Tax Incentives for Extraction and Recycling of Basic Materials in Canada

KIMBERLEY SCHARF

Abstract

This paper provides an empirical assessment of the overall incentives generated by taxes with respect to the choice between extraction and recycling of basic materials in Canada. We calculate measures of the overall impact of the Canadian tax system on the incremental cost of (i) producing virgin material or recycled material that is to be used as an intermediate input in the production of a final product and (ii) producing finished products. The sectors that we examine include producers of primary virgin material (forestry, mining, oil and gas), producers of recycled material (scrap dealers) and producers of finished products (metal, paper, plastic and glass). Our results indicate that the Canadian tax system significantly favours the use of virgin materials rather than recycled materials in the case of metal and glass products, but the reverse is true for plastic products. Features in the Canadian tax system contributing to these findings are not limited to corporate income and mining tax incentives at the exploration and extraction stages of the production of virgin materials, but also include provincial sales taxes on capital, which are borne more heavily by scrap firms than by resource and manufacturing firms, and provincial sales taxes that apply to business inputs, which also fall more heavily upon the recycling sector.

JEL classification: H25, H32, Q31.

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I. INTRODUCTION

A theme that has taken centre stage in the debate on environmental policy in Canada and elsewhere is the identification of the fiscal tools that can be employed to reduce net waste production at both the national and global levels. But a necessary precondition for such debate is addressing the purely empirical question of how current taxes treat recycled materials relative to virgin materials.

Canada’s position in this respect is unique due to the special prominence of resource extraction industries in the Canadian economy, which, throughout the evolution of the Canadian tax system, has resulted in special tax preferences being accorded to investments in resource-based industries. These tax incentives have been widely examined and debated both in the academic literature and in policy circles, and their value has been quantified (Boadway, Bruce, McKenzie and Mintz, 1987); these earlier findings, however, bear only indirectly on the question of how the tax system treats recycled materials in comparison with virgin materials. Capital is only one of various inputs involved in the production of raw materials; and raw materials, in turn, are only an intermediate input in the production of finished goods. To correctly identify the overall tax incentives accorded by the tax system to recycled and virgin material production, it is necessary to take into account inputs other than capital, as well as the fact that the technologies whereby virgin materials and scrap goods are transformed into finished products are different.

This study aims at quantifying the overall incentives generated by taxes with respect to the choice between new and recycled materials in Canada, using a methodology that explicitly takes into account the technologies employed in their production and the tax treatment of all the inputs involved. Specifically, we examine the impact of taxes on the marginal cost of production for firms that (i) produce virgin materials that are to be used as intermediate inputs into the production of a finished product, (ii) produce recycled materials that are to be used as intermediate inputs into the production of a finished product and (iii) manufacture the finished product using the virgin or recycled materials.

The methodology we employ is based on calculation of overall marginal effective tax rates on the marginal cost of production (McKenzie, Mintz and Scharf, 1997). This measure relates to the public finance literature concerning calculations of effective tax rates on marginal investment projects (Auerbach, 1983; Boadway, Bruce and Mintz, 1982 and 1984a), which has shed much light on the possible effects of taxation on investment decisions for manufacturing industries (Boadway, Bruce and Mintz, 1984b) as well as natural resource industries (Boadway, Bruce, McKenzie and Mintz, 1987; Boadway, McKenzie and Mintz, 1989; Livernois, 1989). While earlier literature has focused upon

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1 For example, the Canadian Council of Ministers of Environment (CCME) Solid Waste Management Task Group recently identified the areas of federal and provincial tax disincentives to secondary material processing and marketing as a high priority for environmental action.
calculations of marginal effective tax rates on capital only, here we also take into account the tax treatment of other inputs, as well as substitution possibilities between inputs, and generalise the approach to multi-stage production technologies.

Our calculations of marginal effective tax rates confirm earlier findings that mining (with the exception of oil and gas) enjoys considerable investment tax advantages. Marginal effective tax rates on capital in the forestry and oil and gas sectors, on the other hand, are, on average, significantly higher than those in manufacturing. Provincial sales taxes that apply to business inputs also fall more heavily upon the recycling sector. In comparison, differences in marginal effective tax rates on labour inputs across sectors and provinces are much less pronounced.

In spite of the relatively uniform tax treatment of labour inputs and their relative importance in total inputs, the differences in overall marginal effective tax rates on total marginal cost for products employing virgin and recycled materials remain significant. In the case of paper and glass products, these differences are as high as 3 percentage points (out of an average tax rate of between 20 and 30 per cent). In the case of metal products, virgin-materials-based products enjoy a considerable tax advantage, of around 5 percentage points in most provinces and up to 8 percentage points in the Atlantic provinces. Plastic is an exception: we find that recycling-based products enjoy a tax advantage of over 2 percentage points in some provinces.

Several different factors contribute to these findings, including differences between federal and provincial income taxes, payroll taxes, sales taxes, excise taxes and provincial resource taxes in the mining, forestry and oil and gas sectors. For instance, provincial sales taxes on capital are borne more heavily by scrap and waste recyclers in comparison with resource extraction and other types of activities. Furthermore, the exploration and extraction stages of the production of virgin materials enjoy special corporate income and mining tax incentives. Provincial sales taxes that apply to business inputs also fall more heavily upon the recycling sector. In addition, scrap and waste recycling relies relatively more on inputs such as supplies and fuel, which are subject to high tax rates. These findings underscore the importance of going beyond a calculation of investment tax incentives, taking into account the technology-related aspects of firms’ decisions in conjunction with the tax treatment of other inputs.

The plan of the paper is as follows. In Section II, we describe the methodology and data employed in our calculations. Our main results and

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2 Exceptions in forestry occur in the Atlantic provinces (Newfoundland, New Brunswick, Nova Scotia and Prince Edward Island), where marginal effective tax rates on capital are negative.

3 We wish to stress that the sole aim of this study is to assess the effects of taxes on marginal production costs, fully abstracting from efficiency considerations and related normative conclusions. In view of the other distortions present in the Canadian economy and of the uninternalised external effects arising from different modes of production, differential treatment of different industries may well be justified on efficiency grounds.
conclusions are presented in Section III. An appendix contains details of the formulae that are used.

II. METHODOLOGY AND DATA

Here, we describe the basic methodology and the data used for our calculations. A more detailed account of the formulae employed is given in the appendix.

1. Effective Marginal Tax Rate on Total Marginal Cost

The effective marginal tax rate, $\theta$, on total marginal cost is the hypothetical rate of tax that, if levied directly on the firm’s production costs, would yield the same marginal cost as the existing tax system. This can be formally defined as

$$\theta = \frac{\partial C(q, b, t)}{\partial q} - 1,$$

where $q$ is the marginal unit of production, $b$ is a vector of gross-of-tax factor input prices, $t$ is a vector of taxes on factor inputs and $C$ is a cost function.

In general, this measure depends on the output level $Q$, but for a homothetic specification of technologies (of which a constant-returns-to-scale production function is a special case) this calculation is greatly simplified. For a Cobb–Douglas cost function, for example, the effective marginal tax rate on the marginal cost of production can be expressed simply as

$$\theta(h, b, t) = \prod_{j=1}^{N} (1 + t_j)^{a_j} - 1,$$

where $t_j$ is the marginal effective tax rate on input $j$ and $a_j$ is the factor share in production costs.

In a hierarchical production structure, some of the input prices appearing as arguments of expression (2) refer to primary factors, but others are prices of produced intermediate inputs. We can modify expression (2) to accommodate such multi-stage production technologies. As an example, suppose that $\theta_1$ and $\theta_2$ are the effective marginal tax rates on the marginal cost of production for producers of goods 1 and 2; then, with Cobb–Douglas technologies, the marginal effective tax rate on the marginal cost of production for the producer of a final good 3 that employs goods 1 and 2 as intermediate inputs is given by

$$\theta_3 = (1 + \theta_1)^h (1 + \theta_2)^k \prod_{j} (1 + t_j)^{h_{ij}} - 1,$$
where \( b_1, b_2 \) and \( b_v \) reflect the shares in total production costs of good 1, good 2 and primary factors respectively.

In our calculations, we use expression (2) to determine overall marginal effective tax rates by province for the forestry, mining, oil and gas (virgin materials) and scrap (recycled materials) sectors of the Canadian economy. We consider capital, labour and other materials (including fuel) as inputs into the production process. Once this is done, we employ expression (3) to calculate overall marginal effective rates for manufactured goods (paper, metal, plastic) that employ virgin materials, or recycled materials as intermediate inputs into the production process, in addition to capital, labour and other inputs.

The input value share parameters used for these calculations were obtained from Statistics Canada Catalogue #15-201 at the sM (medium) aggregation level. They are shown in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Input Value Shares in Marginal Production Cost</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital</td>
<td>Labour</td>
</tr>
<tr>
<td>Primary industry, scrap and waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forestry</td>
<td>16.0</td>
<td>27.0</td>
</tr>
<tr>
<td>Mining</td>
<td>47.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Oil and gas</td>
<td>38.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Scrap and waste</td>
<td>19.0</td>
<td>48.0</td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td>18.1</td>
<td>20.7</td>
</tr>
<tr>
<td>Fabricated metal</td>
<td>10.9</td>
<td>29.8</td>
</tr>
<tr>
<td>Glass</td>
<td>18.8</td>
<td>25.7</td>
</tr>
<tr>
<td>Plastic</td>
<td>11.9</td>
<td>23.4</td>
</tr>
</tbody>
</table>

4The Cobb–Douglas specification is consistent with practice in general equilibrium studies. This practice is, in turn, justified by the empirical finding that substitution elasticities between primary inputs are not significantly different from unity, although the evidence is less clear-cut with respect to substitution possibilities between primary and other inputs such as energy (on this point, see Thompson and Taylor (1995)). Note, however, that since we do not attempt to account for backward-shifting of input taxes onto labour, the value adopted for the elasticity of substitution between labour and other inputs is not as crucial as it would be in a fully specified general equilibrium model.

5We exclude some provinces (mainly Saskatchewan and Prince Edward Island) from the analysis of some sectors because of data limitations and/or lack of industry.

6As of the time of publication of this study, these data are 10 years old. However, since the structure of the Canadian economy has not changed dramatically in the last 10 years, and since the last fundamental tax reform occurred in 1994 — the year to which our tax data refer — our results should still be indicative of the current situation.
2. Capital Inputs

Capital inputs present special methodological problems, due to the fact that they constitute a flow of services stemming from a given stock. The derivation of a marginal effective tax rate for capital is linked to a number of different factors: the treatment of depreciation, inflation and the differential treatment of equity and debt financing under corporate tax. The issues involved differ by type of asset, and can also differ by sector owing to the presence of sector-specific provisions in the tax law. For the purposes of our analysis, we will need to distinguish between five different types of capital assets — buildings, machinery, inventories, intangibles and land.

We can express the marginal effective tax rate on capital as

\[
t_k = \frac{r^G - r^F}{r^F},
\]

where \( r^G \) is the gross-of-tax, net-of-depreciation rate of return required to yield the real required rate of return and \( r^F \) is the weighted pre-tax opportunity cost of finance,

\[
r^F = \beta i + (1 - \beta) \rho,
\]

with \( \beta, i \) and \( \rho \) defined respectively as the proportion of the marginal unit of capital financed by debt, the nominal interest rate and the return to equity financing.

For depreciable capital assets, \( r^G \) is equal to the user cost of capital less the physical depreciation rate on the asset. It can be shown that this is

\[
r^G = \left( \frac{r^N + \delta}{1 - \hat{u}} \right) - \delta,
\]

where

\[
r^N = r^F - u \beta i
\]

is the after-tax marginal cost of finance with \( u \) being the combined statutory federal and provincial corporate income tax rates; and where \( \delta \) is the economic rate of depreciation attached to the depreciable asset, \( Z \) is the present value of any tax depreciation deductions on $1 of capital (whose derivation we discuss below) and \( \hat{u} \) represents effective federal and provincial corporate income tax.

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7See McKenzie, Mintz and Scharf (1997).
rates, which differ from $u$ due to special provisions for different sectors in the economy (which will also be discussed below).

In our calculations, we have assumed that Canada is a small open economy with respect to financial markets. The implications of this assumption are twofold. First, we are able to treat the nominal rates of return on debt and equity as exogenous since they are determined on international markets and Canada presumably has no pricing power on international financial markets. Second, the small open economy assumption also means that we can ignore domestic personal taxes on savings as they only determine the proportion of investment financed by domestic rather than foreign firms. This is a common assumption in the effective tax rate literature, and seems particularly justified for the Canadian case.

In order to calculate marginal effective tax rates on capital, we must estimate both $r_F$ and $r_G$. In our calculations, we used information obtained from the Department of Finance to arrive at parameter values of $\beta=0.4$ and $i=0.08$. A value for $\rho$ of 0.067 was obtained by noting the following relationship:

$$
(8) \quad \rho = \frac{i(1-m)}{1-c},
$$

where $m$ was the 25 per cent personal tax on bond interest in 1994 and $c$ was a 10 per cent capital gains tax on personal income. $r_F$ was the same for all sectors and equal to 7.2 per cent.

The calculations required for obtaining $r_G$ are more complex since the impact of taxes on capital depends both upon the characteristics of the tax system, which typically varies across provinces and sectors, and upon the composition of capital assets purchased by the firm: depreciable assets such as buildings and machinery and non-depreciable assets such as land and inventories, as well as intangible assets resulting from expenditure on exploration and development (see the appendix for details).

We should note that our calculations do not take into account the fact that some of the companies in each sector may not be paying any taxes in a particular year. A company that experiences tax losses may be more or less highly taxed than taxpaying companies. When a company is in a tax-loss position, it is only able to carry back losses for three years and carry forward losses, at no interest, for seven years. The effect of this rule on the effective marginal tax rate on

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8For a formal derivation of these formulae, see, for example, Boadway, Bruce, McKenzie and Mintz (1987). Because of special provisions in the Income Tax Act, we use customised versions of the above expressions for the mining, oil and gas, and forestry sectors, and we detail these in the appendix.

9These values have been used in other studies that calculate marginal effective tax rates on capital. See Chen, Mintz and Traviza (1995) for more.

10See Boadway, Bruce and Mintz (1984a and 1987) and McKenzie, Mintz and Scharf (1997).
capital is ambiguous and cannot be fully judged unless more information is available on the time profile of taxable income and losses in all of the sectors.\footnote{The time value of loss deductions, when carried forward, falls as it takes longer for the firms to use up losses. \cite{footnote:11} The implications of this regime are twofold. Compared with companies that never carry forward losses, companies with economic losses or fast write-offs for new investments cannot use the deductions immediately. Thus these companies, often facing risk, are more highly taxed than the taxpaying companies. On the other hand, profitable companies that are carrying forward prior years’ losses can shelter income earned from new investments until the company begins to pay taxes. In this case, the company can face a lower effective tax rate on investments than taxpaying companies.}

Finally, we also excluded the possibility of risk in our analysis and operate under the assumption that producers only experience income risk.\footnote{For more on the implications of this, see McKenzie and Mintz (1992).}

When different types of capital assets are present in a given sector, in order to arrive at an overall $r^{G}$, we must first calculate $r^{G}$’s for each type of capital asset in each sector. These asset-specific $r^{G}$’s must then be weighted in order to obtain a sectoral $r^{G}$. Specifically, let $\phi_j$ represent the share in total capital expenditures of asset $j$, where $j=1,\ldots,N$, and let $r_j^{G}$ be the associated gross-of-tax, net-of-depreciation required return to capital. Then $r^{G}$ is obtained as

$$
r^{G} = \sum_j \phi_j r_j^{G}.
$$

The capital stock weights that we used in our estimations are summarised in Table 2 and were obtained using data from Statistics Canada Catalogue #61-207. We took a five-year average (1984–88) of capital expenditures on depreciable and non-depreciable classes of assets. Depreciable assets include buildings and machinery, while non-depreciable assets are land, inventories and exploration and development expenditures.\footnote{Statistics Canada does not distinguish between mining and oil and gas in its data, so we had to employ the same weights in these sectors. Evidence acquired from other sources indicates that this is not unreasonable as the mining and oil and gas sectors are similar in terms of their capital needs.} Both producers of virgin materials (forestry, mining and oil and gas) and recycled materials (scrap and waste) rely heavily on

\begin{table}
\centering
\begin{tabular}{|l|cccc|}
\hline
 & Buildings & Machinery & Inventory & Land \\
\hline
Forestry & 5.21 & 82.15 & 8.49 & 4.15 \\
Mining and oil & 2.91 & 48.65 & 3.54 & 0.91 \\
\& gas & & & & \\
Scrap and waste & 13.45 & 49.79 & 30.59 & 6.10 \\
Manufacturing & 29.95 & 47.76 & 16.88 & 5.41 \\
\hline
\end{tabular}
\caption{Capital Weights}
\end{table}
machinery as a primary capital input, with the forestry sector being the most machine-intensive. Mining and oil and gas also incur a large amount of exploration and development expenditures, while the scrap and waste sector has a much larger share of inventories.

Statutory and Effective Corporate Income Tax Rates
The statutory rate, $u$, reflects both federal corporate income taxes and corporate income taxes levied by provinces on corporations that are deemed to have a permanent establishment in their province. The tax base for provincial taxes is the same as for federal taxes. Provincial corporate income tax rates range from 8.9 per cent to 17 per cent. In Prince Edward Island, Newfoundland and Ontario, manufacturing and processing firms are eligible for reduced provincial corporate income tax rates varying from 7.5 per cent to 13.5 per cent. Income from mining operations is also taxed at varying rates by all provinces, with rates ranging from 12 per cent in Alberta to 20 per cent in Manitoba and Ontario.

The effective rate of corporate income taxation, $\hat{u}$, in expression (6), differs from the statutory rate due to special provisions for different sectors in the economy; these provisions include federal resource allowances, provincial resource allowances, provincial mining taxes and any applicable provincial processing allowances. Table 3 contains summaries of the taxes that impinge on $\hat{u}$. All sectors in our analysis are subject to a statutory federal corporate income tax rate of 28.84 per cent. As of 1 January 1994, firms operating in either the manufacturing sector (paper, metal, glass and plastic) or the scrap sector may reduce this rate by 7 percentage points by taking advantage of the federal manufacturing and processing tax deduction. This credit is not available for income earned in logging, oil and gas or mining operations.

For federal tax purposes, a resource allowance equal to 25 per cent of net revenues is deductible from corporate taxable income to compensate for the non-deductibility of Crown royalties under the Income Tax Act. Ontario has a 25 per cent resource allowance that applies to both the mining and oil and gas sectors. This allowance compensates producers for the non-deductibility of the federal resource allowance from provincial taxes. Expenditures on processing assets generate other deductions against mining income. Virtually every province allows the deduction of a special processing allowance based upon the original cost of depreciable processing assets. The processing allowance is an annual

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14The federal government has an agreement with most provinces whereby it collects provincial corporate income taxes for the province in exchange for the province’s agreement to use the same tax base. Ontario, Alberta and Quebec were the only provinces not to have entered into this agreement with the federal government in 1994, our year of analysis. But the tax bases used in each of these provinces are similar enough to the federal base that we can assume any substantive differences away.

15For firms that do not qualify as small businesses.
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Federal corporate income tax rate</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
<td>28.84</td>
</tr>
<tr>
<td>Manufacturing and processing tax credit</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Provincial corporate income tax rate</td>
<td>14</td>
<td>15.5</td>
<td>15</td>
<td>17</td>
<td>15.5/14.5</td>
<td>6.9</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Provincial capital asset tax rate</td>
<td>0.3</td>
<td>n/a</td>
<td>0.6</td>
<td>0.3</td>
<td>0.3</td>
<td>0.56</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Provincial stumpage rate</td>
<td>7.6</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>4.5</td>
<td>3.9</td>
<td>7.0</td>
<td>1.0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Provincial royalty rate (oil and gas)</td>
<td>14.1</td>
<td>16.8</td>
<td>17.3</td>
<td>18.9</td>
<td>9.7</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Provincial mining tax rate</td>
<td>13</td>
<td>12</td>
<td>n/a</td>
<td>20</td>
<td>20</td>
<td>18</td>
<td>16</td>
<td>15</td>
<td>n/a</td>
<td>15</td>
</tr>
</tbody>
</table>

Key:
- BC: British Columbia
- Alb: Alberta
- Sas: Saskatchewan
- Man: Manitoba
- Ont: Ontario
- Que: Quebec
- NB: New Brunswick
- NS: Nova Scotia
- PEI: Prince Edward Island
- Newf: Newfoundland
Tax Incentives for Extraction and Recycling

deduction calculated as a specified percentage of the original cost of an asset used for the processing of ore up to the prime metal stage. Typically, limits are placed upon the maximum and minimum amounts that may be claimed as a processing allowance.\footnote{For example, in Ontario, the processing allowance may not be less than 15 per cent, nor more than 65 per cent, of mining and processing income after deducting all expenses. Unused processing allowances may not be carried forward into future years and the processing allowances apply only to the mining sector and not to oil and gas. In our calculations, we used the processing allowance ceiling, where applicable.}

Effective rates of corporate income taxation in the forestry and mining sectors are also affected by stumpage fees, taxes on logging income and royalty taxes. As holders of exclusive timber-harvesting rights, firms that engage in logging activities are required to pay stumpage fees to the province in which they operate. These are deductible when computing taxable income. Stumpage rates are based on current prices as well as on the harvest of timber within the area in which the tenure holder operates. The rates differ by type of wood, region harvested and province. In our calculations, we derived provincial \emph{ad valorem} rates by dividing the total value of stumpage fees in a year by the total value of sales.

Ontario and Québec are the only provinces that levy taxes on logging income. The rate is 10 per cent in each province. British Columbia also offers a one-third logging tax credit against logging taxes paid, while Québec offers a one-third logging tax deduction. A further deduction of two-thirds logging tax paid is offered by the federal government. Notice that, as long as companies are taxable for federal and provincial purposes, the provincial logging tax only affects the distribution of taxes paid between the federal and provincial governments.

Crown royalties are amounts receivable by, or payable to, the Crown as a royalty tax, and they are not deductible in computing taxable income. Per unit royalty rates on oil and gas are tied to current prices and quantities extracted. In our calculations, we estimated the \emph{ad valorem} rates by computing the ratio of the total value of royalties paid to the total value of sales. The provinces that levy royalties are British Columbia, Alberta, Saskatchewan, Manitoba and Ontario.

Capital Cost Allowances

For depreciable assets, such as buildings, machinery and equipment, and new assets, corporate income taxes lower the cost of capital through tax depreciation deductions and investment tax credits. In Canada, depreciation deductions are allowed through a system of capital cost allowances (CCAs). For tax purposes, capital assets are grouped into different classes, which are then each assigned a CCA rate for depreciation of historical costs, \(\bar{d}\). Then, in each period, the CCA rate times the effective federal and provincial corporate income tax rate, \(\hat{u}\), is allowed as a deduction. Let \(A\) represent the present value of tax deductions on $1
of capital, while $Z$ is the present value of any tax depreciation deductions on $1$ of capital. Then

\[ \dot{Z} = \hat{a} A. \]

The present value of tax deductions depends upon the way that CCAs are allowed in the Canadian Income Tax Act. A constant declining-balance rate (unindexed for inflation) is used for most classes of capital assets, although a few receive a straight-line treatment.\(^{17}\)

In our calculations, we estimated the present value of CCA deductions for a variety of CCA classes, for each sector. Some aggregation was required as buildings and machinery comprise a number of different CCA classes.\(^{18}\) In order to aggregate the classes into the asset categories, we obtained a weighted average of expenditures on each CCA class in each sector over a five-year period (1981–86). Data on expenditures were obtained from Statistics Canada Catalogue #13-211 and a summary is available upon request.

Both the federal government and the provinces allow deductibility of CCAs from corporate income taxes, with the provinces employing the same asset classes as the federal government. There is also a 15 per cent federal investment tax credit available in the Atlantic provinces as well as in the Gaspé Peninsula region of Québec. The credit is tied to the cost of depreciable property, such as buildings and machinery and equipment, that has been acquired for use in qualified activities, and has the effect of further reducing CCAs. For federal tax purposes, the resource allowance is deductible as a capital cost from corporate taxable income in the mining and oil and gas sectors.

**Exploration and Development Expenditures**

The presence of exploration and development expenditures in the mining sector also requires a specialised version of expression (6). The user cost of exploration and development, $r^E$, may be expressed as

\[ r^E = \hat{b} E. \]

\(^{17}\)See the appendix.

\(^{18}\)Buildings consist of CCA classes 1–3, 5, 6 and 13. Classes 1, 2 and 3 are allowed declining-balance CCA rates of 4 per cent, 6 per cent and 5 per cent respectively; classes 5 and 6 are allowed declining-balance rates of 10 per cent. Class 13 assets are written off on a five-year straight-line rule. For machinery and equipment, the most important CCA classes for the different sectors are: firms operating in the mining and oil and gas sectors will employ class 41, class 10 and class 12 assets — class 12 includes mine shafts and haulage ways and burden removal costs (the assets are allowed a depreciation rate of 100 per cent), while class 41 includes oil and gas exploration and production equipment as well as mine buildings (class 41 assets are allowed a declining-balance depreciation rate of 25 per cent, while class 10 assets are allowed a rate of 30 per cent); the manufacturing and scrap sectors are most likely to employ class 39 and class 40 assets — class 39 is property and has a declining-balance rate of 25 per cent, while class 40 is allowed a rate of 30 per cent; forestry timber resource limits may be categorised as class 10 or class 33 (with a declining-balance depreciation rate of 15 per cent).
\[ r_E^G = r_N^N \frac{1-V}{1-\hat{u} - g(1-u_p)}, \]

where \( r_N^N \) is the estimated marginal cost of exploration and development, \( V \) is the present value of all exploration and development allowances, \( g \) is the \textit{ad valorem} royalty rate and \( u_p \) is the provincial corporate income tax rate.

Exploration and development expenditures, relevant only for the mining sector and the oil and gas sector, may also be expensed. We take into account three different types of exploration and development: grass-roots exploration and development; post-production development; and property rights acquisitions.¹⁹

The expensing of exploration and development expenditures is guided by a system of rules that are similar to those for depreciable assets: expenditures are accumulated in a variety of accounts, or pools, and written off at specified rates. Expenditures may be categorised as either Canadian Exploration Expenses (CEEs) or Canadian Development Expenses (CDEs) for the mining and oil and gas industries. At the federal level, CEEs are written off at a rate of 100 per cent while CDEs are written off at a 30 per cent declining-balance rate. The only sectors in our analysis that are eligible for these special ‘depreciation’ allowances are the mining and oil and gas industries. Provinces also offer exploration and development expenses, with the federal rates for CEEs and CDEs being applicable in all provinces except Ontario and Québec, where both rates are 100 per cent.

In addition to the aforementioned: Québec allows mining companies an investment allowance on exploration and development expenditures, the rate being one-third and being deductible from mining taxes; and New Brunswick provides an exploration allowance that is 150 per cent of eligible exploration expenditures incurred by mining and oil and gas industries.

\section*{3. Labour Inputs}

An expression analogous to expression (4) can be employed to recover the marginal effective tax rate on labour. This is primarily determined by applicable payroll taxes and personal taxes, but corporate tax provisions can also play a role. Following the same logic as above, the user cost of labour will be the same as the gross-of-tax return to labour since labour is not affected by depreciation.²⁰

¹⁹Grass-roots expenditures involve the actual search for and discovery of the primary resource and evaluation of its grade and characteristics, as well as the development of the infrastructure needed for subsequent production. Post-production development expenditures are costs incurred after the start of commercial production from the resource extraction operation; once incurred, these are expensed.

²⁰An incremental change in labour is an additional work hour by the ‘average’ worker in an industry. For each industry, we first calculated effective income tax rates within each earning class, using effective marginal tax rates at the upper limit of the various thresholds in the tax system; we then obtained the number of workers within each class for each industry and calculated employment shares for each class in each industry; these
There are two additional issues that we must consider with respect to taxes on labour. There is the question of how much, if any, of the personal income tax system is shifted onto the employer. Here, we follow Dahlby (1992) by assuming that one-third of payroll taxes are shifted to the employer and are thus reflected in the marginal cost of hiring labour. We adopt the same assumption for personal income taxes.

Another issue centres around the fact that payroll taxes may be considered as benefit taxes in the sense that payments are used to fund specific benefits directly. This raises the question of whether these levies should be compared to other taxes less directly tied to the provision of benefits, such as general income taxes or sales taxes. There are two main problems that arise in this regard. First, although benefit taxes increase the marginal cost of providing goods, it may be inappropriate to account for the costs associated with these taxes without at the same time accounting for the benefits. Second, in the absence of benefit taxes, employers may fund these benefits themselves, which would lead to higher costs. In either case, the elimination of government services and the taxes that fund them may cause costs to increase. In our analysis, we compute marginal effective tax rates under the assumption that payroll taxes impinge upon costs just like any other taxes.

In our calculations, we have taken into account employer contributions to the Canada and Québec Pension Plans (CPP and QPP), federal unemployment insurance contributions (UIC), provincial health and education payroll taxes and personal income taxes (PIT). The Canada Pension Plan has been in effect since 1966 in all provinces in Canada except Québec, which operates the Québec Pension Plan under the same contribution rules as the CPP. Currently, maximum pensionable earnings of $30,500 and a basic exemption of $3,000 are taxed at 2.3 per cent. Unemployment insurance contributions have employers contributing 3.15 per cent on maximum earnings of $35,360, while employees must contribute 2.5 per cent. Payroll taxes are levied on employers’ payrolls by four provinces (Newfoundland, Québec, Ontario and Manitoba), while Alberta and British Columbia levy healthcare premiums.

shares were then used as weights for averaging the various effective income tax rates in each industry, obtaining a measure of ‘average’ marginal effective tax rates on labour inputs by industry.

Our final calculations are not very sensitive to these shifting assumptions (see McKenzie, Mintz and Scharf (1997)). Payroll taxes are small relative to total income taxes. Furthermore, since the share of labour in total inputs is small relative to the share of other inputs in the production process, adopting a higher shifting parameter (such as the 80 per cent employed by Dahlby in his Ontario Fair Tax Commission (1993) study) would not qualitatively change our results or the conclusions that we derive from them. Our results on marginal effective tax rates on labour are more sensitive to our income-tax-shifting assumption, but so long as the shifting assumption is the same for all sectors, the pattern of taxation across the different sectors remains the same.

The tax credit that employees receive for their contributions have been taken into account in the income tax calculations. Effective rates by income class were calculated for the upper limit of each income range.
Notice that corporate taxes do not appear in the calculation of effective marginal tax rates on labour because labour costs are deductible from taxable income; however, the expression will change in the presence of non-deductible royalty taxes, or stumpage fees that are deductible when computing taxable income. The effect of these is to drive a wedge between the statutory tax rate on corporate income and the rate on labour. Let $w^G$ and $w^N$ denote the gross-of-tax and after-tax marginal cost of labour respectively. Then provisions in the Canadian Income Tax Act applying to the oil and gas industry can be captured by the following expression:

$$w^G = \frac{w^N (1 - u)}{1 - \hat{u} - g(1 - u_p)};$$

in the forestry sector, this becomes

$$w^G = \frac{w^N}{1 - s},$$

where $s$ represents an *ad valorem* stumpage rate.

4. Other Inputs

Provincial retail sales taxes (PST) may affect the marginal cost of production in two ways: the final manufactured commodity is subject to both the provincial sales tax and the federal goods and services tax (GST), but a certain percentage of PST can also be expected to be paid on business inputs and machinery and equipment purchases in all stages of production. For forestry and mining, there are specific exemptions from PST on business inputs, but these do not apply to the manufacturing and scrap sectors. Employing data provided by the Department of Finance, we were able to calculate the percentage of provincial retail sales taxes paid on other inputs as well as on the machinery and equipment class of depreciable capital assets for all sectors.

When computing total marginal cost of production, we need to make assumptions concerning the extent to which taxes that affect the output price of intermediate inputs are borne by the users of the inputs. If Canada were a small open economy with respect to raw materials, the price of these inputs would be fully determined by global market conditions, and therefore any taxes impinging on their production cost would leave price unaffected (i.e. they would be shifted back onto the factors involved in production). Canada, however, is a significant player in world markets with respect to natural resources, implying that some of the tax will actually be shifted forward. In our calculations, we assume that, in sector $j$, a proportion $\beta_j$ of the tax is shifted forward. The values assumed for $\beta_j$
are contained in Table 4. They are sector-specific and based on elasticity estimates obtained from recent studies (Harris and Cox, 1983; Beauséjour, Lenjosek and Smart, 1995).23

III. CALCULATION RESULTS

Table 5 provides a summary of our calculations of marginal effective tax rates on capital. With reference to the primary sector, our calculations agree with results obtained in previous research in that capital investments in the mining sector are taxed at relatively lower rates in all provinces than are investments in the forestry, oil and gas, and scrap and waste sectors: mining tax rates range from 9.6 per cent in Ontario to less than –40 per cent in New Brunswick and Nova Scotia. Forestry capital tax rates are the highest in Saskatchewan, at 91 per cent, and the lowest in the Atlantic provinces, while oil and gas capital tax rates are also highest in Saskatchewan, at 68 per cent. Several factors contribute to the relatively low marginal effective tax rates on capital in the mining sector: the expensing of exploration and development expenditures in the mining and oil and gas sectors in conjunction with a large expenditure share on these assets; fast write-offs on depreciable capital assets; the processing allowance; and provincial sales tax exemptions for purchases of capital goods used by the resource sector. Provincial stumpage fees for forestry and oil and gas royalties also have the effect of increasing the marginal effective tax rate by increasing the gross-of-tax

23We adopt ‘central case’ values of the shifting parameters implied by the various elasticity estimates. See Chen, Mintz and Traviza (1995) for details.
<table>
<thead>
<tr>
<th>Province</th>
<th>Forestry</th>
<th>Mining</th>
<th>Oil &amp; gas</th>
<th>Scrap &amp; waste</th>
<th>Paper</th>
<th>Metal</th>
<th>Glass</th>
<th>Plastic</th>
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<td>-17.0</td>
<td>-22.1</td>
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</tbody>
</table>

TABLE 5
Marginal Effective Tax Rates on Capital

Per cent
user cost of capital. Forestry stumpage fees are particularly high in British Columbia, Ontario, Québec and New Brunswick.

For manufacturing of paper, fabricated metal, glass and plastic, marginal effective tax rates on capital are in the order of –15 per cent in the Atlantic provinces and range from 14.5 per cent to 28.1 per cent in the other provinces. The main reason for this discrepancy is the availability of the investment tax credit in these provinces. Our results also indicate that capital taxes on scrap and waste activities are of a higher magnitude than those in the manufacturing and mining sectors and lower than those in the forestry sector, with rates ranging from close to 0 per cent in the Atlantic provinces to 20 per cent in Alberta and 45 per cent in Saskatchewan. This can be accounted for by the fact that capital used by the scrap and waste sector is subject, on average, to provincial sales tax rates of 6 per cent, much higher than in the manufacturing and forestry sectors, yet still low enough when combined with the manufacturing and processing tax credit to result in a lower effective tax rate than observed in the forestry sector.

Table 6 contains estimates of the marginal effective tax rates on labour by province for each sector. These figures do not indicate substantial asymmetries in the rates on labour: forestry rates range from 17 to 23 per cent; mining rates range from 17 to 21 per cent; scrap and waste rates vary from 17 to 21 per cent; manufacturing rates range from 17 to 23 per cent. Effective tax rates on labour used in the oil and gas sector are relatively higher than those in the other sectors, with rates ranging from 21 to 26 per cent. The reason for these higher rates is that oil and gas royalties are not deductible from the corporate income tax. Otherwise, differences in these rates mainly reflect variations in the income profiles of the labour force across sectors and provinces as well as differences in payroll and health deductions across provinces.

<table>
<thead>
<tr>
<th></th>
<th>Forestry</th>
<th>Mining</th>
<th>Oil &amp; gas</th>
<th>Scrap &amp; waste</th>
<th>Manufacturing</th>
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<td>23.4</td>
<td>18.2</td>
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</table>
Table 7 presents overall marginal effective tax rates for recycled and virgin materials. Our figures indicate that the scrap and waste sector faces tax rates on marginal costs that are higher than for mining and lower than for oil and gas. The substantially lower rates on virgin material produced by the mining sector can be mainly attributed to the combination of a high capital input share and low marginal effective tax rates on capital. The oil and gas sector faces particularly high effective tax rates on marginal costs of production due to royalties. In comparison with the forestry sector, scrap and waste faces lower tax rates in logging-intensive provinces that levy logging taxes, such as British Columbia and Ontario, and higher rates in other provinces. On the other hand, forestry and oil and gas use other inputs besides labour and capital that are taxed at low rates because of the exemption of provincial sales taxes on business inputs.

We should note here that, by definition, scrap is an item for which there may not be an explicit market; scrap collection may be carried out directly by manufacturers and is often the by-product of public provision of garbage and waste disposal services. In our computations, we have included an explicit stage for scrap collection and assume that users of scrap bear the full cost of its provision. Future research should examine the implications for effective tax rates of assuming a different market structure for this sector.

Tables 8 and 9 present overall marginal effective tax rates for finished products that employ virgin materials and recycled materials respectively. These rates were arrived at by aggregating marginal effective tax rates on the individual inputs — capital, labour, other inputs and materials (virgin or recycled). The virgin materials were decomposed into mining, forestry and oil and gas materials. For our analysis, we focus on paper (which uses either virgin forestry products or recycled paper), metal fabricated products (which use either newly
processed metals or scrap metal), glass (which uses sand or recycled bottles) and plastic (which uses crude oil or recycled products).

The figures indicate that all products that employ recycled material are, on average, more heavily taxed than those that employ virgin material. This difference is largest for metal products, which employ large amounts of intermediate inputs from the mining industry: metal produced with virgin material has a Canada-wide weighted average tax rate of 23.4 per cent, while metal produced with recycled material has a rate of 27.9 per cent. The difference

<table>
<thead>
<tr>
<th>TABLE 8</th>
<th>Marginal Effective Tax Rates on Marginal Costs: Final Products Using Virgin Materials as Intermediate Inputs</th>
</tr>
</thead>
<tbody>
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</table>

<table>
<thead>
<tr>
<th>TABLE 9</th>
<th>Marginal Effective Tax Rates on Marginal Costs: Final Products Using Recycled Materials as Intermediate Inputs</th>
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</thead>
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<tr>
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<td>20.0</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>22.5</td>
</tr>
</tbody>
</table>
Tax Incentives for Extraction and Recycling

is still positive but smaller for paper and glass. Plastic is the exception, with marginal effective rates for products using recycled materials well below those applying to products using virgin materials.

The patterns of effective tax rates in each province are fairly similar to the Canadian average. In general, the difference between effective rates on products using virgin and recycled materials is about the same across most provinces (again, with the exception of plastics). For paper, virgin material is taxed at about 2 percentage points less than recycled material in all 10 provinces (the lowest effective tax rates being in Alberta, where there is no provincial sales tax). Recycled fabricated metal is taxed as much as 5 percentage points more than virgin material in the provinces of Saskatchewan, Manitoba, New Brunswick, Nova Scotia and Newfoundland, compared with a Canada-wide weighted average difference of 4.5 percentage points. The difference between effective tax rates on virgin and recycled material by province for glass is around 2 percentage points, except in New Brunswick and Nova Scotia where the difference is more than 3 percentage points. Non-recycled plastic products are taxed less than recycled products in British Columbia, Saskatchewan, Manitoba, Ontario and Québec, while the reverse is true in Alberta and in all four Atlantic provinces.

Some of the most important factors contributing to differences in effective tax rates across provinces are the following: in some provinces, fabricated metal is taxed at a lower rate, especially in the Atlantic provinces where firms qualify for the investment tax credit which affects the cost of capital significantly; mining tax regimes also vary by province, the most generous systems being in Alberta and the Atlantic provinces; non-recycled plastic products are taxed more highly than recycled plastic products due to the high provincial sales tax on business and capital inputs purchased by businesses in the Atlantic provinces, as well as the high royalty rate on the oil and gas industry in Alberta.

Overall, the results of our calculations of marginal effective tax rates indicate that virgin materials enjoy some degree of tax advantage in all sectors except plastic products. The main sources of this advantage are not limited to differences in the tax treatment of capital across sectors and the special corporate income and mining tax incentives provided at the exploration and extraction stages of the production of virgin materials: provincial sales taxes are also borne more heavily by scrap firms than by resource and manufacturing firms, and provincial sales taxes that apply to business inputs also fall more heavily upon the recycling sector. In addition, scrap firms rely more on inputs that are subject to high tax rates than the other sectors, which tend to use materials, such as supplies and fuel, that are taxed at lower rates.

These findings have an immediate policy implication: since these differences mostly come from corporate taxes and provincial sales taxes, our analysis suggests that any shift from corporate taxes to payroll taxes or the harmonisation of provincial and federal taxes would result in a reduction of the gap between the
tax treatments of virgin and recycled materials, as well as to a levelling of interprovincial differentials.

Our results, however, should not be interpreted as identifying a ‘bias’ in the treatment of virgin relative to recycled materials. We only sought to uncover the incentives generated by the tax system for extraction and recycling of basic materials. These would result in a bias only in the absence of other distortions; but if markets are imperfect or missing, then taxes will interact with pre-existing distortions. This is particularly relevant with respect to the scrap and waste sector of the economy. Full pricing of waste disposal could result in an efficient allocation of resources since it would induce individuals and businesses to reduce waste to the socially optimal level. But markets for waste are generally viewed as imperfect, and thus fiscal remedies to internalise externalities associated with waste production would be desirable from a pure efficiency point of view (Goddard, 1994; Kennedy and La Plante, 1994). Although this analysis was beyond the scope of the present study, future research could build on this study to examine the efficiency effects of incorporating corrective measures such as taxes on virgin materials or deposit-refund mechanisms.

**APPENDIX: MARGINAL EFFECTIVE TAX RATE ON CAPITAL**

1. **List of Parameters and Taxes**

\[
\hat{\epsilon} = \left( \frac{r^N + \delta (1 - \hat{u}Z)}{1 - \hat{u}} \right) \delta - \delta
\]

Gross-of-tax, net-of-depreciation rate of return required to yield the real required rate of return

\[
r^N = \beta i (1 - u) + (1 - \beta) \rho
\]

After-tax marginal cost of finance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta )</td>
<td>Fraction of debt financing, parameterised at 40 per cent</td>
</tr>
<tr>
<td>( i )</td>
<td>Nominal interest rate, parameterised at 8 per cent</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Nominal return to equity finance, parameterised at 6.7 per cent</td>
</tr>
<tr>
<td>( u = u_f + u_p )</td>
<td>Combined statutory federal and provincial corporate income tax rates</td>
</tr>
<tr>
<td>( u_f )</td>
<td>Federal corporate income tax rate</td>
</tr>
<tr>
<td>( u_p )</td>
<td>Provincial corporate income tax rate</td>
</tr>
<tr>
<td>( \pi )</td>
<td>Inflation rate, parameterised at 2 per cent</td>
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<tr>
<td>( \delta )</td>
<td>Economic rate of depreciation</td>
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<tr>
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<td>Federal resource allowance rate</td>
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<td>( \hat{u} )</td>
<td>Combined effective federal and provincial corporate income tax rates</td>
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<td>( g )</td>
<td>Ad valorem royalty rates for mining and oil and gas</td>
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<tr>
<td>( s )</td>
<td>Ad valorem stumpage rates for logging</td>
</tr>
<tr>
<td>( \hat{u}_u )</td>
<td>Effective provincial mining tax rates</td>
</tr>
</tbody>
</table>
Tax Incentives for Extraction and Recycling

\[ \tau \] Provincial business tax rates
\[ d \] Tax depreciation rates
\[ \rho = \beta i + (1-\beta) \rho \] Weighted pre-tax opportunity cost of finance
\[ CDE \] Canadian Development Expense
\[ IA \] Investment allowance
\[ EEA \] Exploration expense allowance

2. Depreciable Capital

Manufacturing, Scrap and Waste

In all provinces,

\[ r^G_D = \frac{r^N + \delta - \pi}{1 - \hat{u}} \left\{ 1 - \hat{u} Z + \frac{\tau(1-\hat{u})}{r^N + d} \right\} (1 + PST) - \delta , \]

where \( Z \) is the present value of tax deductions on $1 of capital.

Calculating \( Z \) for a constant declining-balance rate (unindexed for inflation) gives

\[ (A.2) \quad Z = \frac{d}{r + d} . \]

For straight-line treatment,

\[ (A.3) \quad Z = \frac{d}{T} , \]

where \( T \) is the useful service life of the capital asset. Using the half-year rule gives

\[ (A.4) \quad Z = \frac{d}{2} + \left( 1 - \frac{d}{2} \right) \frac{d e^{-r^F}}{r^F + d} . \]

Forestry

\[ (A.5) \quad r^G_D = \frac{r^N + \delta - \pi}{(1 - \hat{u})(1 - s)} \left\{ 1 - \hat{u} Z + \frac{\tau(1-\hat{u})}{r^N + d} \right\} (1 + PST) - \delta . \]

Mining

\[ (A.6) \quad r^G_D = \frac{r^N + \delta - \pi}{1 - \hat{u}} \left\{ 1 - \hat{u} Z_1 - \hat{u}_s Z_2 + \frac{\tau(1-\hat{u})}{r^N + d} \right\} (1 + PST) - \delta , \]
where $Z_1$ is the present value of federal and provincial CCAs, net of federal and provincial resource allowances, and $Z_2$ is the present value of mining tax deductions. The terms $Z_1$ and $Z_2$ are calculated using the appropriate expressions, (A.2)–(A.4), while $\hat{u}$ and $\hat{u}_m$ vary by province and are calculated as follows:

\[
\hat{u} = u_f (1 - \sigma_f) + u_p \\
\hat{u} = (u_f + u_p)(1 - \sigma_f) \\
\hat{u} = \Phi + (u_f + u_p)(1 - \sigma_f)(1 - \Phi) \\
\hat{u}_m = u_m \\
\hat{u}_m = u_f (1 - PAC)(1 - u_p) \\
\hat{u}_m = u_m (1 - \sigma_p)(1 - PAC) \\
\hat{u}_m = u_m (1 - PAC)
\]

British Columbia, Alberta, Ontario
Manitoba, Québec
New Brunswick, Nova Scotia, Newfoundland
British Columbia
Alberta
Ontario
All other mining provinces

### Oil and Gas

\[
\begin{align*}
\hat{r}_C &= \frac{r^N + \delta - \pi}{1 - \hat{u} - g(1 - u_p)} \left\{ 1 - \hat{u}Z + \frac{\tau(1 - \hat{u})}{r^N + d} \right\} (1 + PST) - \delta,
\end{align*}
\]

with $\hat{u}$ being the same as for the mining industry above.

### 3. Exploration and Development

#### Mining

\[
\hat{r}_E = \frac{(r^N - \pi)(1 - \hat{u}Z_1 - \hat{u}_mZ_2)}{1 - \hat{u}}.
\]

The terms $\hat{u}Z_1$ and $\hat{u}_mZ_2$ differ by province and type of expenditure as follows:

**Grass-roots exploration**

$\hat{u}Z_1 = u_f + u_p$
$\hat{u}_mZ_2 = u_m$
$\hat{u}_mZ_2 = u_m (1 - PAC)(1 - u_p)$
$\hat{u}_mZ_2 = u_m (1 - \sigma_p)(1 - PAC)Z_2$
$\hat{u}_mZ_2 = u_m (1 - PAC)(1 + IA)Z_2$
$\hat{u}_mZ_2 = u_m (1 - PAC)EEA$
$\hat{u}_mZ_2 = u_m (1 - PAC)$

All mining provinces
British Columbia
Alberta, Manitoba
Ontario
Québec
New Brunswick
Nova Scotia, Newfoundland
Post-production development

\[
\begin{align*}
\hat{u}Z_1 &= u_f (1 - \sigma_f) + u_p & \text{British Columbia, Alberta, Ontario} \\
\hat{u}Z_1 &= (u_f + u_p)(1 - \sigma_f) & \text{All other mining provinces} \\
\hat{u}_uZ_2 &= u_u & \text{British Columbia} \\
\hat{u}_uZ_2 &= u_u (1 - PAC)(1 - u_p) & \text{Alberta, Manitoba} \\
\hat{u}_uZ_2 &= u_u (1 - PAC)(1 - \sigma_p)Z_2 & \text{Ontario} \\
\hat{u}_uZ_2 &= u_u (1 - PAC)(1 + IA)Z_2 & \text{Québec} \\
\hat{u}_uZ_2 &= u_u (1 - PAC)EEA & \text{New Brunswick} \\
\hat{u}_uZ_2 &= u_u (1 - PAC) & \text{Nova Scotia, Newfoundland}
\end{align*}
\]

Property rights

\[
\begin{align*}
\hat{u}Z_2 &= u_f CDE/(r^N + CDE) + u_p & \text{Ontario, Québec} \\
\hat{u}Z_1 &= (u_f + u_p)CDE/(r^N + CDE) & \text{All other mining provinces} \\
\hat{u}_uZ_2 &= u_u & \text{All mining provinces}
\end{align*}
\]

Oil and Gas

\[
(A.9) \quad r_E = \frac{r^N - \pi (1 - \hat{u}Z_1 - \hat{u}_uZ_2)}{1 - \hat{u} - g(1 - u_p)},
\]

with all parameters being the same as for mining.

4. Inventories

Manufacturing, Scrap and Waste, and Mining

\[
(A.10) \quad r_I^G = \frac{r^N - \pi + (u_f + u_p)\pi}{1 - (u_f + u_p)} + \tau.
\]

Forestry

\[
(A.11) \quad r_I^G = \frac{r^N - \pi + (u_f + u_p)\pi}{(1 - [u_f + u_p])(1 - s)(1 - s) \tau}.
\]
$r^G_L = \frac{r^N - \pi + (u_f + u_p)\pi + \tau}{1 - (u_f + u_p) - g(1 - u_p)}$

5. Land

Manufacturing, Scrap and Waste, and Mining

$\pi \tau^+ + + + = -+−−−$

Forestry

$\pi \tau^+ + + + = -+−−−$

Oil and Gas

$\pi \tau^+ + + + = -+−−−$

REFERENCES


