costs on a cash basis at the same time as the investor. The equivalence with purchased equity is based on the assumption that the government’s opportunity cost is the same as the investor’s. In theory the government can collect taxes for the investment costs or sell bonds to finance the investment. Thus, purchased equity is nothing more than a constant $k$ times any of the three expressions in (8).
3.1.3. Carried Interest

Daniel (1995) has shown that a carried interest can be equivalent to the RRT. Thus, a carried interest can be equivalent to purchased equity and a pure profits tax. A carried interest is a situation where the investor lends the government funds for the investment in exchange for repayments via the government’s share of dividends and capital repayments until the loan is fully amortized. It is straightforward to show that such an arrangement is equivalent to an RRT and thus equivalent to purchased equity and a pure profits tax.

The government gets a loan from the investor in any period when investment, \( I_t \), is greater than zero. The present value of the total loan balance is:

\[
\bar{L} = k \sum_{j=1}^{T} \frac{I_j}{(1 + r)^j}
\]

The government also gets dividends and capital repayments generated from the project, the present value of which is:

\[
\bar{G} = k \sum_{j=1}^{T} \frac{N_j + D_j}{(1 + r)^j}
\]

The Government uses the capital repayments and dividends to repay the loan. Thus, in the end the Government, in present value terms, receives:

\[
\bar{G} - \bar{L} = k \sum_{j=1}^{T} \frac{-I_j + N_j + D_j}{(1 + r)^j} = kNPV_{shareholders}.
\]

3.1.4. True Free Equity

What we will call “True Free Equity” is the situation where the government gets shares of the special purpose entity without charge. That is, the government in any period receives assets (shares of stock) equal to:

\[
\text{Government Equity} = kI_t \quad (11)
\]

If the government retains an interest in the SPE, then it forgoes the opportunity to realize the value of this asset in cash. That is, the government incurs the forgone opportunity cost equal to the cash value of the capital transfer in exchange for a cash payment of dividends and capital repayments, in any period, equal to:

\[
k(N_t + D_t)
\]

Thus, from the government’s perspective, the net present value is identical to the NPV of a pure profits tax, RRT, and other equivalences noted above:
\[ \text{NPV}_{\text{Gov}} = k \left( \sum_{t=1}^{T} \frac{-I_t + N_t + D_t}{(1+r)^t} \right) = k \text{NPV}_{\text{spe}} \quad (12) \]

The investor’s reported balance sheet might record the total capital investment, but this is effectively an accounting error. What should be reported is the capital expenditure (presumably from cash in this case) plus an immediate capital loss equal to the proportional value of the investment transferred to the government. In effect, the investor is making a lump sum transfer to the government equal to the \( k \) share of NPV of the SPE on an accrual basis via the granting of free equity and this fact should be reflected on the economic balance sheet.

It might be the case that in conventional accounting the investor will carry the full value of the investment on the accounting balance sheet and thus it would appear that the NPV for the investor is:

\[ -\sum_{t=0}^{T} \left( \frac{I_t}{(1+r)^t} \right) + (1-k) \left( \sum_{t=0}^{T} \left( \frac{N_t + D_t}{(1+r)^t} \right) \right) = \text{NPV}_{\text{spe}} - k \left( \sum_{t=0}^{T} \left( \frac{N_t + D_t}{(1+r)^t} \right) \right) \quad (13) \]

This is correct, but only in the sense that there must be an offsetting adjustment in the investor’s balance sheet to reflect the capital loss. In effect, true free equity is equal, in present value terms, to the purchased equity plus the immediate capital gain realized at the time of the investment. In summary, a pure profits tax, purchased equity, and a carried interest are equivalent as long as the NPV is positive, while the government accrues a proportional share of the present value plus an initial capital gain under true free equity.

### 3.2. Equivalences: Capturing a Return to Equity

#### 3.2.1. Traditional Profits Taxes and Withholding Taxes on Distributions

Traditional profits taxes capture a portion of the return to equity capital, assuming that economic depreciation is allowed as part of the derivation of profits. The tax is imposed on both the return to equity and any economic surplus, which in the current case is defined to be dividends.

\[ kD_t = k(R_t - C_t - \delta S_t) = k \left( r_t \sum_{m=0}^{t-1} K_m + \Pi_t \right) \quad (14) \]

This result is also equivalent to withholding taxes or branch profits taxes, paid on actual or deemed distributions, as long as the definition of dividends is consistent with measures of accrued income.

Withholding taxes might be imposed on a different definition of dividends, however. For instance, dividends can be defined as any proportional distribution to shareholders other than a liquidation.\(^{19}\) In this case, the withholding tax is imposed on what, on an accrual basis, would be

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\(^{18}\) Through time the capital loss will be realized via a lower return on the total investment. That is, if free equity is 20% and the marginal return on investment is 10%, then the firm will realize an 8% return (or will adjust investment so the free-equity-inclusive return will be equal to 12.5%).

\(^{19}\) See Hussey and Lubick (1996).
both income and capital repayments. Such behavior results in withholding taxes being equivalent to true free equity described in the previous section.

3.2.2. “Non-Capital Free Equity”

Traditional profits taxes and withholding taxes are also equivalent to a type of “free equity,” which we will call “non-capital free equity.” This is a situation in which the government allows the investor to recover the full value of the capital stock for profits tax purposes. Shares of the stock are issued to the government, but the investor’s tax balance sheet carries the full value of the investment and the investor can recover that basis. The government’s equity has a zero basis for accounting (although not economic) purposes and the government is not allowed any depreciation for tax, or economic, purposes. This type of free equity is a type of carried interest with a zero interest rate. That is, the investor’s balance sheet could include its proportional interest in the equity plus a loan equal to the government’s share and the loan is amortized at zero interest and repaid in accordance with economic depreciation.

In this case, the shareholders’ NPV after the non-capital free equity payment is:

\[
NPV_s^* = \sum_{t=0}^{T} \frac{-I_t + N_t + (1-k)R_t S_t}{(1+r)^t}; \text{ if government receives } kD_t
\]

3.2.3. Production Sharing and Traditional Profits Tax

Pure production sharing is a system in which the investor earns a return of all capital costs on a cash flow basis. Thus, a traditional production sharing contract (Indonesia for example) as well as a carried interest at a zero interest rate (or equivalently the RRT at a zero compound factor) is equivalent to the present value of the pure profits tax.

4. Risk Sharing: The ARC and Other Methods Compared

Our second result is that what is equivalent under perfect certainty may not be equivalent when risk sharing is considered. Now two things matter with respect to payment form: the expected value of the payment in NPV terms and risk sharing. For instance, purchased equity is known to be an efficient risk-sharing method, but the RRT, our proposed ARC, and other profits-based methods in practice may not have properties identical or even similar to purchased equity. For current purposes, equivalence in the presence of uncertainty means that both the expected value and standard deviation of the net present value are the same for two payment schemes.

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20 If the government’s basis is equal to its proportional share of the investment (with the investor taking an immediate loss) and the government is taxable (as it should be), then the profits tax is simply an additional neutral charge.

21 We define efficient risk sharing where the marginal rates of substitution between risk and return are equal for those who share in a project’s risk. Equity participation is known to have such potential. Using current notation, the proportion \( k \), can be used to adjust the relative shares to establish the efficient tradeoff. See Leland (1978). In addition, and unlike Garnaut and Clunies Ross (1983) and others, we do not assume that the government is risk neutral. In fact, there are reasons to believe that the shareholders of large diversified firms may have lower costs of risk bearing relative to the citizens of poor, undiversified economies with costly access to international capital markets. In addition, a relatively low \( k \) for government may provide stronger efficiency incentives for the investor.
Differences arise at least in part because of different timing of cash flows to the government and the investor. For instance, autocorrelation might be introduced into the system when loss carry forwards and carry backs are allowed because they affect the value basis for the government’s share. That is, the basis for the government’s share in any period may be conditional on values in other periods and, in addition, the government may have a lower bound on its return (usually zero) under some payment regimes.

As noted, it should be clear that regimes with identical mathematical structures will result in equivalent outcomes. This means that as a matter of method, five regimes – Purchased Equity, Pure Profits Tax, Pure Free Equity, Pure Carried Interest, and a Pure RRT – will have identical results. Note that the modifier “Pure” has been added to the terms because no methodologically pure method can be applied in actual situations. Governments must share the losses in order for there to be risk sharing identical to that found with equity sharing arrangements. As well, book income accounting as practiced differs from economic accounting, and related party transactions exist which means that even cash flow accounting to be employed in instruments like the RRT are only approximations. Our emphasis is on application, and so we restrict our analysis to examples of commonly used regimes in addition to the practical application of the ARC. In practical situations, it is possible for regimes with different names to have identical outcomes when there is randomness of some type. In particular, identical results will arise with a dividend withholding tax, and free equity when dividends are defined to exclude capital repayments. This means that the number of structures examined in the last section is reduced to six:

1. Case 1: Purchased Equity Sharing,
2. Case 2: Pure Profits Tax (no negative tax),
3. Case 3: RRT (with no refund and no carry back),
4. Case 4: Free Equity and Dividend Withholding (using depreciation based on book value as opposed to economic depreciation) and Traditional Profits Tax (no carry back and no refund)
5. Case 5: Dividend Withholding (using the free cash flow definition of dividends), and

Part of the impetus for schemes such as the RRT is risk sharing. There may be significant risks to mining and fiscal regimes that accrue significant government shares of expected NPV without compensating investors for risk that may deter investment. There is a second part to risk sharing, however, and that is the relative cost of risk bearing both in total and at the margin. Those advocating instruments such as the RRT seem to be implicitly assuming that the government of a resource-rich economy is risk neutral so that only the investor bears the cost of risk. This may or may not be the case. The stockholders of the investors may have both higher wealth and easier access to relatively cheap diversification via international capital markets than the citizens of a low-income resource-dependent economy. It is certainly the case that the investors’ risks associated with any particular mining project in a given country can be diversified. At the same time, the government of a relatively small country with only a limited number of mining projects might find it difficult to diversify its risks related to mining. Thus, the cost of risk bearing may be relevant for both governments and investors.

22 We have assumed that the SPE’s losses will be borne by the shareholder. This might mean that the shareholder will pay even if bankruptcy is an option for the SPE and the investor’s liability is limited.

23 See Garnaut and Clunies Ross (1983) and a more recent statement by Hogan and Goldsworthy (2010).
One concern with the RRT is that the resource-owning country could have a perfect RRT and never receive any revenue either because of bad luck or the fact that the resource producer has an incentive to drive the value of the marginal product of the reserves to zero (see Conrad, Hool and Nekipelov 2017). That is, a country might have 1 billion barrels of oil which could be extracted under a perfect RRT and the country would receive zero because the NPV is zero; the investment is marginal. We believe it is counterintuitive for a country to have significant reserves of a supposedly valuable asset and never be compensated for it because that factor is always treated as being in excess supply economically speaking.24 Such results are generally not the case with other payment structures, as shown below.

Even if the RRT generates positive payments to the government, the payments accrue generally later than under pure risk sharing, pure income taxation, and most other profits-related tax instruments. One way to preserve the “rent” notion but speed up the potential payments is to exploit the similarities between the RRT and pure profits taxation in an applied environment. That is, instead of using discounted cash flow as the basis for the charge, the charge can be based on accrued net income. After all, dividends are based on net income, not cash flow, and stockholders are not waiting for the repayment of their capital before receiving part of “income.” The state may operate in the same way.

In particular, we propose the following Accrued Rent Charge (ARC) that is equivalent, we believe, to the state receiving dividends where dividends are defined relative to economic concepts, to the extent that such concepts can be implemented in practice, as opposed to accounting concepts. The steps necessary to develop the ARC include:

1. Create one pooled account for all preproduction expenses and a second account for all capital expenses after production commences.25

2. Impose a “placed-in-service” rule combined with capitalized interest for all preproduction expenses. All capital expenses will be amortized during the production period. Accrued expenditures during the preproduction period are added to the balance and accrued interest is added to the balance of the pooled preproduction account.

3. Use the unit-of-production method (or a declining balance method for a specified time period) once production begins to amortize the balances both capital accounts.

4. Disallow any additional accumulated interest on the capital balance once production begins.

24 Of course, investors gamble every day and risk losing it all. Thus, it might be reasonable for a country to never receive any compensation for investing its valuable assets. Our point, however, is that undertaking the risks of losing it all should be made with a reasonable understanding of the opportunity cost involved. That is, if the value of reserves is greater than zero, then risking it all is not costless.

25 Alternatively, all tangible personal property and real assets could be grouped into different asset accounts with different depreciation rates. The present value of the error resulting from using one pooled account will depend on the differences between the economic asset lives of the property relative to the asset life of the pool.
5. Reduce the balance of the unified mineral expenditure account by the amount of the accrued depreciation and increase the account by any additional accrued capital expenditure made during the accounting period. (Effectively, assume that the placed-in-service date is equivalent to the date capital expenses accrue once production begins.)

6. Compute profit during the accounting period, the basis for the charge, as accrued revenue less the following:
   a. accrued cost,
   b. depreciation,
   c. royalties,
   d. the investor’s capital cost (capital costs are derived as the product of the investor’s nominal cost of capital and the current asset basis), and
   e. any compounded accumulated loss carry forward.

7. Disallow a deduction for loan interest expense because such a deduction would be double counting. The full cost of capital is deducted in step six.

8. If the base of the charge is greater than zero, then impose and collect the charge.

9. If the base of the charge is negative, then allow unlimited accumulated loss carry forwards multiplied by the nominal return on equity capital.

10. Use the market-determined cost of equity capital for investors who have shares traded on markets. Use the industry average cost of equity capital for investors who do not have shares traded on markets.26

11. Compute all values in nominal terms, including the investor’s cost of capital. Thus, there is no need for additional inflation adjustments during the investment period.27

12. Adjust for inflation in the pooled depreciation accounts during the production period by multiplying the ending balance of the pooled account by a measure of inflation (such as the U.S. GDP Deflator, if accounts are measured in dollars). No other inflation adjustments should be necessary because there is no interest deduction and the value used to measure the cost of equity capital should be nominal.28

26 Some averaging over several years might be necessary to smooth the observed returns.
27 This is one of at least two methods to adjust income for inflation over a time period. One alternative is to adjust the asset basis for inflation each period and then apply a real capital charge. The present value of either approach is the same, but “income” accrues sooner under the proposed method.
28 The charge should be ring fenced. In addition, we would disallow any head office charges, overhead attributions, overriding royalty payments, and other related party payments based on fixed costs (such as payments for royalties for technology). Ring fencing may not be necessary for income tax purposes, depending on the policy. One common justification for ring fencing the income tax is to insulate positive taxable income from one property from exploration and development losses from other properties. The need for such protection depends on the amortization policy. If income tax rules follow principles for economic income, then such expenditures would be capitalized (or become part of a unified basis for amortization through time), mitigating the need for ring fencing.
As a practical matter, we believe the steps necessary for computing the ARC are no more onerous administratively than the RRT imposed on the measure of book income, adjusted for inflation. A comparison of the similarities and differences in the necessary computations for some of the basic profit-based measures is found in Table 2. In addition, because the base of the ARC can be determined relative to other pre-existing measures such as the base of the profits tax, the amount of additional detail is relatively straightforward. Finally, note is made of the fact that accrual accounting is easier to administer relative to cash accounting because it is based on accounting documentation, which is the theoretical basis for the RRT. Cash accounting is also based on accounting documentation, but then there must be a matching of cash receipts with the accounting documentation.

In addition to comparing our proposed ARC to the RRT, we believe it is useful to compare both our proposal and the RRT to the other four cases described above. This approach will enable a more complete presentation of the possible options.

In general, we are not aware of any other equivalences, although there might be some other equivalences given particular facts and circumstances. These results and others are illustrated by the simulations discussed below.

4.1. Simulation Results

In order to illustrate numerically the nature of the potential outcomes, the cash flows from a simple mine are used to compute the expected values and risk (measured using the coefficient of variation). Table 3 contains the cash flow developed for the illustration. Our intention is to

29 Reference is made to contracts such as the contract between Rio Tinto and the Government of Guinea, particularly the accounting appendix. It should be noted that the amount of technical detail required for any fiscal regime can be significant because of the need to define various computations, the bases for each payment, timing, and other aspects such as how output is defined.

30 As a practical matter, the basis of the RRT is more likely cash flow attributable to a project and not the firm’s actual cash flow. Much mineral investment is made by subsidiaries of multinational firms and so the actual cash flowing through the accounts of the subsidiary may bear little relation to the cash flow attributable to the project. For example, output sales may be to a marketing subsidiary, offshore, and based on a transfer price. Given the relationship between the parties, it is possible for there to be no payment for the sales. In fact, the only cash flow of the subsidiaries may be the foreign exchange necessary to pay the domestic expenses plus the value of related party assets contributed to, or from, the subsidiary.

31 For example, sales may be made on an accrual basis and so the receipt of cash must be matched with the particular sale at the time of the cash payment. Such tracking is necessary for governments because of the need to determine the differences between items of income and capital contributions, or distributions. That is, if a domestic subsidiary makes an allowable payment to a parent (or related) company, then for RRT purposes it is necessary to make a determination about whether the payment is from net cash flow. Such determinations are made on an accrual basis for profit, in general, and for the ARC in particular. That is, the ARC is imposed on net income, as defined, regardless of whether any payments are made to the related party.
compute the effect of various instruments on the ex post distribution of NPVs to each party described above.\textsuperscript{32}

The first step in this process is to determine the rates that equilibrate the ex-ante NPV shares between the government and investor for the project with our parameters. One way to think of this situation is that the government and the investor are negotiating a contract for a specific property within the parameters of our project. There is an agreement about how much each party will receive, given the expected values of the parameters. We measure the ex-ante payments to each party in terms of NPV shares. Thus, the issue is how the risks are shared under each of the contractual regimes. This means that the rates for each charge are set so that the shares accruing to both parties are constant.

For convenience and purposes of illustration, we assume that the objective is for the government to obtain one half of the ex-ante expected NPV. These results are illustrated in Table 4. Note the following results for the rates:

1. Contemporaneous loss offsets are allowed with the pure profits tax. Thus, the rate that sets the government’s share at 50% is identical to both the RRT and equity participation.\textsuperscript{33}

2. The low rate for Case 4, free equity and dividend withholding on a cash flow basis, results because the government’s free equity means that the government claims both income and repayments of capital; repayments for which it does not pay.

3. The low rate for Case 5, dividend withholding using a free cash flow definition, results for a reason similar to the relatively low rate in Case 4. Defining dividends as all payments to shareholders except liquidating distributions implies that withholding taxes are paid on both repayments of initial capital investments and real economic income. In effect, the government uses the withholding tax as a type of free equity when the dividends are defined in this manner.

Given the rates, the issue becomes how the risks are shared; we used a Monte Carlo simulation to determine the various outcomes.\textsuperscript{34} Uncertainty is introduced by assuming, again for purposes of illustration, that the output price is log normally distributed, with a mean of 80 and a standard deviation of 40 with zero autocorrelation across time. Results for 1,000 iterations are reported in Table 5.

Table 5 contains the means and standard deviations for the investor and government as well as the coefficient of variation and the probability that the NPV is non-negative. In addition, the

\textsuperscript{32} Ten alternatives are described in Table 1 but we noted that five (Pure Profits Tax, Purchased Equity, Pure Free Equity, Pure Carried Interest, and a Pure RRT) yield identical results. Therefore, the Pure Profits Tax is included in the analysis as a representative outcome for these five regimes, leaving six separate alternatives to compare.

\textsuperscript{33} In general, a pure income tax with no negative tax and an RRT with no refunds or carry back might require less than 50\% rates for the government to obtain 50\% of NPV. This is because negative returns sometimes could take place in the last or close-to-last tax periods and the investor would not be able to carry forward all of the losses. In our simulations, however, this situation never occurred.

\textsuperscript{34} Crystal Ball software package was used to compute the simulations.
ratio of the coefficient of variation of the investor and the government to the coefficient of variation for the project as a whole is reported. This is a convenient summary statistic. If risk sharing is proportional, then this ratio should be one. If the ratio is less than one, then the participant will bear less risk in proportion to the expected present value. The opposite result will be the case when the ratio is greater than one: the participant will bear more risk in proportion to the NPV. The pure profits tax, equity participation, and pure cash flow taxation exhibit proportional risk sharing.

The other options are based on rules commonly applied in practice. That is, carry backs are no longer commonly employed and are not used at all in most RRT and production sharing regimes. Negative taxes (after adjusting for any carry forward or carry back) are not paid to the investor in most instances. In general, the government bears lower risk and captures a higher return under the options as commonly applied. This is no surprise. Placing a lower bound for government exposure (at zero) and limited carry forwards and carry backs will mean that, other things equal, the government will capture the upside only. In general, such methods are inefficient absent administrative costs. The similarity between production sharing with dividend withholding (or free equity), although not perfect, should be noted. Production sharing captures undiscounted net cumulative gains and a dividend withholding tax captures only net gains computed on a per annum basis. Thus, there is a timing difference and the effect of cumulative loss carry forwards is responsible for the small difference. In cases commonly analyzed, a period of negative cash flow is followed by a period of positive income, and the difference between production sharing and free equity/withholding is reduced to simply timing of depreciation repayments.

Note that the regimes, other than proportional risk sharing, increase the risk to be shared between the two parties. That is, because risk sharing is not perfect, the risk (measured as a standard deviation) of the sum of the parts is greater than the risk for the project as a whole. With respect to the various withholding taxes and the profits tax, note that the rate is significantly lower than 50% ex ante, so it is natural for the government to bear proportionally less risk. The fact that the probability of zero revenue for the government is zero accounts for the government's relatively higher expected net present value.

Finally, note that the expected NPV to the resource owner (the government) is higher with our proposed ARC than with the RRT or even production sharing. In addition, the government bears less risk with the ARC relative to the RRT and bears a bit more risk relative to production sharing. These results reflect timing differences. The ARC will generally accrue government revenue earlier relative to either production sharing or the RRT. Both of these properties may benefit the government. In particular, the government and the private shareholders will begin to accrue payments at roughly the same time (absent transfer pricing). Thus, the population's and the shareholders' interest are more in accord with respect to timing. This may be important because part of the justification for using a profits-based charge is to capture the return from a depleting asset. Thus, having payments to reproducible capital and to natural resource capital coincide in time has appeal. The government can point to the fact that the shareholders (the ultimate shareholders, not the parent company) get returns at the same time as the government as trustee for the reserves. The fact that risk for the investor is a bit higher, while the total risk to be shared is lower, with the ARC relative to the RRT may indicate that there could be gains from trade between two risk averse parties – the citizens of the country holding the reserves who are subject to risky returns and the shareholders who accrue an uncertain return from their invested capital.

5. Summary and Discussion
We have reviewed the basic relationships between the Net Present Values and Economic Income of different ways the government can share in the returns to mining, whether or not the government owns the reserves. This review has produced two main results. First, we identified equivalences between various charges used in natural resource contracts. Second, we proposed an alternative to the current Resource Rent Tax, the Accrued Rent Charge (ARC). Under our proposal, the government and shareholder interests are better aligned, particularly with respect to risk. In effect, we are taking advantage of the fact that the measure of the entity's income is not total profit from the operation. Recall that most analyses of natural resource economics are concerned with the firm’s present value after payments to the resource owner, which when measured on an accrual basis, is:

\[ NPV_N = \sum_{t=1}^{T} \frac{R_t - C_t - (r + \delta)S_t}{(1 + r)^t} \]  

(16)

We suggest, however, that the total NPV includes the opportunity cost of using the reserves by the government, or:

\[ NPV_N = \sum_{t=1}^{T} \frac{R_t - C_t - (r + \delta)S_t - \rho_t Z_t(x_t)}{(1 + r)^t} \]

where \( \rho_t \) is the opportunity cost of extraction on the part of the resource owner at time \( t \), \( Z_t \) denotes resource owner's valuation of reserves at time \( t \), and \( x_t \) is the stock of reserves at time \( t \).

Note that the value function for the natural resource owner serves the same purpose as the value function of the capital stock owner, so the opportunity cost per unit is the combined value of the return from holding a particular type of capital and the depreciation (depletion) of that type of capital.

Thus, in effect the total assets of the entire enterprise at any point in time is the value of the reproducible capital plus the value of the in-situ reserves and the land (or ocean) that contains those reserves. Therefore, the ARC rate can be thought of as the proportion of the initial reserve value to the total assets of the entire enterprise, or \( \frac{Z_0}{Z_0 + S_0} \). So the ARC is equivalent, if perfectly measured, to the state’s equity participation, making the analogy with shareholders complete. The citizens of a country would be getting returns from holding a scarce resource, reserves in the ground, at the same time as shareholders receive dividends, at least when dividends are defined as payments from after-tax income. The present value of revenue is higher and the government’s risk sharing is the same under the ARC relative to the RRT when the rates are the same. This means that the government can accrue the same ex ante present value of revenue with lower risk relative to the RRT with a lower rate, making the ARC potentially more efficient relative to the RRT.

With respect to the first point, the equivalence of charges raises the issue of why countries impose two or even three similar charges. Australia, for instance, has imposed a profits tax and an RRT. Some countries, such as Mongolia, seek free equity, profits tax, and even excess profits taxes. We believe that these redundant charges may be neither desirable nor useful. Even if the policy intent of the charge differs, it is difficult to see why governments would devote significant resources to administering charges that have the same basic results, although the annual information flows might be different. For instance, if Mongolia wants to use an income charge to tax the return to invested capital and to capture natural resource rent, however defined, then it might be
administratively less cumbersome to simply require separate corporate reporting by project, use the same measure of the base, and impose three differentiated rates: one for the generally applicable corporate tax, one for the resource “Rent” charge, and still another for free equity.\textsuperscript{35}

With regard to the second point, we find the RRT neither efficient nor desirable as a policy instrument for most governments. First, Conrad, Hool and Nekipelov (2017) have shown that an RRT is inefficient because it does not provide for pricing a scarce factor of production – the reserves in the ground. In a policy environment, we believe that claiming that the returns to resource ownership are “rent” may distort perceptions and lead to the misguided conclusion that the social opportunity cost of extraction for a resource-rich country is zero (reserves are in excess supply) – an immediate implication of the application of the RRT in its pure form. Second, we believe that the RRT is undesirable absent a royalty because shareholders get a competitive return to their assets, perhaps adjusted for risk, before the resource owners (the citizens of a country) get any return from their assets (the reserves in the ground) as is the case with the RRT implemented in Norway and the UK.\textsuperscript{36} From an economic perspective, the return from a mine is the total return to both reproducible and natural capital. Natural capital is just that: capital. There is no need to discriminate against the owners of one type of equity capital by placing them at the end of a queue a priori. Risk is not a justification in our view because the returns to natural capital are just as risky as the returns to physical capital when both are combined in one project. In addition, there are ways for both owners of natural capital and investment capital to diversify the idiosyncratic risk associated with a particular mine.

The ARC has the same undesirable trait absent the royalty. Our proposal, however, restores some balance with respect to the return to equity capital. Owners of shares in the mining firm and owners of natural capital accrue returns at the same time. Both bear risk that the mine will have a negative NPV (the NPV of the investment in the reproducible capital stock and the opportunity cost (total) of owning mineral reserves) and both will share the gains proportionally if the rate is constant. The fact that the government can collect the same ex ante revenue with lower risk and with a rate lower than the RRT may further increase the potential efficiency gains of the ARC. In summary, natural capital is one factor of production and equity ownership in natural capital is identical to the ownership of shares in a mining firm. At a minimum, our proposal restores some basic symmetry to joint ventures and hopefully will be an aid in understanding the importance of computing returns accruing from mineral resources.

\textsuperscript{35} Such a supplemental charge might be imposed on a ring-fenced basis.

\textsuperscript{36} We know that carried interests (such as the RRT) are not unique to natural resources. Such schemes are common in finance and, to some extent, venture capital. Carried interests can serve as a commitment device to help make the interests of the agent coincide with those of the principal. In addition, these schemes are sometimes used when one party contributes financial capital and another party contributes an asset (a natural resource stock, intellectual property, or other assets) of unknown value to a joint venture. We believe that both properties might be relevant for governments owning natural resources as long as the population understands that alternative contractual forms exist. In addition, usually neither the greediest Wall Street investment banker nor the poorest entrepreneur with an idea but no capital agrees to a carried interest as their sole source of compensation. The same point might apply to natural resource owners.
Table 1
Profit Tax Equivalences
Perfect Certainty

<table>
<thead>
<tr>
<th>Pure Profits Tax</th>
<th>Government Revenue in any Period $t$</th>
<th>Present Value of Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k(R_t - C_t - (\delta + r)S_t)$</td>
<td>$k \sum_{t=0}^{T} \frac{R_t - C_t - (\delta + r)S_t}{(1 + r)^t}$</td>
<td></td>
</tr>
</tbody>
</table>

| Resource Rent Tax | $k(R_t - C_t - pK_k)$ if $NPV > 0$ and $R_t - C_t - pK_k > 0$, 0 otherwise | $k \sum_{h=M}^{T} \frac{R_h - C_h - p_h K_h}{(1 + r)^h} = k \sum_{t=0}^{T} \frac{R_t - C_t - (\delta + r)S_t}{(1 + r)^t}$ if $NPV > 0$ |

| Paid Equity | $k(-I_t + N_t + D_t) = k(R_t - C_t - (\delta + r)S_t)$ | $k \sum_{t=0}^{T} \frac{R_t - C_t - (\delta + r)S_t}{(1 + r)^t}$ |

| Carried Interest | $= 0$ if $L_t = k \sum_{j=0}^{t-1} (I_j - N_j - D_j)(1 + r)^j > 0$, $k(R_t - C_t - (\delta + r)S_t)$ otherwise | $k \sum_{h=M}^{T} \frac{R_h - C_h - E_h}{(1 + r)^t} = k \sum_{t=0}^{T} \frac{R_t - C_t - (\delta + r)S_t}{(1 + r)^t}$ |

| Free Equity Type 1 | $k(N_t + D_t)$ | $k \sum_{t=0}^{T} \frac{N_t + D_t}{(1 + r)^t} = k \text{NPV}_{SPE} + \sum_{t=0}^{T} \frac{I_t}{(1 + r)^t}$ |

---

37 Perfect loss offsets are assumed. The loss offset is either via a refund for the negative tax periods where economic profit is zero or via perfect carry forwards and carry backs including the opportunity cost of capital.
Table 1 (continued)

<table>
<thead>
<tr>
<th>Government Revenue in any Period $t$</th>
<th>Present Value of Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traditional Profits Tax</strong></td>
<td></td>
</tr>
<tr>
<td>$kD_t = \begin{cases} 0 &amp; \text{if } k(R_t - C_t - \delta S_t) = k \left( \sum_{m=0}^{t-1} rS_m + \Pi_t \right) &lt; 0 \ k(R_t - C_t - \delta S_t) = k \left( \sum_{m=0}^{t-1} rS_m + \Pi_t \right) &amp; \text{otherwise} \end{cases}$</td>
<td>when RHS $&gt; 0$</td>
</tr>
<tr>
<td><strong>Withholding Tax</strong></td>
<td>$kD_t$</td>
</tr>
<tr>
<td><strong>Type 2 Free Equity</strong></td>
<td>$kD_t$</td>
</tr>
<tr>
<td><strong>Production Sharing</strong></td>
<td>$k(R_t - C_t - p_k K_t) = \sum_{j=0}^{t} (R_j - C_j - p_k K_j) &gt; 0$</td>
</tr>
<tr>
<td></td>
<td>and $R_t - C_t - p_k K_t &gt; 0$</td>
</tr>
<tr>
<td></td>
<td>0 otherwise</td>
</tr>
<tr>
<td><strong>Carried Interest at Zero Interest Rate</strong></td>
<td>Same as Production Sharing</td>
</tr>
</tbody>
</table>
Table 2
Comparison of Computational Provisions

<table>
<thead>
<tr>
<th>Item</th>
<th>Case 1 ARC-Equity Sharing</th>
<th>Case 2 Pure Profits Tax</th>
<th>Case 3 RRT</th>
<th>Case 4 Free Equity and Dividend Withholding</th>
<th>Case 5 Dividend Withholding</th>
<th>Case 6 Production Sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Capital Expenditures</td>
<td>Two Pools and Capitalized (Preproduction and Operating Period)</td>
<td>Classification by Assets and Capitalized</td>
<td>One Pool</td>
<td>Classification by Asset and Capitalized</td>
<td>Classification by Asset and Capitalized</td>
<td>One Pool</td>
</tr>
<tr>
<td>2 Depreciation</td>
<td>Capitalized during preproduction with interest and placed-in-service rule during production period</td>
<td>Amortized based on placed-in-service rules using economic depreciation rates</td>
<td>Expensed</td>
<td>Amortized by asset classification using book depreciation rates</td>
<td>Same as Case 4</td>
<td>Expensed</td>
</tr>
<tr>
<td>3 Basis of Accounting</td>
<td>Accrual</td>
<td>Accrual</td>
<td>Cash</td>
<td>Accrual</td>
<td>Accrual</td>
<td>Cash</td>
</tr>
<tr>
<td>4 Treatment of Interest on Loans</td>
<td>Not-Deductible</td>
<td>Deductible</td>
<td>Not-Deductible</td>
<td>Deductible</td>
<td>Deductible</td>
<td>Not-Deductible</td>
</tr>
</tbody>
</table>

---

38 A pure cash flow tax (such as the Brown Tax) would not allow interest deductions. The equivalent alternative would be to include loans as cash-in and then allow a deduction for principal and interest. In this case, the present value would be unaffected if the interest rate for loans is the same as the discount rate used in computing the RRT.
<table>
<thead>
<tr>
<th>Item</th>
<th>Case 1 ARC-Equity Sharing</th>
<th>Case 2 Pure Profits Tax</th>
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<th>Case 5 Dividend Withholding</th>
<th>Case 6 Production Sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Loss Carry Forward</td>
<td>Unlimited</td>
<td>None</td>
<td>Unlimited</td>
<td>None</td>
<td>None</td>
<td>Unlimited^39</td>
</tr>
<tr>
<td>6 Interest on Carryforwards</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>7 Inflation Adjustment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes^40</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

^39 In the general case, there would be unlimited loss carry forwards. Some countries, such as Mongolia, may limit loss carry forwards as a means to limit revenue losses.

^40 Either carry forwards need to be adjusted for inflation and compounded using a real risk-adjusted interest rate or one must assume that the nominal risk-adjusted rate chosen includes expected inflation.
Table 3
Extraction, Revenues, Cost and Net Cash Flow (Government Payment Inclusive)*

Assumptions: Inflation: 2% Per Annum
Real Interest Rate: 12%
Nominal Interest Rate: 14.24%

<table>
<thead>
<tr>
<th>Time</th>
<th>Extraction</th>
<th>Price</th>
<th>Cash In</th>
<th>Cash Receipts</th>
<th>Factor</th>
<th>Cash Out</th>
<th>Investment</th>
<th>Operating Costs</th>
<th>Net Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>100.00</td>
<td>-</td>
<td>-</td>
<td>6.00</td>
<td>600,000.00</td>
<td>(600,000.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>102.00</td>
<td>-</td>
<td>-</td>
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*Cash Receipts, Investment, Operating Costs, and Net Cash Flow are measured in thousands of US Dollars.
### Table 4
Rates for Each Instrument Necessary for Government to Obtain 50% of NPV

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<tr>
<th>Case #</th>
<th>Type of Instrument</th>
<th>Rate</th>
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<tbody>
<tr>
<td>1</td>
<td>Purchased Equity Sharing</td>
<td>50.00%</td>
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<tr>
<td>2</td>
<td>Pure Profits Tax (No Negative Tax)</td>
<td>50.00%</td>
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<tr>
<td>3</td>
<td>RRT (with no refund and no carry back)</td>
<td>50.00%</td>
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<tr>
<td>4</td>
<td>Traditional Profits Tax (no carry back and no refund); Free Equity: Dividend Withholding (using depreciation based on book value as opposed to economic depreciation)</td>
<td>17.97%</td>
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<td>5</td>
<td>Dividend Withholding (using the free cash flow definition of dividends)</td>
<td>13.78%</td>
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<td>Production Sharing (no carry back)</td>
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<td>Item</td>
<td>Expected Value</td>
<td>Standard Deviation</td>
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<td>Total Project</td>
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<td>5,600,907.20</td>
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<td>Proposed Charge (ARC)</td>
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<tr>
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<td>Case 2: Pure Profits Tax</td>
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<td>Case 3: Resource Rent Tax (RRT)</td>
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Case 6: Production Sharing (No carry back)

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* The average intertemporal correlation between output prices was 0.84 with a standard deviation of 0.12.
Acknowledgements

We express our appreciation to Ms. Gina Brosius for editing and research assistance. As well, we thank an anonymous referee who suggested a number of improvements to an earlier draft. The usual disclaimer applies.

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