## Introduction

The purpose of this report is to provide cost of capital formulae for assessing the effects of taxation on the incentive to invest in oil and gas industries in Canada.

The analysis is based on the assumption that businesses invest in capital until the after-tax rate of return on capital is equal to the tax-adjusted cost of capital. The cost of capital in absence of taxation is the inflation-adjusted cost of finance. The after-tax rate of return on capital is the annualized profit earned on a project net of the taxes paid by the businesses. For this purpose, we include corporate income, sales and other capital-related taxes as applied to oil and gas investments.

For oil and gas taxation, it is necessary to account for royalties in a special way. Royalties are payment made by businesses for the right to extract oil and gas from land owned by the property holder. The land is owned by the province so the royalties are a rental payment for the benefit received from extracting the product from provincial lands. Thus, provincial royalty payments are a cost to oil and gas companies for using public property.

However, since the provincial government is responsible for the royalty regime and could use taxes like the corporate income tax to extract revenue, one might think of royalties as part of the overall fiscal regime to raise revenue. In principle, one should subtract the rental benefit received from oil and gas businesses from taxes and royalty payments to assess the overall fiscal impact. This is impossible to do without measuring some explicit rental rate for use of provincial property. Further, royalty payments may distort economic decisions unlike a payment based on the economic rents earned on oil and gas projects. Instead, for comparability across jurisdictions, one might calculate the aggregate tax and royalty effective tax rates (such as between Alberta and Texas).

## The Effective Tax Rate on Capital: A Brief Explanation

Business investment decisions are affected by corporate income, capital, sales taxes on business inputs and other capital-related taxes. The theory below derives the now well-known concept: the *marginal effective tax rate*. The marginal effective tax rate is a summary measure of the extent to which taxes impinge on investment decisions. It is measured by calculating the amount of tax paid as a percentage of the pre-tax return on capital that would be required to cover the taxes and the financing of capital with debt and equity. For example, if a business invests in capital that yields a pre-tax rate of return on capital equal to 10 percent and, after taxes, a rate of return on capital equal to 6 percent, the marginal effective tax rate would be calculated as 40 percent (10 minus 6 percent divided by 10 percent).

To derive the marginal effective tax rate for resource companies, expressions are provided for the marginal rate of return on capital for investments in exploration, development, depreciable capital, land and inventories. The gross-of-tax rate of return on capital is equal to the inflation-adjusted cost of financing capital (taking into account interest deductibility), adjusted for taxes. The net-of-tax rate of return on capital is equal to the weighted average of the interest rate for debt and the imputed cost of equity finance used to fund the investment by savers. The tax paid by the business is the difference between the gross-of-tax rate of return on capital and the net-of-tax rate of return on capital. The effective tax rate on capital is equal to tax paid divided by the gross-of-tax rate of return on capital.

In the analysis, federal and provincial/state corporate income, capital and sales taxes are included. Royalties are also modeled. We take into account various features of taxes such as the valuation of inventories, capital cost allowances, statutory tax rates and, for the Atlantic, investment tax credits.

## General Theory

The modelling follows a version of Boadway, Bruce and Mintz [1984], Boadway, Bruce, McKenzie and Mintz [1987], McKenzie et al [1997] and Mackie-Mason and Mintz [1991]. There are two stages of production. The first is an exploration and development phase to discover and make available reserves for extraction. With this stage, the analysis is based on a flow-input-point-output process which can be considered a "time to build" analysis. The second stage production – the extraction phase – depletes the discovered reserves until exhaustion.

The "time-to-build" analysis leads to lower effective tax rates on exploration and development compared to that characterized in Boadway et al [1987] whereby exploration and development expenditures result in reserves that can be immediately exhausted. The underlying reason is that the income and expenses are mismatched as tax deductions for exploration and development spending are taken prior to income being earned when the resource is exploited. If deductions could be taken (delayed) until resources are exploited, the analysis would in essence, become similar to Boadway et al [1987] resulting in higher effective tax rates.

A number of important assumptions are made in this modelling.

- *Investor Objectives*: Businesses maximize the present value, V, of their nominal cash flows, $CF_t$, discounted by the nominal interest rate, $R = Bi(1-u)+(1-B)\rho$, with B signifying the portion of investment financed by debt, i is the nominal interest rate on debt, u is the federal and provincial the corporate income tax rate ($u = u_f + u_p$) and $\rho$ is nominal discount rate for equity. Debt is taken to be a fixed portion of capital and unchanging over time. This assumption is different than the alternative model whereby debt is issued until the marginal tax benefit from issuing debt is equal to the marginal attendant costs incurred with debt. As Mackie-Mason and Mintz [1991] show, the debt-capital ratio will rise during the building phase until the project is completed.

- *The Firm's Decisions*: The firm maximizes its present value of cash flows by choosing its optimal extraction of oil and gas from discovered reserves ($Q_t$), investments in post-production depreciable capital ($K_t$) and pre-production exploration and development ($e_t$,). Below, other forms of capital investment will be considered but not formally included in the model (for simplicity) including processing, inventory and development investments.

- *Investor Market Equilibrium*: The nominal discount rate for equity is determined from an international capital market equilibrium whereby the after-tax returns on equity and bonds are equal to each other: $i(1-m) = \rho(1-\Theta)$, with m is the average worldwide personal tax rate on bond interest and $\Theta$ is the average personal worldwide personal tax rate on equity returns (that in turn is a weighted average of capital gains and dividend taxes). In this formulation, the capital gains arising from currency revaluation affects nominal interest rates and is taxed at a different rate than m or t but for simplicity we assume currency gains are taxed as part of interest or equity income.[1]

The problem for the oil and gas business is to maximize the cash flows from its project subject to the constraint that the extracted resources is equal to the amounts discovered over time. Let T be the period in which reserves are discovered and prepared for extraction that begins at that time.

(1) $\text{Max } V = \sum_0^\infty (1+R)^{-t} CF_t \, dt$

(2) subject to $\sum_T^\infty Q_t dt = X = \sum_0^T f[e_t]$ (accumulated reserves equals total extraction)

with $CF_t = P_tQ_t - C(Q_t,K_t)(1+\pi)^t - (\delta K_t + k_t)(1+\pi)^t - T_{c[t]} - T_{R[t]}$ for $t \geq T$

$CF_t = -e_t(1+\pi)^t - T_{c[t]}$ for $t \leq T$

$C(Q_t,K_t)$ are current costs that are strictly concave in output (denoted as $C' > 0$ and $C'' > 0$) and capital that reduces costs (denoted as $C_K < 0$ and $C_{KK} < 0$).
$K_t$ = depreciable capital stock
$k_t$ = new investment = $K_{t+1} - K_t$
$\delta$= economic depreciation
$f[e_t]$ = reserves of oil and gas found through spending on exploration in period t with the function being strictly concave ($f' > 0$ and $f'' < 0$).
$T_{c[t]}$ = corporate tax payments (paid in each period and can be negative)
$T_{R[t]}$ = royalty payments in each period t (only paid after extraction begins)
$P_t$ = nominal price of output normalized to one and equal to all other prices ($P_t = P(1+\pi)^t$).

[1] See Boadway, Bruce and Mintz [1984]. For example, two interest rates on domestic and foreign bond (* indicating foreign) would be linked as $i(1-m) = i^*(1-m) + \rho(1-c)$ with $\rho$ denoting the appreciation of the foreign currency relative to the domestic one. If c=m or $\Theta$, then the international equilibrium for bond and equity is specified accordingly.

The analysis below first focuses on Alberta with corporate income taxes and royalty payments for both conventional and non-conventional sources. Capital taxes are being phased out in Saskatchewan and Nova Scotia and hence ignored. Sales taxes on capital purchases are considered for British Columbia and Saskatchewan with retail sales taxes.

Corporate tax for oil and gas companies is imposed on the revenues earned from the sale of oil and gas net of the costs of production which include current extraction costs, capital costs allowances and exploration and development costs (exploration is expensed but development is capitalized and written off at the declining balance rate $\sigma$). This implies the following:

(3) $T_{c[t]} = u\{P_tQ_t - C(Q_t,K_t)(1+\pi)^t - \alpha D_t - \sigma E_t(1+\pi)^t - T_{R[t]}\}$

(4) $D_t = (\delta K_s+k_s)(1+\pi)^t - \alpha D_s$

(5) $E_t = e_t(1+\pi)^t - \sigma E_s$

(6) with $\alpha$ = capital cost allowance rate, $D_s$ = the undepreciated capital cost base and $E_s$ = the undepreciated "stock" of exploration and development spending at time s.

Manipulating the terms associated with capital cost allowances and investment, $(\delta K_t+k_t)(1+\pi)^t$, in equation (1) with the insertion of terms in (3), (4) and (5), one can show that the investment costs are reduced by the present value of capital allowances so that:

(2') $CF_t = \{ P_0Q_t-C(Q_t,K_t)\}(1-u)(1+\pi)^t - (\delta K_t+k_t)(1-uZ)(1+\pi)^t - T_{R[t]}(1-u)$

for $t \geq T$

(2') $CF_t = - e_t(1-uZ)(1+\pi)^t - T_{R[t]}(1-u)$ for $t < T$

with $Z = \alpha/(\alpha+R)$ [2]

In 2', it also assumed that the deductibility of resource royalties from income is fully phased in and, therefore, the resource allowance no longer applies. Note that royalty payments in the exploration and development phase are "negative" if such costs are deductible from the royalty base, which will be the case in some situations. All provinces with oil and gas production provide for the deductibility of resource royalties from income (Ontario is the only province that continues to use the resource allowance that applies to mining).

[2] The half-year convention is ignored here. When incorporated, $Z = \alpha/2 + (1-\alpha/2)/(1+R)(\alpha+R)$. We will also discuss the case when capital cost deductions cannot be used against income at a later point.

In the next section, the analysis begins with Alberta conventional and non-conventional oil and gas to be followed by Alberta non-conventional oil (oil sands). Other provinces will follow.

**Oil and Gas in Alberta**

Tax and royalty regimes differ for conventional and non-conventional oil and gas. With conventional oil and gas, royalties are a percentage of the value of extracted output and corporate income tax system allows companies to deduct exploration and development expenses against other income earned. With non-conventional oil and gas, the royalty is a percentage of the project's cash flow and accelerated capital cost allowances for oil and gas (CCA in excess of 30 percent declining balance) can only be taken against the project's income (the March 19, 2007 federal budget phased out the accelerated capital cost allowance for oil sands).

**Conventional Oil and Gas in Alberta**

As stated, the royalty payment is based on the value of production. Let $\tau$ be the ad valorem payment on sales, PQ, so that $T_R = \tau PQ$ (suppressing time scripts here on in unless needed). Maximizing equation (1), subject to (2) and (2'), choosing Q, K, k, and E, yields the following:

<u>Output Decision</u>

The choice of Q yields the following result ($\lambda$ is the Lagrange multiplier for the constraint in (2)):

$$(7) \qquad (1+r)^{-t}(P(1-\tau)- C')(1-u) = \lambda$$

$$\text{with } r = R - \pi = Bi(1-u)+(1-B)\rho - \pi.$$

The shadow price of extracted output is equal to marginal value of extracting a marginal unit of output.

Differentiating (7) for time (let p denote the time change in the price), yields the familiar Hotelling condition that the increase in the quasi-rents from rent extraction is equal to the discount rate:

$$(8) \qquad (p(1-\tau) - C')/(P(1-\tau) - C'') = r$$

The royalty rate on ad valorem sales generally reduces quasi-rents and the incentive to extract since the royalty reduces revenues relative to costs of extraction.[3] On the other hand, the deductibility of interest expense from taxable income lowers the cost of finance and, therefore, increases extraction to early periods.

Depreciable Capital

The choice of capital stock and new investment, post-exploration and development, as well as the undepreciated capital cost base and changes to it, yields the following cost of capital for depreciable capital:

$$(9) \qquad -C_K = (\delta+R-\pi)(1-uZ)/(1-u)$$

This is the familiar cost of capital expression noting that R is the weighted average of the cost of debt and equity finance and Z is the present value of depreciation. Note, given the characterization of capital as providing a reduction in current (e.g. labour) costs, holding output constant royalty payments based on output are constant and therefore do not directly affect the cost of capital.

Inventory

With First-in-First-out (FIFO) accounting, the nominal profit from holding inventories (I) is subject to corporate income tax. This implies the following cost of capital assuming inventories are held for less than one year:

$$(10) \qquad -C_I = (R-\pi(1-u))/(1-u).$$

Exploration and Development

The choice of exploration and development, E, yields the following for the cost of capital:

$$(11) \qquad (P_T-C_T')f_t' = (1-uZ)(1+r)^{(T-t)}/[(1-u)\{1-\tau P/(P-C')\}]$$

Expression (11) treats royalties as a tax. The quasi-rent earned by investing in exploration $(P_T-C_T')f_t'$ is equal to the interest-adjusted cost of exploration (the price of exploration and development is set equal to unity) divided by the one minus the royalty imposed on the cost of capital. The term in the denominator $\tau P/(P-C')$ is the advalorem tax paid as a share of the quasi-rents on incremental sales (this is expected to be less than one so long as the advalorem tax rate is less than margin $(P-C')/P$). As in Mackie-Mason

[3] This can be seen by differentiating the Euler condition (7) with respect to $\tau$. Assuming output prices are determined by world market conditions and unaffected by tax and royalty rates in Canada, we obtain the following by differentiating equation (7): $\partial Q/\partial\tau = P/-C'' < 0$.

and Mintz [1991], the cost of exploration is reduced by interest deductions taken early at time t relative to the earning of income at time T.[4] Given the deductibility of interest expense from income, the effect of corporate taxation is to reduce the real cost of finance (r) and the discount factor $(1+r)^{(T-t)}$ resulting in a lower cost of capital (and lower effective tax rate on capital).

If royalties are treated as a cost, the expensing of exploration leads to negative effective tax rate given that the corporate income tax rate is imbedded in the expression for the cost of finance:

$$(12) \quad (P_T(1-\tau) - C_T')f_t' = (1-uZ)(1+r)^{(T-t)}/(1-u)$$

Note under expensing for exploration, Z=1. The terms (1-u) in expression (12) cancel out, implying neutrality. However, unlike the Boadway, Bruce, McKenzie and Mintz [1987] analysis, the "time to build capital" implies that early use of deductions for interest expense under the corporate income tax lowers the cost of finance and hence increases the incentive to explore.

**Non-conventional Oil (Oil Sands)**

The non-conventional royalty tax is assessed on the cash flow earned by oil companies engaged in oil sand production. Cash flow is equal to the revenues net of both current and capital costs incurred in undertaking the project. Interest expense is not deductible (since it would give undue advantage to investments since capital costs are already expensed) and unused deductions are carried forward to be written off in later years, indexed at the equivalent of the government bond rate (the investment allowance).

Until 2009, a minimum royalty of 1 percent of sales is applied when capital costs are written off but for the analysis below we ignore this payment (where this will have a small impact in increasing the effective tax rate when royalties are treated like taxes). After 2009, the royalty on sales is 1 percent for oil prices below $55 (Canadian dollar price for West Texas Intermediate) but rising up to a maximum of 9 percent when oil prices peak above $120. For this case, the previous equations for conventional oil and gas are relevant in determining the effective tax rate on oil sand investments if the minimum royalty is paid.

Prior to 2009, the cash flow royalty rate on oil sands was 25 percent and is paid if the amount is more than the minimum royalty as discussed above. Post 2009, the rate varies according to the price of oil. For prices below $55, the royalty rate remains 25 percent. The rate rises by 0.23 percent for each dollar increase in oil prices up to a maximum of 40 percent when prices of oil are more than $120.

[4] While we have fixed the debt/capital ratio to be time invariant, see Mackie-Mason and Mintz [1991] for a more complicated version that allows for endogenous choice of debt policy.

Given the new Alberta royalty regime has varying royalty rates, one might wish to model explicitly royalty rates that vary by price over time. This would be best handled by introducing a stochastic model that would enable one to consider marginal effective rates that vary according to market conditions. It would be a complexity that is best handled for future work since its empirical application would be difficult to apply without characterizing the volatility and growth in oil prices. For this reason, we take the simple case that royalty rate are constant.

Under the corporate income tax, oil sand producers were given an additional deduction over and above regular depreciation for investment in "new mine assets". The regular deduction was at least 30 percent declining balance for new mines or major expansions of mines. For oil sand producers, an additional deduction could be claimed against income earned from a project up to 100 percent of the cost of the asset. The federal government is phasing out the accelerated deduction of costs.

The royalty payment in the oil sands after payout, and assuming that the amounts are greater than the minimum royalty, is the following.

$$T_R = \tau[P_tQ_t - C(Q_t,K_t)(1+\pi)^t - (\delta K_t+k_t)(1+\pi)^t - e_t(1+\pi)^t]$$

The determination of output, Q, accords with the following Euler equation:

$$(13) \quad (1+r)^{-t}(1-\tau)(P-C')(1-u) = \lambda$$

The extraction decision is determined by selling output until the increase in the quasi-rent from higher prices net of marginal cost (p-C") per dollar of quasi-rent is equal to the cost of finance.

$$(14) \quad (p - C'')/(P-C') = R-\pi$$

As in the conventional case, even though taxes do not appear in the left hand side of equation (14), they do influence the cost of finance (R) due to the deductibility of interest expense from corporate taxable income. Thus, interest deductibility results in higher extraction as companies produce more output lowering the return until the capital gain from keeping the resource in the ground is equal to the cost of capital.

Depreciable Capital

The user cost for depreciable capital for the oil sands case is similar to equation (9), but royalties directly affect the cost of capital because current costs are deductible from the royalty base. That is, changes in the stock of capital reduce current costs which are netted from royalty payments with output assumed to be fixed.

Royalties as a tax:

$$(15) \quad -C_K = (\delta+R-\pi)\{1-\tau(1-u) - uZ\}/[(1-u)(1-\tau)]$$

$$\text{with } Z = \alpha/(\alpha+R)$$

If royalties are treated as a cost, the expression is the same since the royalty paid at the margin is equal to zero.

Inventory

With First-in-First-out (FIFO) accounting, the nominal profit from holding inventories (I) is subject to corporate income tax (Boadway, Bruce and Mintz [1982]). This implies the following cost of capital assuming inventories are held for less than one year:

(16) $-C_I = ((R-\pi)(1-\tau(1-u))+u\pi)/[(1-u)(1-\tau)]$.

And if royalties are treated as a cost:

(17) $-C_I\,(1-\tau) = ((R-\pi)(1-\tau(1-u))+u\pi))/1-u)$.

(Note with corporate income tax exhaustion as discussed above, the corporate income tax rate is equal to zero for inventories held less than one year).

Exploration and Development

The user cost for exploration and development for the oil sands case is the following:

(18) $(P-C')f_t' = (1-uZ-\tau(1-u))(1+r)^{(T-t)}/[(1-u)(1-\tau)]$

for both the tax and cost cases respectively. The term of Z is the typical CCA allowance by which the deduction could be used against other income.

Note that if Z=1, capital costs are fully expensed and if there is no mismatch between deductions and income (such as t=T or r does not have interest deductibility for debt), the decision to invest is independent of corporate taxes.

Accelerated Capital Cost Allowance and Corporate Tax Exhaustion

It is possible, and in fact likely, that the expensing of capital costs under the accelerated cost deduction may not be fully used since it is limited to the project's income. In this case, corporate income is not taxed until the deductions are fully used up. This case is similar to the tax holiday problem modelled by Mintz [1990]. During the years in which no corporate income tax is paid (until time X when the company becomes taxable), the present value of tax depreciation deductions changes from year to year until the company becomes taxable). The cost of capital in this case will be the following:

Royalties as a tax:

(15') $-C_K = (\delta+R_0-\pi)\{1-\tau-uZ_t)\}/(1-\tau) + (1+R_0-\pi)(uZ_t - uZ_{t-1})/(1-\tau)$ for $t<X$

with $Z_t = Z(1+R)^{-(X-t)}$ (with Z=1 for expensing when capital is written off fully at time X) and $R_0 = Bi+(1-B)\rho$ (the no-tax cost of finance).

Note that if other tax deductions cannot be used (as sufficient income is not earned), other costs of capital for depreciable assets and inventory are similarly affected due to changes in the present value of tax depreciation allowances varying from one year to the next.[5]

## Other Provinces

It would be useful to note several additional issues that would affect the cost of capital expressions above arising from provisions applying in British Columbia, Newfoundland & Labrador, Nova Scotia, and Saskatchewan. These include the following:

1. Retail sales taxes in British Columbia and Saskatchewan on capital inputs would be equal to $\kappa$ times the price of capital (which is normalized to be equal to unity in the model without loss of generality).
2. Unlike Alberta, these four provinces have a corporate tax base harmonized with the federal base. However, in practice, the modelling is not affected.
3. An investment tax credit is provided at the rate $\varphi$. It reduces the cost basis for annual depreciation allowances that is available in the Atlantic Provinces.
4. Newfoundland & Labrador have a complicated royalty system whereby the rate depends on profitability. This is discussed further below.

Oil and gas provinces are abolishing capital taxes and hence these taxes are excluded from the analysis.

### British Columbia and Saskatchewan

British Columbia and Saskatchewan levy royalties on the revenues received by the producer. Like the federal government and Alberta, royalties are deductible from corporate income tax. Therefore, the only significant difference between British Columbia and Saskatchewan from the Alberta case is that a sales tax, at the rate $\kappa$, applies to purchases of machinery and equipment under the retail sales tax. Thus, the only adjustment in the formulae presented above is for depreciable capital:

$$(19) \quad -C_K = (\delta+R-\pi)[(1-uZ)](1+\kappa)/(1-u).$$

The interpretation of the above is obvious.

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[5] For example, the cost of capital for other depreciable assets under tax exhaustion would be the following, assuming that depreciation deductions are used at time X (based on Mintz [1995]):

$-C_K = (\delta+R_0-\pi)\{1- \tau - uZ_t)\}/(1-\tau) + (1+R_0-\pi)\ (uZ_t - uZ_{t-1})\ )/(1-\tau)$ for $t<X$ with $Z_t = [(1-\alpha)/1+R)^{(X-t)}]Z$ with $Z= \alpha/(\alpha+R)$

### Newfoundland & Labrador and Nova Scotia

Leaving aside the royalty regimes, the tax structure of both Newfoundland & Labrador and Nova Scotia is similar to that of British Columbia and Saskatchewan except for the provision of the Atlantic investment tax credit, as mentioned above. Further, both provinces have converted retail sales taxes to the Harmonized Sales Tax of which the base is identical to the federal Goods and Services Tax. Therefore, the sales tax on capital purchases is refunded to the business and therefore does not affect the cost of capital.

Where the two provinces differ significantly from other provinces is with respect to their royalty structures, which have a complicated impact on investment decisions.

#### Newfoundland & Labrador

The Newfoundland & Labrador offshore royalty is composed of two parts. The generic offshore royalty structure applies to all oil projects (except Hibernia and Terry Nova).

- A basic royalty is charged on gross revenues (net of transportation costs) at rates rising from 1 percent to 7.5 percent as cumulative production rises.
- A net royalty is paid after accumulated unused deductions for operating costs, capital costs, successful exploration costs, the basic gross royalty and the return allowance are exhausted.
- The return allowance is an "interest" rate by which unused deductions are carried forward. The return allowance rate is equal to the long-term bond rate plus an additional amount of either 5 or 15 percent. Effectively, the allowance rate is far in excess of a market interest rate that would be used to preserve the time value of expensing capital costs and, hence, delays the time by which a net royalty is paid once unused deductions are exhausted.
- The first tier net royalty is a 20 percent rate applied to net revenues once the payout begins after unused deductions are exhausted based on a return allowance equal to 5 percent plus the long-term government bond rate applied to unrecovered costs.
- The basic royalty on gross revenues is credited against the tier one net royalty.
- The second tier is a royalty rate of 10 percent applied to net revenues based on a return allowance equal to 15 percent plus the long-term government bond rate (and therefore incremental to the first tier royalty resulting in a potential royalty rate on net revenues).
- The royalty rate therefore rises as the return on capital invested in the project rises.

As for Hibernia and Terra Nova, the royalty is structured in a similar way to the generic system but at different rates than those given above. The main point, however, is the royalty rate varies according to the profitability of a project.

To solve for the cost of capital, taking into Newfoundland & Labrador's royalty regime[6], the maximization problem in equations (1) and (2) are adjusted to account for three royalty payments: gross royalties (RG), tier one net royalties (RN1) and tier two net royalties (RN2). This problem is far more complex since the royalty payments depend on profitability and the length of time taken up for upfront exploration and development and other capital and operating expenditures to be exhausted. In principle, fluctuations in pricing could result in royalty payments varying amongst the three categories over time.

Given that Newfoundland & Labrador's unused deductions are carried forward at different return allowances to define tiers, a simple characterization of profitability is considered. From time $t=0\ldots.. T_0$, the oil and gas company only incurs exploration and development expenses (that can be written for corporate income tax purposes against other income), which make available reserves, X, as before. Production begins after $T_0$ whereby the project incurs operating and capital costs. However, for $T_0 < t \le T_1$, the project only pays the gross royalty, $RG = \tau P_tQ_t$. At time $T_1$, the unused deductions that are carried forward at a return allowance rate, $\psi_1$, are fully used and the project now pays tier 1 royalties. The tier one royalties are paid during the period from $T_1$ to $T_2$ equal the following after discounting:

$$(20)\quad NR_1 = \sum_{T_1+1}^{T_2} (1+R)^{-t}\tau_1\{ P_tQ_t - C(Q_t,K_t)(1+\pi)^t - (\delta K_t+k_t)(1+\pi)^t\}$$

$$+ \tau_1(1+R)^{-T_1}\sum_0^{T_1} \{[P_tQ_t-C(Q_t,K_t)(1+\pi)^t - (\delta K_t+k_t)(1+\pi)^t - e_t(1+\pi)^t](1+\psi_1)^{T_1-t}\}$$

The latter part of equation (20) reflects the payment of tier one royalties for the first time when the carryforward value of unused deductions is fully exhausted (note the payment is discounted at time $T_1$ when tier one payouts begin).

Similarly, for tier 2 royalties, $NR_2$, we have the expression:

$$(21)\quad NR_2 = \sum_{T_2+1}^{\infty} (1+R)^{-t}\tau_2\{P_tQ_t - C(Q_t,K_t)(1+\pi)^t - (\delta K_t+k_t)(1+\pi)^t\}$$

$$+ \tau_2(1+R)^{-T_2}\sum_0^{T_2} \{P_tQ_t-C(Q_t,K_t)(1+\pi)^t - (\delta K_t+k_t)(1+\pi)^t - e_t(1+\pi)^t\}(1+\psi_2)^{T_2-t}\}$$

To simplify the analysis (at least to some extent), it is assumed that the gross royalty is fully credited against the tier one net royalties. The expression for the user cost of capital when the gross royalty is only paid is taken to be similar to the conventional oil and gas project in Alberta. Hence, we ignore the gross royalty altogether.

Using the expression for net royalties, the producers maximize the value of cash flows (choosing e, K and Q) according to the following:

$$(22)\qquad \text{Max } V = \sum_0^{\infty} (1+R)^{-t}CF_t\, dt$$

[6] The Nova Scotia royalty is similar except that the unused deductions carried forward at a return allowance are not compounded. The effect of a non-compounding return allowance on the formula is straightforward and shown below.

With

$$CF_t = [P_tQ_t\text{-}C(Q_t,K_t)(1+\pi)^t](1\text{-}u)(1\text{-}\tau_2) - (\delta K_t+k_t)(1+\pi)^t[(1\text{-}uZ)(1\text{-}ø)\text{-}\tau_2(1\text{-}u)]$$

for $t > T_2$,

$$CF_t = [P_tQ_t\text{-}C(Q_t,K_t)(1+\pi)^t](1\text{-}u)(1\text{-}\tau_2) - (\delta K_t+k_t)(1+\pi)^t[(1\text{-}uZ)(1\text{-}ø)\text{-}\tau_2(1\text{-}u)]$$

$$+\tau_2(1\text{-}u)\sum_0^{T_2\text{-}1}\{P_tQ_t\text{-}C(Q_t,K_t)(1+\pi)^t - (\delta K_t+k_t)(1+\pi)^t - e_t(1+\pi)^t\}(1+\psi_2)^{T_2\text{-}t}$$

at $t = T_2$,

$$CF_t = [P_tQ_t\text{-}C(Q_t,K_t)(1+\pi)^t](1\text{-}u)(1\text{-}\tau_1) - (\delta K_t+k_t)(1+\pi)^t[(1\text{-}uZ)(1\text{-}ø)\text{-}\tau_1(1\text{-}u)]$$

for $T_2 > t > T_1$,

$$CF_t = \{[P_tQ_t\text{-}C(Q_t,K_t)(1+\pi)^t](1\text{-}u)(1\text{-}\tau_1) - (\delta K_t+k_t)(1+\pi)^t[(1\text{-}uZ)(1\text{-}ø)\text{-}\tau_1(1\text{-}u)]$$

$$+\tau_1(1\text{-}u)\sum_0^{T_1\text{-}1}\{P_tQ_t\text{-}C(Q_t,K_t)(1+\pi)^t - (\delta K_t+k_t)(1+\pi)^t - e_t(1+\pi)^t\}(1+\psi_1)^{T_1\text{-}t}$$

at $t = T_1$,

$$CF_t = - e_t(1+\pi)^t(1\text{-}uZ) \quad 0 < t < T_1,$$

And

(23) subject to $\sum_T^\infty Q_t dt = X = \sum_0^T f[e_t]$ (accumulated reserves equals total extraction).

Note that the positive terms in the cashflow associated with the carryforward of unused deductions up to periods $T_2$-1 and $T_1$-1 under the two tiered royalties respectively act as tax credit at time $T_2$ or $T_1$ and hence lower tax payments in the first period that the new tier applies.

The Euler conditions for extraction of oil and gas (Q) depend on the "regime" under which royalty regime operates (tier 1 or 2 royalties):

(24) $[P\text{-}C'](1\text{-}u)(1\text{-}\tau_2)(1+r)^{-t} = \lambda$ for $t > T_2$,

(25) $(1+r)^{-t}[P\text{-}C']\{(1\text{-}u)(1\text{-}\tau_1)+[\tau_2(1\text{-}u)(1+\psi_1\text{-}R)^{T_2\text{-}t})]\} = \lambda$

for $T_1 < t < T_2$,

Equations (24) and (25) both yield the typical condition for production decisions whereby quasi- rents on deposits held in the ground would rise by the (after-tax) discount rate of the firm: $(p-C'')/(P-C') = r$. With equation (25), however, an additional term arises from the higher royalty payment at $T_2$ when the firm anticipates paying once reaching the new tier. Specifically, production decision will shift down at $t= T_1$ and $t=T_2$ since the return allowance rate is more than the firm's discount rate.

Note it is possible that tier two may not be reached so equation (25) is irrelevant and only equation (24) holds for the case in which $\tau_2$ is replaced by $\tau_1$.

Given that equations (24) to (25) hold, the costs of capital are derived by solving for K and e as follows:

Depreciable Capital Investment

For $t> T_2$,

$$(26)\quad -C_K = (\delta+R-\pi)\{(1-uZ)(1-\varphi)- \tau_2(1-u)\}/(1-u)(1-\tau_2).$$

For $T_1< t<T_2$,

$$(27)\quad -C_K = \{(\delta+R-\pi)[(1-uZ)(1-\varphi) - \tau_1(1-u)-\tau_2(1-u)(\delta+\pi)(1+\psi_2-R)^{T_2-t}]\}/Y$$

$$\text{with } Y = [1-\tau_1 -\tau_2(1+\psi_2-R)^{T_2-t})](1-u)$$

Compared to the much simpler royalty system used in Alberta for oil sands, the Newfoundland & Labrador tiered royalty increases the tax levied on rents in the future once the resource company enters into future years. The tiered royalty structure also lowers the effective cost of investments since replacement cost depreciation $(\delta+\pi)$ reduces royalty payments at the higher tiered royalties.[7]

As discussed above, the second tier royalty may not be reached which would simplify the above expression to a formula similar to equation (26), except that $\tau_2 = \tau_1$ and equation (27) can be ignored.

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[7] Note that if there is a period in which only the gross royalty is paid, the user cost of capital for depreciable capital is adjusted as the following:

For $T_0< t<T_1$,

$$-C_K = \{(\delta+R-\pi)[(1-uZ)(1-\varphi)-\tau(1-u) - \tau_2(1-u)(\delta+\pi)(1+ \psi_2-R)^{T2-t})$$
$$- \tau_1(1-u)(\delta+\pi)(1+ \psi_1-R)^{T1-t}]\}/N$$

with

$$N = [1-\tau_1 -\tau_2(1+ \psi_2-R)^{T2-t}) -\tau_1(1+\psi_1-R)^{T1-t})](1-u)$$

Exploration and Development

The user cost of capital for exploration and development expenses under the Newfoundland & Labrador tiered royalty is derived by choosing e, making use of one of the three alternative Euler conditions for the extraction decision, all of which, are set equal to λ (the simplest is equation (24) so long as the project is expected to eventually reach tier 2 – otherwise alternative Euler conditions should be used and adjusted for the fact that tier 2 is not reached[8]):

$$(28)\quad (P–C')f_t' = (1+r)^{(T_2-t)}\{1-uZ- \tau_2(1-u)(1+\psi_2-R)^{T_2-t}- \tau_1(1-u)(1+\psi_1-R)^{T_1-t}\}/ W$$

with $W = (1-u)(1-\tau_2)$.

Note that even with expensing (Z=1), the user cost for exploration and development will not be independent of royalty rate since the allowance allows the expenses reduce tier one or tier two payments in future years. Given the discounting factors involved, it is an empirical matter to determine whether the effective tax and royalty rate as it affects exploration is positive or negative for exploration and development expenses.

Nova Scotia

Nova Scotia uses a similar profit-sensitive approach although it differs in three ways from the Newfoundland & Labrador approach. First, the federal investment tax credit reduces project costs. Second, eligible costs include past royalties paid to determine the computation of the project payout (but not the net revenue). Third, Nova Scotia does not compound the return allowance. The generic regime (that does not apply to Cohasset-Panuke and Sable Offshore Energy Project) has four tiers. The first tier is a 2 percent royalty applied to gross revenues. The second tier is a 5 percent royalty applied to gross revenue once accumulated revenues are in excess of accumulated operated and capital project costs and the non-compounded rate of return allowance, which is equal to the long-term bond rate plus 5 percent. The third tier is 20 percent royalty on net revenues once unused operating and capital costs, carried forward on the long-term bond rate plus 20 percent, is exhausted. The fourth tier is similar except unused deductions are carried forward at the long-term bond rate plus 45 percent.

[8] For example if tier one is only reached, the user cost of capital is as follows:

$$(P–C')f_t' = (1+r)^{(T2-t)}\{1-uZ- \tau_1(1-u)(1+\psi_1-R)^{T1-t})\}/ (1-u)(1- \tau_1).$$

Note that if only tier one is ever reached, the user cost for depreciable capital is similarly affected in the tier two would be ignored in expression

Without developing the full analysis, we take note that the absence of compounding under the Nova Scotia system implies that the discounted return allowance is equal to $(1+(T_1-t)\psi_1/(1+R)^{T_1-t})$ (instead of $(1+\psi_1-R)^{T_1-t}$) in expression (30) and investment tax credit reduces the cost of investment for royalty purposes as well (the use of royalties to determine the payout extends the length of time when the project reaches a new tier). This implies the following:

For $t > T_2$,

$$(29)\quad -C_K = (\delta+R-\pi)\{(1-\varphi)(1-uZ)-\tau_2(1-u)\}/(1-u)(1-\tau_2).$$

For $T_1 < t < T_2$,

$$(30)\quad -C_K = (\delta+R-\pi)[(1-\varphi)(1-uZ)-\tau_1(1-u)-\tau_2(1-u)(\delta+\pi)(1+(T_1-t)\psi_1/(1+R)^{T_1-t}]/Y$$

$$\text{with } Y = [(1-\tau_1-\tau_2(1+(T_1-t)\psi_1/(1+R)^{T_1-t})](1-u).$$

**Effective Tax Rates**

For application, we simply refer to how the above formulae are converted to effective tax rates on capital, consistent with the past literature.

Effective tax rates are estimated as marginal rate of return on capital, gross of taxes, net of marginal rate of return, net of taxes, taken as proportion of the gross-of-tax rate of return on capital. The marginal rate of return on capital is the user cost of capital net of economic depreciation. For example, for depreciable capital, the marginal rate of return on capital investments, net of depreciation, is equal to the following: $R_g = -C_K - \delta$. The net of tax rate of return on capital is equal to $R_n = Bi + (1-B)\rho - \pi$.

The effective tax rate is calculated as $T = (R_g - R_n)/R_g$.

The formulae developed above will need to be empirically implemented to draw conclusions regarding the impact of various fiscal regimes on oil and gas investments.

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