Taxing Hydroelectricity in Ontario

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En utilisant des données provenant d’états financiers d’Hydro Ontario ainsi que les coûts observés d’importation d’électricité dans la province, nous obtenons un estimé sur la rente hydroélectrique qui est potentiellement disponible comme revenu provenant des taxes en Ontario. Nos résultats indiquent que les frais associés à l’utilisation de l’eau en Ontario pourrait être augmentés par un facteur de dix afin de capter cette rente. Nous évaluons l’impact de la taxation de cette rente sur le prix de l’électricité ainsi que les prix des produits manufacturés étant donné qu’une partie importante de la rente potentielle est couramment utilisée à la subvention de la consommation d’électricité. Nous établissons un rapport entre nos résultats et la restructuration dans le marché de l’électricité en Ontario.

Using data from the financial statements of Ontario Hydro and an observed cost of importing electricity to the province, we provide an estimate of the hydroelectric rent that is potentially available in Ontario as tax revenue. Our results suggest that the existing water charges in Ontario can be raised ten-fold to capture this rent. We assess the impact that fully taxing the rent would have on the prices of electricity and manufacturing products, given that a substantial portion of the potential rent is currently used implicitly to subsidize electricity consumption. We relate our findings to the ongoing restructuring of the electricity market in Ontario.

INTRODUCTION

The government of Ontario has announced plans to restructure the province’s electricity market and to privatize assets belonging to its public utility (Electricity Act, 1998). As part of the privatization strategy the government may impose a special charge on electricity sales in order to pay down the debt owed by Ontario Hydro. The Ontario government currently levies a water charge equivalent to $0.344 cents per kilowatt-hour (kWh) on generators of hydroelectricity (mainly the public utility) in the province, amounting to $113 million in 1995.1 The objective of this paper is to estimate the availability of hydroelectric economic rent as a revenue source for the Ontario government, and to assess the impact that fully appropriating this rent through an increased water charge would have on consumers.

Electrical power in Ontario and elsewhere is generated using several energy sources, generally categorized as hydro (water), thermal (coal, oil, gas) and nuclear. Jurisdictions with hydraulic resources are fortunate since waterpower is renewable and the energy cost of hydropower per kilowatt-hour (kWh) is nil. The other fuels for electrical generation — natural gas, coal, oil, uranium — are purchased in open markets at prices that reflect their extraction costs and their values in alternative uses. Furthermore, the capital development and environmental
costs for many hydraulic sites are cost-effective in comparison to nuclear and fossil plants (IPPSO 1997).

In Ontario, as well as in most other jurisdictions, ownership of the waterbeds used to generate electricity rests with the government. One of the public choices required of the natural resource authorities is to determine the allocation, explicitly or implicitly, of the economic rent that arises by virtue of the scarcity of hydraulic sites suitable for development. Economic rent refers to the surplus of value accruing to the owner of a scarce resource, when the total market value of the resource exceeds the long-run total opportunity cost of supplying it. Since the best alternative use value of the waterbeds used to generate electricity is relatively small in most cases, the economic rent per kWh of electricity is given by the difference between the competitive market price of electricity and the average fixed costs associated with developing and managing the waterbeds. Thus waterbeds that are earmarked for future development, such as Mettagami and Little Jackfish, are expensive to exploit and so may be only marginally economical, while some existing stations, such as Sir Adam Beck at Niagara Falls, can generate large cash surpluses or rent.

Historically, in countries endowed with hydraulic resources, much of this rent has been implicitly used to subsidize manufacturing industries and residential consumption by setting an artificially low price for electricity, rather than collected as tax revenue. The point has been made in Canada by Bernard (1993) and Gunton and Richards (1987). The Economic Council of Canada (1985) noted that the underpricing of electricity stems from the fact that utilities have not sought to achieve competitive returns on assets, due to government-backed loans, no provisions for income taxes, explicit government encouragement to maintain low consumer rates, and other factors.

There are at least three distinct economic reasons why the government should attempt to capture the full amount of hydroelectric rents. The first justification is that a government must raise tax revenue to pay for public goods and services, and it should attempt to do so in a manner that minimizes its effect on the business decisions of the private sector. Otherwise, taxes distort the allocation of resources, resulting in economic inefficiency. The appropriation of economic rent by the government does not, in principle, affect a profit-maximizing company’s level of investment. This is because taxing pure economic rent still allows an electric utility to earn a normal return on investments that is sufficient to induce any investment that at least breaks even. Thus, all profitable investments are carried out even though the government taxes the excess returns. The public capture of economic rent is a perfect tax in the sense of minimizing tax-induced distortions.

A second reason why public rent capture is increasingly appropriate is that electricity generation is no longer viewed as being characterized by the increasing returns to scale associated with natural monopoly (Jaccard 1996b). As a result of this changing view, there is a strong likelihood that the public utility will be privatized. The prices at which the utility’s assets, including access to the hydraulic sites, are sold to private investors may inadequately reflect the capitalized value of the future rent stream, if the auction market for power-generating assets is insufficiently competitive due to the large financial requirements of bidders. As the private utilities raise their electricity prices to levels justified by market demand, the rent that is currently forgone in favour of consumers through artificially depressed prices will materialize as private profits. As a matter of fairness, the government would be hard pressed to justify this windfall transfer from consumers to owners of private firms. By taxing rents, residents of the province can collectively retain the rents, but now as public revenues rather than private rebates.

Thirdly, taxing rents and concurrently raising electricity prices to the competitive market equilibrium level would curtail overusage of electricity and
conserve capital in the long run. In order to tax rents the government regulatory authorities must first allow the public utility to generate a financial surplus by raising its prices in line with the marginal cost of supplying electricity. A proxy for the market equilibrium price of electricity is the price at which Ontario Hydro can export or import a long-term supply of base electricity.

An international survey by UNIPEDE (1993) lists the wide range of policies used by governments to extract some hydraulic rents. Most of the methods used are imperfect, in that they serve only as indirect ways of taxing rent, and may in fact be quite distortionary. The Norwegian economists Amundsen, Andersen and Saunnarnes (1992) have urged Norway to adopt a Resource Rent Tax (RRT) on hydroelectricity. In theory this is a tax on pure economic profits, engendering no distortions. The method is implemented in practice by taxing the free cash flows of a company using its financial statements. One difficulty with the RRT is that it would necessitate a reconstruction of the free cash flows of Ontario Hydro over the long history of its assets. An alternative but imperfect tax on rents would be to charge a royalty on electricity production and/or a tax on the capital base of the firm. This so-called water charge is the fiscal structure currently in place in Ontario. Our estimate of the impact of extracting additional hydroelectric rent in Ontario is based on raising the water charge from its present level.

In the next section, we illustrate on a diagram the concept of rent and the costs and benefits associated with moving toward an optimal rent tax. We then provide an estimate of the rent potentially available in Ontario and compare our results with previous studies. We also evaluate the politically sensitive impact that the optimal (higher) water charge would have on the price of electricity consumed in the residential sector, and on the prices of goods and services produced by manufacturing, mining, forestry, commercial, and agricultural sectors. In this exercise, the manufacturing sector is disaggregated to two-digit industries. Finally, we present our conclusions and policy recommendations.

**AN ILLUSTRATION OF RENT**

Figure 1 illustrates both the idea of economic rent generated by a scarce natural resource, and the social cost associated with the underpricing of electricity. The long-run marginal cost (LRMC) is drawn as an increasing step function to reflect the notion that each hydraulic site generates electricity at a constant short-run marginal cost, but that the capital costs of developing the waterbeds are increasing, as less suitable sites are exploited. In the figure, $P^*$ is the competitive “world price” of electricity, at which Ontario utilities can import or export electricity. At that price, it is profitable for domestic utilities to produce $Q^*$ units of electricity, corresponding to point C. Domestic (Ontario) consumers would purchase $Q^d$ units, and exports would equal $Q^* - Q^d$. Rent is given by area $P^*CA$, equal to the difference between revenues and the area under the LRMC curve. Equivalently, rent per unit of electricity is $P^*-S$ in Figure 1, where $S$ is the average or “unit cost” of electricity production at $Q^*$.

Suppose that the utilities sell electricity at an artificially low price, given as $P$ in Figure 1, and that the public utility is required to meet domestic demand, $\bar{Q}$, at that price. Then revenues are given by the area $P\bar{Q}$, while total costs are $AD\bar{Q}$, so that total rent generated is reduced to $P\bar{Q} - AD\bar{Q}$. The portion $P^*CGP$ of the potentially available rents is implicitly being transferred to domestic consumers of electricity. Furthermore, there is a resource loss on the units $\bar{Q} - Q^*$ equal to the vertical distance between the marginal cost curve and the demand curve. This loss occurs because artificially low electricity prices generate overuse of electricity, leading to a wasteful development of marginal hydraulic resources represented by area GC'ED, or, equivalently, by unit costs that are higher than the amount $S$. 

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Developing a rent measure requires some method of establishing the true value, or “shadow price,” of hydraulic resources, which is $P^*$ in Figure 1. Zuker and Jenkins (1984) and Bernard, Bridges and Scott (1979, 1984) estimate this by performing a counterfactual experiment, where they ask: What would be the unit cost of electricity generation if hydro sites were unavailable? To frame the question properly, they suppose that the use of alternative electricity sources — natural gas, coal, oil, and nuclear — would exploit the most effective combination of technologies available at the time of their studies (i.e., early 1980s) to satisfy the load duration curve actually observed. The difference between this hypothetical cost without hydro and the actual cost of producing electricity with thermal, nuclear, and hydropower is a measure of the rent from access to hydroelectricity.

An alternative way of measuring the shadow price of electricity generation is to examine the competitive market price of electricity imports or exports. This measure should be net of incremental transmission costs if the transmission lines needed to import or export electricity are comparable to the lines needed within Ontario to exploit its hydroelectricity. If new transmission lines must be built to permit additional imports or exports of electricity, or if there are transmission tariffs imposed by other jurisdictions, then these incremental costs should be compounded into the wholesale price of electricity.

**Figure 1**
Illustration of Hydroelectric Rent

| P* is the “world price” of electricity |
| P is the price charged in Ontario |
| P*CA is the total available rent |
| PEQ minus ADQ is the actual net rent collected |
to obtain a proper estimate of the shadow price in Ontario.

Until fairly recently, electricity trade between provinces or internationally was restricted to short-term contracts for surplus electricity, rather than long-term firm supplies. However, a 1989 contract between Ontario Hydro and Manitoba for up to 1000MW of power per year — equal to 15 percent of the hydroelectric capacity of public utilities in Ontario — for 22 years provides a good indication of the expected market price for a long-term supply of electricity. Although Manitoba Hydro is a public utility, there seems little reason to suppose that it does not behave to maximize profits in its out-of-province sales. In this vein, it is noteworthy that Ontario Hydro negotiated for some time to purchase up to 4000MW per year from Hydro-Québec, without a deal because of the comparatively high price quoted by the Quebec utility (Ontario Hydro 1989).

If, on the other hand, Ontario Hydro is able to exercise a degree of monopsony power in its purchase agreements, then the contract price will underestimate the shadow price. Both Manitoba and Quebec export electricity to the United States, which tends to mitigate against Ontario’s bargaining power. Nevertheless, a previous contract price between Manitoba and a US utility set the price of power at only 80 percent of the marginal cost of thermal generation (Bernard and Payne 1987).

Ontario Hydro terminated its long-term power purchase contract with Manitoba Hydro in December 1992 due to a projected surplus in generating capacity, but the excess supply may be regarded as a temporary situation caused by the severe and prolonged recession in North America during the first half of the decade. The contract terms (see Ontario Hydro 1989) consider transmission arrangements separately, so that the agreed-upon price reflects electric generation only. The associated transmission costs, however, are relatively insignificant. The price of electricity quoted in the agreement was 3.7 cents per kWh in 1989, which is 4.106 cents in 1995 when adjusted for inflation using the gross domestic product (GDP) deflator for Canada. This is the figure we use as the shadow price of electricity.

If Ontario were to rely on electricity imports to replace its entire hydroelectric output, it would need to purchase an amount equal to seven times the Manitoba contract. Where could this supply be acquired? In addition to its links to Manitoba and Quebec, Ontario has import interface capabilities to purchase electricity from Michigan, New York, and Minnesota. These areas can supply large quantities of electricity. For example, the Niagara Mohawk utility in New York plans to sell 4200MW of capacity (Ontario Hydro 1998). Presently the importation of electricity into Ontario is, however, limited by the physical capability of the transmission lines. Ontario can import a total of 4000MW on its existing lines, and is planning to build an additional 2000MW of lines by the year 2003. Although even more interconnect capacity would be required if Ontario were not endowed with hydraulic power the unit cost of these lines is only about 0.07 cents/kWh. In addition, states in the US charge a tariff for transmission along their lines. The tariffs range from a low of 0.15 cents/kWh in Michigan to 0.8 cents/kWh in New York. These data on the costs of importing electricity suggest that the Manitoba contract price is a reasonable but conservative estimate of the value Ontario’s hydropower. An upper bound on the shadow price of electricity including the maximum cost of transmission is 5.0 cents/kWh.

As a supplement or alternative to importing electricity, Ontario could, hypothetically, replace hydropower with domestic nuclear and thermal power. The unit costs of producing electricity with nuclear- and thermal-based generation are consistent with a shadow price based on the Manitoba contract. From Ontario Hydro’s financial statements for 1995, these costs are about 5.1 cents/kWh and 6.7 cents/kWh, respectively. Moreover, the cost of electrical generation is decreasing as a result of the increased use of industrial co-generation and new natural gas-fired plants. Estimates of the cost of gas-
powered generation lie between 4 and 4.5 cents/kWh. The total capacity and location for these new electric generation facilities across Ontario are relatively unlimited (Ontario Hydro 1998).

To complete the calculation of the available rent in Ontario, we require an estimate for the unit cost of hydroelectricity, represented by S in Figure 1. Ontario Hydro’s unit cost of producing hydroelectricity in 1995, including capital costs but net of water rental charges, was 0.718 cents per kWh. There is a strong belief among industry participants that a privatization of the public utility would achieve significant cost savings relative to this historical data. This view is consistent with our framework in Figure 1, where the correct measure of the average cost, S, relates to the competitive equilibrium level of output, $Q^*$, rather than the historical level of output, $Q$. On the other hand, the use of historical cost accounting in the balance sheet may result in an understatement of the cost of capital. In particular, using a standard accounting method for estimating the capital-weighted average age of the hydroelectric plants and then grossing up the cost of capital by the accumulated inflation, the unit cost of hydroelectricity can be raised by 37 percent to 0.98 per kWh (excluding water charges).

The precise estimate of hydroelectric rent depends on the entire set of assumptions that is adopted regarding the present and future competitiveness of the international electricity market, the cost of transmission, the future cost savings associated with privatization, and the inflation adjustment to the cost of capital. The caveats described above are approximately offsetting and are of second-order importance in our estimation of rents. In our view, therefore, a transparent and reasonable, if likely conservative, estimate of the potential rent per kWh is given by the difference between the inflation-adjusted Manitoba contract price and the unadjusted unit cost of hydroelectric generation reported in the financial statements of Ontario Hydro (net of water rental). Thus, a point estimate of the rent equals 3.388 cents/kWh.

The aggregate hydroelectric rent in Ontario is given by the rent per kWh multiplied by the total kilo-wattage of hydropower generated in the province. This yields about $1.3 billion in 1995 and $1.4 billion in 1996, or about 2.5 percent of the provincial government’s total tax revenues. How do these calculations align with other estimates? Our results along with the values reported in other studies are presented in Table 1.

The estimates of Zuker and Jenkins (1984) are similar to ours, but both are much higher than Bernard, Bridges and Scott (1984). The principal reason why the estimates of Bernard et al. are lower than ours is due to differences in estimates of unit costs of hydroelectricity generation. Converting Bernard et al.’s unit cost of hydropower into 1995 dollars results in a cost of 2.67 cents/kWh (net of water rental charges), three times our figure. Bernard (1993) explains some of the differences between the

### Table 1
Comparison of Rent Calculations with other Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>1990 Cents/kWh</th>
<th>Aggregate Rent 1990 (million $s)</th>
<th>1995 Cents/kWh</th>
<th>Aggregate Rent 1995 (million $s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zuker and Jenkins (1984)</td>
<td>3.6</td>
<td>1,335</td>
<td>3.870</td>
<td>1,436</td>
</tr>
<tr>
<td>Bernard et al. (1984)</td>
<td>0.9</td>
<td>381</td>
<td>0.968</td>
<td>410</td>
</tr>
<tr>
<td>Gillen and Wen</td>
<td>na</td>
<td>na</td>
<td>3.380</td>
<td>1,315</td>
</tr>
</tbody>
</table>
studies of Bernard, Bridges and Scott and Zuker and Jenkins, but he is unable to reconcile the substantial gap in their bottom lines. Our study is the only one using an observed market price to measure the shadow price of electric generation. The differences in the methodologies and data used in these three studies lend robustness to their general conclusion that Ontario very substantially under-taxes hydroelectric rent.

THE IMPACT OF A WATER CHARGE ON PRICES

Generating and collecting the full amount of hydroelectric rents requires higher electricity prices, which adversely affects the well-being of residential, commercial, and industrial consumers of electricity. Residential customers consume electricity directly as part of their consumption bundle. Commercial and industrial consumers use electricity as an input for the production of other goods and services. An increase in electrical rates will affect their costs and hence what they may charge for the goods and services that they produce.

In this section, we assess the impact of a 3.388 cents/kWh water charge on the electrical rates faced by residential, commercial, and industrial customers. We then estimate the indirect effect of the higher electricity rates on the prices of manufacturing, mining, and forestry products, using cost function relationships for different two-digit industries. These estimates provide policymakers some indication of the politically sensitive adverse price consequences of fully appropriating hydroelectric rent. A more complete evaluation of the net benefits of imposing an optimal level of rent tax would assess the changes in consumer welfare, business profits, the value of the public revenues collected, and the value of economizing on resources associated with a reduced quantity of supplied electricity. The economic logic of setting electricity rates equal to the marginal cost of generation and taxing rent would, however, inevitably imply a positive net benefit from such a policy.

The average revenue in cents per kilowatt-hour of primary power and energy sold by Ontario Hydro was 6.464 in 1995, yielding total sales to primary customers of about $8.5 billion, based on primary energy sales of 131.6 billion kWh. This average price of electricity sold by Ontario Hydro is based on a markup on the aggregate unit costs of all facets of its business relating to electricity sales: electricity generation, transmission and distribution, and administrative facilities. In order to assess the impact that a higher water charge would have on the retail electricity prices faced by producers and residential consumers, it is necessary to decompose the average price into its various components of cost. In Table 2, the average price of electricity charged by Ontario Hydro in 1995, given the existing water rental charge of 0.344 cents/kWh, is decomposed. We then reconstruct a hypothetical new average price based on a water charge of 3.388 cents/kWh, assuming that the unit costs of transmission, administration, and normal profit or markup on costs (excluding water rental) are unchanged. From this analysis, raising the water-rental charges ten-fold from 0.344 cents/kWh to 3.388 cents/kWh would imply an average electricity price increase of about 14.5 percent to 7.40 cents/kWh.

Once the increase in the average price of electricity has been established we can infer how it is distributed across major categories of electricity users. Not all categories are similarly impacted by water rentals because some cross-subsidization of electricity prices may exist. An approximate way of translating the average electricity price increase into the prices faced by specific categories of users is to take the ratios of the existing rates for residential, commercial, and industrial markets, and assume that these relative prices will be maintained in the future. Thus, the percentage increase in electricity prices is assumed to be the same across customers (14.5 percent), but the changes in absolute prices vary across groups. Table 3 reports the estimated electricity prices across sectors, after a water charge is levied for the full amount of hydroelectric rent.
### Table 2
Cost and Price Data (in cents/kWh)

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>Projected</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNIT COST OF ELECTRICITY GENERATION</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic (excluding water rental)</td>
<td>0.718</td>
<td>0.718</td>
</tr>
<tr>
<td>Water rental</td>
<td>0.344</td>
<td>3.388</td>
</tr>
<tr>
<td>Nuclear</td>
<td>5.113</td>
<td>5.113</td>
</tr>
<tr>
<td>Fossil</td>
<td>6.702</td>
<td>6.702</td>
</tr>
<tr>
<td><strong>SHARE IN TOTAL GENERATION</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic</td>
<td>0.308</td>
<td>0.308</td>
</tr>
<tr>
<td>Nuclear</td>
<td>0.473</td>
<td>0.473</td>
</tr>
<tr>
<td>Fossil</td>
<td>0.219</td>
<td>0.219</td>
</tr>
<tr>
<td>Average unit cost of generation (excluding water rentals)</td>
<td>4.107</td>
<td>4.107</td>
</tr>
<tr>
<td>Average unit cost of generation (including water rentals)</td>
<td>4.213</td>
<td>5.395</td>
</tr>
<tr>
<td>Transmission cost&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
<td>Administrative cost&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.677</td>
<td>1.677</td>
</tr>
<tr>
<td>Total unit energy cost (including water rentals)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>5.940</td>
<td>7.122</td>
</tr>
<tr>
<td>Normal profit&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.524</td>
<td>0.524</td>
</tr>
<tr>
<td>Average price of electricity&lt;sup&gt;g&lt;/sup&gt;</td>
<td>6.464</td>
<td>7.400</td>
</tr>
</tbody>
</table>

**Notes:**

<sup>a</sup>Unit costs are based on the 1995 Ontario Hydro annual report.

<sup>b</sup>The shares are based on Statistics Canada bulletin No. 57-202 (July 1996) and represent 1994 data. We note that the shares have changed significantly since 1990. In 1990, the shares were: hydro, 0.185; nuclear, 0.612; fossil, 0.136. The shares will change again given the autumn 1997 permanent shutdown of several of Ontario Hydro’s nuclear reactors. We use the most recently available (1994) shares as weights in our calculations of the costs of energy generation.

<sup>c</sup>Bernard (1993) estimates that transmissions costs are: 0.04 cents/Kwh in 1979 dollars for Ontario.

<sup>d</sup>The unit costs of corporate administrative activities are estimated on the basis of subtracting from total unit energy cost (see the next line of the table) the cost of generation and transmission.

<sup>e</sup>Total energy cost (including water rentals) is calculated from the 1995 Ontario Hydro annual report as follows: Costs ($4,941 million) — secondary power and energy revenues ($233 million) — other revenues ($315 million) + financing charges ($3427 million). The unit cost is total energy cost divided by energy production. See Ontario Hydro, Annual Report 1995, p. 34 for a similar definition.

<sup>f</sup>Normal profit refers to a “fair market” return on equity capital. It is the amount of the markup on costs. It is commonly argued that the return earned by Ontario Hydro is below a normal profit rate for a host of institutional and regulatory reasons. See, e.g., Bernard, Bridges and Scott (1984), and Economic Council of Canada (1985). We calculate the markup on costs as the difference between the average revenue from primary sales by Ontario Hydro (see the next line in the table) and the total unit cost of energy.

<sup>g</sup>Average revenue per primary energy sales is given in the Ontario Hydro annual report. In the table, this average price of electricity is, by construction, the sum of the unit costs of generation, transmission, administration, and the markup.
We can estimate the impact of higher electricity prices on the prices of manufactured goods. Assume the cost function for a firm or industry can be represented in a general way as:

\[ C = \phi(p_1, p_2, \ldots, p_n, Q) = \sum_{i=1}^{n} p_i x_i^* \]  

where \( p_i \) are input prices, \( Q \) is output and \( x_i \) are input quantities. Suppose the cost function exhibits constant returns to scale and is separable in the input arguments. This means that the long-run marginal and average cost curves are horizontal, so unit costs are constant over a range of output. For a price change of one of the inputs it can be shown that the firm’s (or industry’s) costs will change as follows:

\[ \%\Delta C = \left\{ \sum_{i=1}^{n} S_i [1 + \eta_i] + \sum_{i=2}^{n} S_i \xi_i \right\} \times (\%\Delta p) \]  

where \( \%\Delta C \) is the percentage change in the cost of the good, \( \%\Delta p \) is the percentage change in the price of electricity, \( S_i \) is the \( i \)th cost share, \( S_1 \) is the cost share of electricity, \( \eta_i \) is the output-constant own-price elasticity of demand for electricity and \( \xi_i \) is the output-constant cross elasticity of input demand for factor \( i \) with respect to a change in the price of electricity. In the absence of any cross-price effects, equation (2) becomes

\[ \%\Delta C = \left\{ S_1 [1 + \eta_1] \right\} \times (\%\Delta p) \]  

Given the increase in industrial electricity prices, the demand elasticities for electricity can be used to assess how the markets for particular goods would be affected. The estimated price effects based on equation (3) are summarized in Table 4.

The table shows the prices of industrial goods increasing on average by slightly less than 0.1 percent if the full rent is charged. The relatively more strongly affected industries are pulp and paper (0.35 percent), minerals (0.47 percent) and primary textiles (0.23 percent). Food prices can be expected to rise by about 0.07 percent. None of the price increases for manufactured products are particularly large. In the forestry sector the increase is negligible, while the price of mining outputs may rise by as much as 0.33 percent.

The relatively small projected increase in the price of goods is unsurprising, because electricity expenditures are only a small proportion of the total value-added of industrial goods. Similarly,
residential households spend about 2 percent of their annual household income on direct electricity consumption. An increase of 14.5 percent in electricity prices would have a relatively small impact on total household expenditures.

CONCLUSIONS

We have endeavoured to estimate the availability of hydroelectric rent in Ontario, using financial information from Ontario Hydro’s annual reports and an observed market price of importing electricity to Ontario. The total rent in the province from both private and public utilities was found to be between one and one-and-a-half billion dollars per year, or more than ten times the water charges currently levied. The economic logic of taxing pure economic rent implies that a policy of fully taxing these rents would generate a positive net benefit for Ontario.

Capturing hydroelectric rent would require that electricity prices rise to market equilibrium levels in order for the utilities to generate taxable financial surpluses. Since price increases can be politically unpopular, we provided estimates of the price implications of rent taxation for residential electrical consumption, and for the cost-push price effects
on industrial goods. We note that many commentators believe that the present restructuring of the electricity market in Ontario may cause prices to fall. If competitive pressures make operating costs and prices decline by the same amount, as one might expect, then the rent remains the same as our estimate, even though consumers pay less for electricity.

Our study suggests that the Ontario government currently substantially under-taxes hydroelectric rent, which other authors have also argued. The existing water charge levied by the government needs to be raised more than ten-fold to appropriate fully the potential rent. In that case, retail electricity prices would rise by about 14.5 percent, while the prices of goods and services would increase principally in the mineral, and pulp and paper sectors, though by less than 0.5 percent. On average, the costs of manufactured goods can be expected to rise by less than 0.1 percent.

The government of Ontario’s plan for the electricity market, as recently unveiled by the Market Design Committee, maintains the existing water rental charges at their present rates, while also levying a tax at the retail level ostensibly to pay $8 billion of “stranded” debt owed by Ontario Hydro.24 The precise rate for this “Competition Transition Charge” is not yet specified. At the same time, under the Market Power Mitigation Agreement, there is a price cap of 3.8 cents/kWh on (90 percent of) the electricity sold to the wholesale pool by Ontario Power Generation Inc., which is a successor company to Ontario Hydro. The price cap was selected as a compromise between the unit cost of existing generation and the cost of new generation. As such, the price cap discourages economical new capital investments in electric generation.

It remains to be seen what are the overall effects on tax revenues and retail electricity prices, resulting from the combination of the price cap, a retail electricity tax, and water rental charges. If the prices of electricity faced by industrial, commercial, and residential users that emerge from the government’s policy are higher than justified by the shadow price of electric generation, the Competition Transition Charge will distort consumer choices like the effect of any commodity tax. If, on the other hand, the prices that consumers pay do not reflect a full appropriation of the available hydroelectric rent, rents will be captured by electricity consumers or continue to be dissipated through inefficient allocations of resources. Although the policy parameters for the electricity market may change, a constraint on policy is that the government is aiming to preserve the current average residential electricity rate of 7.2 cents/kWh.

In our view, there is a more logical approach to the issues of stranded debt and electricity taxation than is contained in the government’s plans. The economically sound policy is to appropriate the full amount of hydroelectric rent with a suitable water charge, in lieu of the Competition Transition Charge, and to allow the price of electric generation to rise to its estimated marginal cost. Regarding the structure of the water charge itself, more reliance should be placed on royalties from hydroelectric generation, rather than taxing the capital base of generators. The potential instability of government revenues that this change can engender is more than offset by the benefit of greater profit stability for the electric generators, and the removal of a disincentive to invest in new generation.

NOTES

We are indebted to the editors and four anonymous referees for comments that significantly improved the paper.

1The Ministry of Natural Resources has the power to adjust lease rates at any time. Current waterpower rental rates are tied to the consumer price index and are based on a capacity charge of $13,4710 per kilowatt and a royalty fee of $1,2131 per megawatt/hour for Ontario Hydro. Private sector rates approximate those of Ontario Hydro but with a slightly different formula. Some private developments were awarded through a call for proposals and pay a substantially higher rent. Of the 150
leases currently in place, six have expired. Half of all leases will expire by 2002.

2Access to natural resources can be auctioned in combination with water charges in the form of annual royalty fees. Royalties link tax payments to the actual rather than the expected value of hydraulic resources, thereby raising a risk-averse bidder’s willingness to pay for the remaining expected surplus. This compression of the available rent by the royalty fee stimulates bidding competition (McMillan 1994). See also Garnaut and Clunies Ross (1983) for details on the use of bidding to capture natural resource rents.

3In a non-competitive public utility such as Ontario Hydro, the regulatory authority encourages the utility to set price below the competitive level. In that case, there may be little or no rent to tax. Imposing an imperfect proxy for a rent tax, such as a royalty payment based on output, would in that case impose losses on the utility if it were obliged to maintain its production level and were impeded from raising its price by the regulatory authority. The point is that the attempt to tax unrealized (i.e., potential) rent does not in itself lead to higher electricity prices. Rather, the decision to tax rents can only be made with a simultaneous decision to allow electricity prices to rise. In practice, if the public utility’s pricing strategy is based on “cost-recovery,” where cost is defined to include taxes, or if it faces a regulation on its rate of return, then imposing a royalty fee for the use of hydraulic resources would lead the firm to raise its electricity prices by just the amount required to generate enough rent to pay the royalties. Thus, royalties would put upward pressure on prices, which in turn generates rent to pay the royalties.

4The term “free cash flows” refers to the funds available to a firm beyond what it requires to invest in all available positive net present value projects.

5The levy on the capital base is likely to be more distortionary than the royalty fee. Revenues from taxing the capital base are, however, more stable for the government than taxing the output of electricity.

6See also Bernard (1993), which summarizes the 1979 and 1984 findings and expresses them in 1990 dollars using a deflator.

7Historically a large portion of hydroelectric generation in Ontario has been used for base loading (Ontario Hydro 1991).

8A study (Ontario Hydro 1989) indicates that the purchase of 1000MW of electricity from Manitoba, in combination with plans to develop hydraulic sites in Northern Ontario, may require an additional 500kV line to be built at a cost of $200 million (or $215 million in 1995 dollars). Assuming that transmission lines have a lifetime of 35 years (Bernard, Bridges and Scott 1984), then the unit cost of transmission associated with a long-term supply of 1000MW is less than 0.08 cents/kWh.

9Eleanor Clitheroe, the president and CEO of the Ontario Hydro Services Co., indicated in a 20 January 1999 speech in Toronto that the 2000MW of new transmission lines cost $450 million. If the lines have a life of 35 years, the levelized cost of the transmission is about 0.07 cents/kWh.

10The figures are from a study by the Reliability Assessment Subcommittee of the North American Electric Reliability Council (1998).

11The cost of thermal generation may be overstated compared to the nuclear option because the thermal stations have historically been used for intermediate and peaking energy, while nuclear stations have been used at higher capacity (so its fixed costs are assigned to more units of energy production). The nuclear costs, on the other hand, may be understated, as Ontario Hydro’s accounting policy assumes a 40-year lifetime for nuclear stations, whereas the problems with Ontario’s nuclear portfolio make a 20-year lifetime more plausible. See IPPSO (1997) for a discussion of these points.

12These figures are commonly cited by industry experts. We are grateful to Russell Chute, a member of the Market Power Negotiating Team representing the Market Design Committee in the restructuring of the electricity industry in Ontario in 1998, for confirming these figures for us in private correspondence in 1999.

13The unit costs we report are based on accounting data from Ontario Hydro’s annual reports. Accounting conventions can result in discrepancies between an accounting notion of costs and true economic costs relevant for rent calculations. The unit cost of electricity from a particular power station is the sum of three components: capital costs, operating and maintenance cost, and fuel cost. The potential measurement problem lies with capital costs. For example, consider a power station whose initial cost is $K/kW. If the station life is n years, and the discount rate (required rate of return) is r, then the fraction
of the initial investment that must be paid off in each year in order to clear all debts by the end of the year \( n \) is:

\[
\frac{r(1+r)^n}{(1+r)^n-1}.
\]

This annual capital cost, adjusted for the station’s load factor, represents unit capital costs. Since, in equilibrium, a firm is indifferent between owning and renting capital, and a competitive rental charge would just be sufficient to cover interest (i.e., the owner’s required rate of return) and depreciation expenses, the mathematical expression above must also equal \( r + \delta \), known as the “implicit rental rate,” where \( \delta \) is the true rate of depreciation. Total annual capital costs are given by the implicit rental rate for capital times the initial capital outlay. Annual reports show the value of financing and depreciation charges, based on actual interest paid by Ontario Hydro and an accounting measure of depreciation expenses, which are based on historic prices of capital. We acknowledge that the debt guarantees offered by the Ontario government to the utility’s creditors reduces the interest costs below the normal market rate by between 0.5 and 0.75 percentage points, according to Farlinger, Homer and Caine (1995).

14Farlinger, Homer and Caine (1995) projected that operating expenses for Ontario Hydro would decline by as much as 25 percent (over two years) in a privatization scenario for the public utility. Evidence that privatization of public companies can lead to efficiency gains of 25 percent is provided in Megginson, Nash and Van Randenborgh (1994). Moreover, one can expect that the criterion for the economic viability of power projects would be stricter under private ownership. Indeed, a reason why Ontario Hydro substantially raised its prices during this decade is to pay for an uneconomical expansion in its capacity.

15The use of straight-line depreciation by Ontario Hydro means that the average age of the assets is equal to the amount of accumulated depreciation divided by the depreciation expense for a given year. In 1995, these figures for hydroelectric generating assets were $832 million and $32 million, respectively, yielding an age of 26 years. Compounding the deflator for non-residential construction by 26 years leads to 405 percent inflation from 1969 to 1995. The $32 million depreciation can be rendered into 1995 current dollar accounting by multiplying by 405 percent, and then expressed as 0.35 cents/kWh by dividing by the output of the hydro generation. If unadjusted for inflation, the depreciation figure is 0.085 cents/kWh in 1995. Thus, the cost of capital reported in the 1995 financial statements of Ontario Hydro can be adjusted for inflation by adding 0.27 cents/kWh, yielding a unit cost of hydroelectricity of 0.98 cents/kWh.

16The total volume of hydroelectricity generated in Ontario by utilities and industry was 41,659,177 megawatt-hours in 1996, and 37,461,142 in 1995 (Statistics Canada, Electric Power Statistics, No. 57-202).

17The figure is from the 1995 Ontario Hydro annual report.

18Ontario Hydro annual reports do not provide measures of the rates paid by each of residential, commercial, and industrial customers. They do provide average revenue for residential, farm, and industrial/commercial customer groups but the average revenue measure is in cents per kilowatt-hour for all sales. It is not clear how “other” revenue (i.e., not related to electricity sales) is distributed across each customer group and therefore the base from which to measure any change could not be established from this information.

19A superior alternative assumption would be to consider that in a liberalized-privatized environment, cost increases are allocated across customer classes on the basis of willingness to pay as measured by elasticities. Unfortunately, we are unable to complete this calculation because of a lack of information on group elasticities.

20The assumption is not as strong as it sounds. It is merely saying that constant returns characterize the cost relationship in the neighbourhood of the current output.

21We assume the cross-elasticities are zero due to a lack of information, thus we are measuring only the direct effects of the price change. To the extent that factor substitution occurs within firms to avoid the higher electrical rates, the price of industrial goods may change by more or less than shown in Table 4.

22The data are values of gross output in millions of 1990 dollars, as reported in Manufacturing Industries of Canada: National and Provincial Areas, 1991-1992, Statistics Canada, 31-203. The total cost of electricity is taken from a special tabulation from Information and Classification Services Section, Industry Division, Statistics Canada. The elasticities of demand were gathered from various sources (Cameron and Schwartz 1979; Denny, Fuss, and Waverman 1981; McRae 1981; Rao 1981; Rao
and Preston 1983; Taher, McMillan, Gillen, and Buse 1983; Taher and McMillan 1984) by Felice Martinello and published in the data appendix of Renzetti and Dupont (1997). We use the median values for the own-price elasticity of energy holding output constant, which are very similar to the reports of elasticities of demand for electricity holding the total energy input constant. We assume that the elasticity of demand for electricity in mining and forestry is the same as for manufacturing. Lack of data requires us to assume that for the mining industry the entire category of value-added called “fuels and electricity” is attributable to electricity. The figures in the table have been rounded.

23 The calculation is based on the average cost per kWh for residential customers and their annual consumption of electricity, as reported in the Ontario Hydro Annual Report 1995, and annual household income from Statistics Canada, Canadian Economic Observer, No. 11-010, 1995.

24 “Stranded” debt refers to the portion of Ontario Hydro debt that will remain even if the utility’s successor companies meet their revenue targets.

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