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Policy Evaluation in a Small Open Price Taking Economy: Canadian Energy Policies

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This paper contains preliminary findings from research work still in progress and should not be quoted without approval of the author.

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POLICY EVALUATION IN A SMALL OPEN PRICE TAKING ECONOMY: CANADIAN ENERGY POLICIES

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I. Introduction

Canadian energy policies include a complex system of controls which keep most producer and consumer prices of energy products below world levels (for both oil and natural gas).\(^1\) Since Canada is a small net energy importer, energy imports at world prices are subsidized, with the revenues needed being raised through an additional consumer tax.

This system of controls is often rationalized as producing a 'made in Canada' price system. However, since both consumer and producer prices are set below world prices, a national welfare loss will clearly result from over-consumption and under-production of energy. On the other hand, a significant fraction of the leases for energy extraction in Canada are foreign owned, so that controlling producer prices at levels lower than world prices also transfers rents from foreign owners of Canadian resources to domestic residents. Thus, whether or not Canadian policies are nationally desirable depends on the net effect of the revenue (rent) transfer from foreigners and the deadweight loss in consumption and production.

In this paper we report on an applied general equilibrium model for a price taking economy which we use to evaluate the impacts of Canadian energy policies, focusing specifically on these two effects. Unlike the more multipurpose applied general equilibrium open economy models (recently surveyed by Shoven and Whalley (1984)), our model is sparse in detail. Its features are designed to highlight the key elements of equilibrium structure relevant to the policy issues at hand; energy price controls and foreign ownership of petroleum and natural gas leases. The price taking assumption also substantially simplifies computation.

\(^1\)See the description of these policies by Lenjosek in Trebilcock et al. (1984).
Specifically, our model uses the assumption that Canada is an international price taker in both energy and other products to determine cost covering factor prices from given world goods prices. Using these factor prices, full-employment conditions for factors then determine industry production levels. Once domestic demands are calculated, excess demands (imports and exports) for goods are known. Since the rest of the world is assumed sufficiently large to accommodate Canadian excess demands in goods at unchanged goods prices (subject to Walras' Law), demand-supply equalities need only hold in domestic factor markets.

The approach allows for further complicating structural elements to be introduced as required. These include a system of energy price controls, energy import subsidies generated by energy consumption taxes such that no net revenues or losses are realized by the government, and the presence of non-traded goods. The major restriction on the use of the approach is the requirement that the number of factors equal the number of traded goods produced domestically, but for the policy issues analyzed here the resulting model is not in any way unsuitable because of this.

The advantage of our approach is that it is much simpler than the traditional method of modelling the small open economy used in applied general equilibrium literature. The traditional approach uses an Armington formulation and allows elasticities of substitution between similar domestic and foreign commodities to become large in order to approximate a small open economy. Our approach sharply reduces the dimension of the equilibrium problem; first by assuming internationally homogeneous rather than heterogeneous (Armington) products, and second by removing the need to satisfy demand-supply equalities for goods since the large foreign country accommodates any domestic imbalance. Furthermore,
no fixed point or other computational algorithm is required to solve our model. The simplicity of the basic approach also allows other complications, such as foreign ownership of factors and the complexities of differing policy regimes, to be more easily introduced than in the case of the traditional approach. Thus, as a manageable and quickly implementable approach to equilibrium policy evaluation modelling in the small open economy, this seems a natural route to explore.

II. The Basic Approach

To illustrate our approach we consider an N good, N factor, static general equilibrium model of an economy which we treat as a taker of goods prices on world markets. In our model of Canada, we specify three goods producing industries: manufacturing, non-manufacturing (including services) and energy (oil and natural gas). The three factors of production are capital services, labor services and resources. To simplify the exposition, we initially ignore all complications arising from government intervention through price controls and taxes; these are discussed in the next section.

Production in each industry is described by the two-level fixed coefficient, value added production system

\[ Y_i = \min \left\{ \frac{v_i}{a_{vi}} ; \frac{H_{ki}}{a_{ki}} \right\}, (k=1,\ldots,N) \]  \hspace{1cm} (i=1,\ldots,N) \]

where \( Y_i \) is the gross output of industry \( i \), \( v_i \) is the value added in industry \( i \), \( a_{vi} \) is the value added requirement per unit of output \( i \), \( H_{ki} \) is the use of good \( k \) in industry \( i \), and \( a_{ki} \) is the requirement of good \( k \) per unit of output of good \( i \).

1A more complex dynamic formulation in which the country involved is a taker of a price path for all goods (with energy prices obeying Hotelling's rule) could also be used. We ignore dynamic issues here both to simplify the presentation and keep the numerical model more manageable.
While we consider fixed coefficient intermediate production, we allow for substitution between primary factors in meeting each industry's value added requirements. Value added for industry \( i \) is given by the CES function

\[
v_i = \beta_i \left( \sum_{j=1}^{n} \gamma_{ij} \frac{F_{ij}}{\sigma_i} \right) \left( \frac{\sigma_i - 1}{\sigma_i} \right) \quad (i=1, \ldots, N)
\]

where \( \beta_i \) is a units parameter, \( \gamma_{ij} \) are the share parameters on the factor inputs in industry \( i \), and \( F_{ij} \) are the amounts of factor \( j \) used by industry \( i \).

The use of factor \( j \) per unit of output \( i \), \( \frac{F_{ij}}{Y_i} \), is denoted by \( f_{ij} \). \( \sigma_i \)
defines the elasticity of factor substitution in industry \( i \).

Net output for each industry, \( N_i \), is

\[
N_i = Y_i - \sum_{k=1}^{n} a_{ik} Y_k \quad (i=1, \ldots, N).
\]

On the demand side, we assume each of \( Q \) consumers has a utility function, which for convenience we also assume to be CES, represented by

\[
U^q = \left\{ \sum_{i=1}^{n} \frac{\sigma^q}{\sigma_i^q} \right\} \frac{\sigma^q}{\sigma^q - 1} \quad (q=1, \ldots, Q)
\]

where \( C^q_i \) is consumption of good \( i \) by consumer \( q \), \( \sigma^q_i \) are share parameters for consumer \( q \) and \( \sigma^q \) is consumer \( q \)'s elasticity of substitution in preferences.

We denote commodity prices as \( p_i \) \((i=1, \ldots, N)\) and factor prices as \( w_j \) \((j=1, \ldots, N)\). These can be normalized to sum to unity if so.

---

1. In our model of Canada, the resource factor input only enters the energy industry (i.e., \( F_{ij} = 0; i=1,2, j=3 \)).

2. A more general multi-staged CES function could be used in which more than one elasticity appears.
desired, i.e., \( \sum_{i=1}^{N} P_i + \sum_{j=1}^{N} w_j = 1 \) since factor demands are homogeneous of degree zero in \( P_i \) and \( w_j \). Since the \( f_{ij} \) will reflect the outcome of cost minimization we write these as \( f_{ij}(w) \) where \( w \) denotes the vector \( w_1, \ldots, w_N \).

The economy-wide endowment of each of the factor inputs is \( \bar{F}_j \). If there is any foreign ownership of any factor it is denoted by \( \bar{F}_j^R \). Domestic ownership of each factor, \( \sum_{q=1}^{Q} \bar{F}_j^q \), equals \( \bar{F}_j - \bar{F}_j^R \).

Maximizing (4) subject to each domestic consumer's budget constraint yields the domestic commodity demands

\[
C_{iq} = \frac{\alpha_i^q \sigma_i^q r_i^q}{\sum_{q=1}^{Q} \sigma_i^q (1-\sigma_i^q) \left( \sum_{k=1}^{N} \alpha_k^q P_k \right)} \quad (i=1, \ldots, N), \ (q=1, \ldots, Q)
\]

where consumer \( q \)'s income \( r_i^q \) is given by the value of his factor endowment (i.e., \( \sum_{j=1}^{N} w_j \bar{F}_j^q \)).

Given fixed world goods prices, \( \bar{P}_i \), a domestic equilibrium in this model is characterized by a vector \( w^* = (w_1^*, \ldots, w_N^*) \) such that two sets of conditions hold:

(i) demands equal supplies for factors

\[
\sum_{i=1}^{N} f_{ij}(w^*) y_i^* = \bar{F}_j \quad (j=1, \ldots, N)
\]

and

(ii) zero profit conditions hold in domestic industries

\[
\bar{F}_i = \sum_{k=1}^{N} a_{ki} \bar{P}_k + \sum_{j=1}^{N} f_{ij}(w^*) \cdot w_j^* \quad (i=1, \ldots, N)
\]

---

1 In our model of Canada, there is foreign ownership of resources but no foreign ownership of either capital or labor (i.e., \( \sum_{q=1}^{Q} \bar{F}_j^q = \bar{F}_j; \ j=1,2 \)).
At such an equilibrium, domestic commodity excess demands (foreign trades) are given by

\[
X_i^* = \sum_{q=1}^{Q} C_i^q + \sum_{k=1}^{N} a_{ik} y_i^* - y_i^* \quad (i=1, \ldots, N).
\]

Summing the domestic consumers' budget constraints and using the zero profit conditions, it follows that

\[
\sum_{i=1}^{N} \frac{p_i x_i^*}{p_i} = 0
\]

i.e., trade balance holds.

At such an equilibrium, domestic excess demands for goods are accommodated by the foreign country which is considered to be large enough that buying or selling the required quantities at the given world prices will not affect global equilibrium. Other than this willingness to buy or sell any quantities of goods at fixed world prices (subject to trade balance), no further characteristics of the foreigner's behavior need to be specified in the model.

Solving this model for an equilibrium is considerably easier than for the traditional general equilibrium model. From the first-order conditions for cost minimization in each industry,

\[
f_{ij}(w) = \frac{y_i}{\beta_i} \left\{ \frac{v_i}{y_i} \left[ \frac{1}{(1-\sigma_i)} \left( \begin{array}{c} \sum_{k \neq j} a_{ik} \left( \frac{y_i}{y_{ij}} \right) \left( \frac{w_k}{w_j} \right)^{\sigma_i} \left( 1 - \sigma_i \right) \\ \left( 1 - \sigma_i \right) \end{array} \right) + 1 \right] \right\} \quad (i=1, \ldots, N; \ j=1, \ldots, N).
\]

Using these solutions for the \( f_{ij}(w) \) in the zero profit conditions (7) provides a system of \( N \) equations involving \( N \) unknown factor prices.
Given the commodity prices, the equilibrium factor prices \( w_j^* \) satisfying (7) can then be solved for. If the values of \( w_j^* \) corresponding to the given goods prices \( \bar{P}_i \) yield goods and factor prices which do not sum to unity, goods and factor prices can be rescaled so that they lie on a unit simplex since both demands and the solutions to cost minimization are homogeneous of degree zero in goods and factor prices. However, any normalization of prices can be used as only relative goods and factor prices are relevant in the model.

Given the equilibrium factor prices, the equilibrium values of gross outputs \( Y_i^* \) satisfying (6) can be determined. Further, consumer incomes \( I_i^* \) and hence consumer demands \( C_i^* \) can also be solved for by using the equilibrium factor prices in equation (5). Equilibrium domestic excess demands for goods (imports and exports) are given by (8). Implementing this basic approach requires no computational algorithm. Provided the system of non-linear equations (10) can be solved for the \( w_j^* \), no fixed point solution procedure is necessarily required in determining an equilibrium.

The key feature making the approach operational is that there are the same number of traded goods as factors so that equations (7) can be solved. However, it is not ruled out that specialization in production may occur in which case the model can become underdetermined unless extra goods are added. A poorly specified numerical model which has production sets that yield large supply responses when prices change (unrealistically large supply elasticities) is typically indicated if this occurs. In the energy price control case, we choose values of substitution elasticities in energy production approximately consistent with literature estimates of energy supply elasticities such that specialization does not occur for the policy changes we consider.
With the modifications described in the next section, this same
approach can be used to evaluate the impacts of domestic price distortions
such as tariffs, taxes or (as in the present paper) energy price
controls. It is important to stress, however, that it is the operational
simplicity of the approach rather than general properties, such as
existence of equilibrium for all possible numerical specifications,
which motivates its use here.

III. Extensions to Analyze Canadian Policies Specific to Energy

The analysis of the effects of Canadian energy policy involves a number
of extensions to the model presented in the previous section. Producer and
consumer energy price controls, and the degree of foreign ownership of energy
resources must be specified. Factor and excise taxes on energy industries and
products must be incorporated. The model also needs to be generalized
to incorporate the blended price mechanism actually used in Canada (a zero
revenue system of taxes on domestic energy consumers and subsidies for energy
imports). Modifications to accommodate the existence of non-traded goods are
a further extension which can be made.

(i) Producer and Consumer Energy Price Controls

Under a government declared system of producer and consumer energy
price controls set below world energy prices, an approach similar to that
described above can be used to determine a domestic equilibrium. However,
modifications to the basic approach are needed. In this section, we present
the changes needed to incorporate an arbitrary system of consumer and producer
price controls on all goods even though we consider only price controls on
energy products in the model of Canada used in subsequent sections. We
denote the (given) world price of any good as $\bar{P}_i$ and the controlled domestic
producer and consumer prices by $\overline{p}_i^D$ and $\overline{p}_i^C$. Consumer prices are net of excise taxes.

Determining a domestic equilibrium in this case involves using $\overline{p}_i^D$ rather than $\overline{p}_i$ on the left hand side of equation (7), and $\overline{p}_k^D$ rather than $\overline{p}_k$ in the summation term on the right hand side in (7). The latter reflects the assumption that $\overline{p}_k^D$ is the controlled price applying to domestic intermediate users of the $k^\text{th}$ good. As above, equations (7) and (10) can be used to determine equilibrium values for the factor prices $w_j^*$ which satisfy the zero profit conditions modified to include controlled producer rather than world prices. Equation (6) is again used to determine gross industry output $Y_i^*$. 

The major change relative to the previous section arises in the way equation (5) is used to generate consumer demands. Controlled consumer prices, controlled producer prices, and world prices differ. A subsidy or tax, at a rate equalling the difference between domestic and world prices, is required if a price controlled good is imported or exported, respectively. The income of the consumer is affected in both cases. This occurs through either an income loss due to lump-sum taxes needed to finance the subsidy or an income gain as export taxes are returned to consumers through lump-sum transfers.

Denoting these transfers, $T$, as

$$T = \sum_{i=1}^{N} (\overline{p}_i - \overline{p}_i^D) \left( \sum_{q=1}^{Q} C_q^i \right) - \sum_{i=1}^{N} (\overline{p}_i - \overline{p}_i^D) (Y_i - \sum_{k=1}^{N} a_{ik} Y_k)$$

the income term in the demand functions equation (5) must be written as

$$I_q = \sum_{j=1}^{N} w_{jq}^* - T_q$$

where $T_q = \alpha_q T$. The terms $\alpha_q$ sum to unity and determine the share of consumer $q$ in the lump-sum tax or transfer.
T plays the same role in this system as the revenue term in the
analysis of general equilibrium in the presence of taxes due to Shoven
and Whalley (1973). As with taxes, a simultaneity is created with price
controls in the evaluation of demands. Until consumer demands are known,
the revenues either created by or required to sustain the controlled prices
are unknown. Equally, the size of such revenues depends on the values of
demands. This simultaneity is accommodated in the same way that Shoven
and Whalley accommodate the revenue simultaneity from taxes, namely by
making T endogenous to the model.

Thus, given world prices and controlled domestic producer and
consumer prices, an equilibrium is characterized by a vector \( \mathbf{w}^* = (w_1^*, \ldots, w_N^*) \)
and a value \( T^* \) such that equations (6) and (7) hold. In addition, equation
(11) holds and the equilibrium demands are given by (5) where the income
term is modified as in equation (12).

Solving this version of the model for a domestic equilibrium is
slightly more complex than the procedure described above because of the
endogeneity of \( T \). It is no longer possible to solve the model directly
from the given world goods prices through the factor prices to the excess
demands for goods since a value \( T \) must be assumed in order to make the
calculations. Typically this will not be the equilibrium value \( T^* \) so
that a fixed point or other computational algorithm will be required to
solve for an equilibrium in this case. However, a one dimensional simplex \( (T, \lambda) \)
can be used where \( \lambda \) is a scalar applying to the world goods prices \( \mathbf{P}_i \), and
controlled producer and consumer prices \( \mathbf{P}^P_i \) and \( \mathbf{P}^c_i \).

If price controls apply only to a subset of goods, this same procedure
can be used. In our model of Canada, price controls apply only to energy
products.
(ii) A Blended Price Mechanism for Energy Price Controls

The current energy price controls in Canada differ slightly from the description of price controls above in that the controlled producer and consumer prices are not independent of each other. Instead, a "blended price mechanism" is used under which subsidies on imports are fully financed by a tax on domestic consumers. The blended consumer price is set such that world prices for imports and controlled prices for domestic production are blended into a single consumer price at zero net government cost.

Introducing this system into the approach above differs only in that $P^C_E$ (the controlled consumer energy price net of excise taxes) is now endogenously determined while $T$ becomes exogenous (set equal to zero through the government zero revenue requirement). For any given world energy price $P^E$ and controlled producer price for energy $P^D_E$, the consumer energy price $P^C_E$ will be endogenously determined such that in equilibrium $\bar{T}$, given by (13) below, equals zero.

\[
(13) \quad \bar{T} = (P^E_E - P^C_E) (\sum_{q=1}^Q \sum_{E} C^q_E) - (P^E_E - P^D_E) (Y_E - \sum_{k=1}^N a_k Y_k)
\]

This blended price case bears the same relationship to the pre-specified controlled consumer and producer price case as the equal tax yield equilibria, considered by Shoven and Whalley (1977), to general equilibria under pre-specified tax rates. In the former case, tax rates are endogenous and the revenue requirement exogenous; in the latter case these are reversed.

To solve the model for a blended energy price equilibrium, both $P^D_E$ and $P^E_E$ are pre-specified. For any given consumer energy price $P^C_E$, the model could be solved for a domestic equilibrium using the procedures outlined in the previous section. However, a computational problem arises in that the zero revenue requirement that $T=0$ will typically not be satisfied for an initial
arbitrarily chosen value of $\overline{P}_E^C$. Thus, as with the consumer and producer price control case described in III(i), a fixed point or other computational algorithm is required to find a domestic equilibrium although, once again, the dimension of the equilibrium problem is relatively small. In our case of a single controlled consumer energy price, the one dimensional simplex $(\overline{P}_E^C, \lambda)$ can be used, where $\lambda$ is a scalar applying to the given world price $\overline{P}_E$ and the controlled producer price $\overline{P}_E^P$. In this case $\overline{P}_E^C$ rather than $T$ is endogenously determined.

(iii) Extensions to Incorporate Non-traded Goods

The model discussed thus far has $N$ traded goods and $N$ primary factors. While this feature is necessary in order to be able to solve for equilibrium factor prices from the given world goods prices, the procedure can be augmented by also including an arbitrary number of non-traded goods. Thus far, we have not incorporated this feature into our analysis of Canadian energy policies because the required coding changes are significant and it is our belief that the impact on our results would be of second order. However, for other applications of this approach, such as in analyzing the effects of a tariff change, the addition of non-traded goods would be an important extension and therefore we discuss it here.

Suppose there are $G$ non-traded goods whose prices are denoted by $P_{xi}^N$, $i=1,\ldots,G$. Each non-traded goods industry has production functions as described by equations (1) and (2), and the non-traded goods appear as part of the consumer demands (equation (5)). Since the goods are not traded, there are no foreign demands and consequently the domestic economy is not a price-taker for these commodities.

To determine a domestic equilibrium in the presence of non-traded goods, equation (7) can be solved both for the values of factor prices $w^*$ and the values of non-traded goods prices $P_{wi}^N$ which satisfy the zero profit conditions for
the traded goods industries. With all endogenous prices calculated in this way, consumer demands for non-traded goods can be determined from (5) and the per unit factor demands in non-traded goods industries calculated from (10). This enables the total factor requirements of non-traded goods industries to be determined. These are then subtracted from the economy-wide endowments $F_j$ and a so modified version of equation (6) used to determine the equilibrium domestic production of traded goods. With these modifications, the remainder of the approach can be used in the same way as described above.

IV. Parameterizing a Model of Impacts on Canadian Energy Policies

We have used the approach outlined in the previous sections applied to a numerical model of Canada benchmarked to a 1980 micro-consistent equilibrium data set to analyze the impacts of changes in Canadian energy policies. To specify parameter values for the functions used in the model, we follow the calibration procedure outlined in Mansur and Whalley (1984) which requires exogenous specification of key elasticity parameters prior to calibration to a benchmark data set.

The main features of the benchmark data we use are displayed in Table 1. We consider three industries (manufacturing, non-manufacturing, and energy), three factor inputs (capital services, labour services, and resources) and domestic consumers with identical homothetic preferences. The data set is built from flow data so that the resource factor input refers to the resource flow used during the year rather than to the stock of available resources in the ground. As a result, the welfare effects of energy price controls are calculated on a flow basis in $ per year and are based on the simplifying assumption that resources are available each year at the same flow rate as that extraction which occurred
### TABLE 1
1980 BENCHMARK EQUILIBRIUM DATA SET FOR CANADA
($1980 MILLION)

#### Intermediate Transactions

<table>
<thead>
<tr>
<th>Industry</th>
<th>Manufacturing</th>
<th>Non-Manufacturing</th>
<th>Energy</th>
<th>Total Intermediate Use</th>
<th>Total Value of Domestic Production Net of Intermediate Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>C O M M</td>
<td>100,506.0</td>
<td>89,513.1</td>
<td>1,215.6</td>
<td>197,234.7</td>
<td>96,706.4</td>
</tr>
<tr>
<td>O N D</td>
<td>101,302.1</td>
<td>108,723.6</td>
<td>7,606.2</td>
<td>217,387.7</td>
<td>123,952.5</td>
</tr>
<tr>
<td>D</td>
<td>3,816.2</td>
<td>408.7</td>
<td>13.2</td>
<td>4,238.1</td>
<td>12,526.5</td>
</tr>
<tr>
<td>I T I E S</td>
<td>211,624.3</td>
<td>198,645.4</td>
<td>8,291.0</td>
<td>418,560.7</td>
<td>223,185.4</td>
</tr>
</tbody>
</table>

#### Value Added

<table>
<thead>
<tr>
<th>Service</th>
<th>Capital Services</th>
<th>Labour Services</th>
<th>Resource</th>
<th>Total Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Services</td>
<td>21,311.4</td>
<td>22,836.9</td>
<td></td>
<td>45,148.3</td>
</tr>
<tr>
<td>Labour Services</td>
<td>35,386.1</td>
<td>107,117.9</td>
<td></td>
<td>143,504.0</td>
</tr>
<tr>
<td>Resource</td>
<td></td>
<td>565.6</td>
<td></td>
<td>565.6</td>
</tr>
<tr>
<td>Total Value Added</td>
<td>56,697.3</td>
<td>139,954.8</td>
<td></td>
<td>189,652.6</td>
</tr>
</tbody>
</table>

#### Factor Taxes

<table>
<thead>
<tr>
<th>Tax</th>
<th>Capital Taxes</th>
<th>Labour Taxes</th>
<th>Resource Taxes (Royalties)</th>
<th>Total Factor Taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Taxes</td>
<td>14,213.4</td>
<td>8,490.8</td>
<td></td>
<td>23,817.2</td>
</tr>
<tr>
<td>Labour Taxes</td>
<td>1,405.9</td>
<td>5,401.6</td>
<td></td>
<td>5,401.6</td>
</tr>
<tr>
<td>Resource Taxes (Royalties)</td>
<td></td>
<td>4,340.0</td>
<td></td>
<td>4,340.0</td>
</tr>
<tr>
<td>Total Factor Taxes</td>
<td>15,619.3</td>
<td>12,440.2</td>
<td></td>
<td>33,559.5</td>
</tr>
</tbody>
</table>

#### Gross Of Tax Value Added
(NBD at factor cost)

| Gross | 72,316.8       | 142,395.0     | 8,473.6                    | 223,185.4         |

#### Gross Output

| Gross | 283,941.1      | 341,040.4     | 16,764.6                    | 641,746.1         |

**NOTE:** All numbers presented are valuated at domestic prices.
<table>
<thead>
<tr>
<th></th>
<th>Total Value Of Domestic Production Net Of Intermediate Use</th>
<th>Net of Tax On Value Of Domestic Consumption</th>
<th>Taxes On Value Of Domestic Consumption</th>
<th>Gross of Tax Value Of Domestic Consumption</th>
<th>Value Of Exports</th>
<th>Value Of Imports</th>
<th>Value Of Net Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>86,706.4</td>
<td>92,351.2</td>
<td>13,215.5</td>
<td>105,566.7</td>
<td>63,355.1</td>
<td>68,999.9</td>
<td>-5,644.8</td>
</tr>
<tr>
<td>Non-Manufacturing</td>
<td>123,952.5</td>
<td>118,227.2</td>
<td>2,979.3</td>
<td>121,206.5</td>
<td>23,967.9</td>
<td>18,242.6</td>
<td>5,725.3</td>
</tr>
<tr>
<td>Energy (Oil and Gas)</td>
<td>12,526.5</td>
<td>12,562.7</td>
<td>402.0</td>
<td>12,964.7</td>
<td>15,295.3</td>
<td>15,375.8</td>
<td>-80.5</td>
</tr>
<tr>
<td>Total Commodities</td>
<td>223,185.4</td>
<td>223,141.1</td>
<td>16,596.8</td>
<td>239,737.9</td>
<td>102,318.3</td>
<td>102,618.3</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**NOTE:** All numbers presented are valued at domestic prices except those relating to the value of exports, imports and net exports which are valued at world prices.
in 1980. Further, the use of identical preferences means that we restrict our analysis to aggregate national impacts. A more complex calculation focusing on impacts on subgroups (such as the poor, or regions) could be performed using the same general approach.

The data set is based on a number of different source materials. The broad aggregates, such as Net Domestic Product (NDP), are consistent with national accounts totals. The detail by industry and commodity relies heavily on the 1972 Canadian micro-consistent data set reported in St-Hilaire and Whalley (1983) which we have aggregated and updated to 1980. Due to the importance of the energy industry and the resource input to the calculations reported here, however, all data relating to this industry have been separately calculated. We use data from the Canadian Petroleum Monitoring Agency (1981) and Statistics Canada (various years) for this purpose. Adjustments are also required to the foreign trade data to yield zero trade balance in the benchmark data set. The data, especially on intermediate energy use, but also on some of the other transactions, implied by this set of procedures are not wholly satisfactory, and in subsequent work we plan to improve this component of the data set when more recent data becomes available.

In addition to the benchmark equilibrium data, a series of other parameter values are required to complete the specification of the model. We assume the resource input in the Canadian energy industry is 70% foreign-owned (approximately the 1980 situation). Price controls on producers are treated as leaving producers with a net price of 45% of world prices (approximately the situation prevailing in 1980). Price controls on consumers involve them also paying 45% of world prices for energy consumption, net of excise taxes and the tax component of the blended price mechanism. Resource taxes on value added represent provincial government royalties. Treating resource taxes
separately from the federal government price controls and taxes allows the
effects of each to be individually analyzed. While no foreign ownership of
capital services is considered in our central case specification, this could be
incorporated in sensitivity variations on our basic calculations and may change
our results.

Elasticities in the CES functions in the model are specified as follows.
In the CES value-added functions, elasticity values of 0.5 and 0.6 are used
in manufacturing and non-manufacturing industries, respectively (see Mansur
and Whalley (1984) for a discussion of literature values). In the energy
industry the value used is crucial in determining the elasticity of supply of
energy since a low value makes the constraint of the value of the industry-
specific resource factor more severe. The lower the value, the more difficult
it is to substitute capital and labour for resources. We use a value of 0.05
for this elasticity since this implies an energy supply elasticity of approximately
0.1 (towards the bottom of the range of the energy supply elasticities used by
Thirsk and Wright (1977)). The substitution elasticity on the demand side
is set at 0.6, implying a point estimate of energy demand in the benchmark
equilibrium of approximately -0.5 (see Thirsk and Wright, and Kouris (1982)).

To apply the calibration procedures described in Mansur and Whalley
(1984), the benchmark equilibrium data set is separated into price and quantity
observations using a unit convention similar to that in Harberger (1962).
Quantities of commodities are taken as those amounts selling on world markets
for $1; domestic controlled prices are thus 45¢ for producers and 45¢ for
consumers (the latter net of excise taxes and the tax associated with the
blended price). Quantities of productive factors are those amounts generating
factor incomes of $1 net of factor taxes.
Once specified in this way, the model reproduces the benchmark data as a domestic equilibrium using the methods described in earlier sections. The model can then be used to examine counterfactual equilibrium situations and to evaluate the impacts of both the 1980 system of energy policies, including price controls, and changes to these policies.

V. Results

In this section we present our model results of the impacts of modifying the 1980 energy price controls in Canada as well as changing the system of price controls to incorporate a blended price mechanism corresponding to that introduced in 1981. We use a base case model specification for our analyses around which we perform sensitivity analyses. In Table 2, we summarize the characteristics of the base case model variant for the Canadian situation described in Section III.

Table 3 presents welfare and other impacts of both increasing energy prices to move them closer to world prices and eliminating controls entirely in the counterfactual equilibrium. Welfare impacts are reported as Hicksian compensating and equivalent variations in the sense described by Harberger (1976). A sign convention is employed so that, for either measure, a negative number indicates a welfare loss while a positive number indicates a welfare gain.

The main result emerging from Table 3 is that either increasing energy prices or removing energy price controls in Canada is a nationally welfare losing proposition since the welfare gain from reducing or removing the subsidy on energy consumption is more than offset by the loss associated with a larger transfer of rents to foreigners as prices rise towards world levels. A welfare loss in the range between $7 and $8 billion from eliminating energy price controls equals approximately 4% of 1980 Canadian NDP. The rent transfer effect in favor of foreigners in this case is around $11 billion, larger than
Table 2

**Characteristics of the Base Case Model Variant**


2. Energy policies include price controls on producers and consumers with imports subsidized down to domestic prices (1980 policy regime). Price ceiling on energy set at 45% of the world price for energy.

3. Elasticity configuration: value added substitution elasticities of 0.5 in manufacturing, 0.6 in non-manufacturing and 0.05 in energy; substitution elasticity in demands set equal to 0.6

4. Degree of foreign ownership of natural resources in Canada set at 70%. Degree of foreign ownership of capital in Canada set at 0%.

5. Canada is a small net importer of energy under the price controls.
**Table 3**

**Welfare and Other Impacts of Removing Energy Price Controls**

(Base Case Model Variant)

A. **Base Case**

<table>
<thead>
<tr>
<th>Counterfactual Domestic Energy Price as % of World Energy Price</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
</table>

1. **Welfare Impacts on Canada**
   (\$ 1980 million)

<table>
<thead>
<tr>
<th></th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensating Variation</td>
<td>-722.5</td>
<td>-2,883.5</td>
<td>-5,838.3</td>
<td>-8,115.9</td>
</tr>
<tr>
<td>Equivalent Variation</td>
<td>-710.7</td>
<td>-2,796.9</td>
<td>-5,593.6</td>
<td>-7,717.3</td>
</tr>
</tbody>
</table>

2. **Change in Value of Energy Rents in Canada**
   (\$ 1980 million)

<table>
<thead>
<tr>
<th></th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accruing to Foreigners</td>
<td>3,019.3</td>
<td>6,072.5</td>
<td>9,140.4</td>
<td>11,190.4</td>
</tr>
<tr>
<td>Accruing to Canadians</td>
<td>1,294.0</td>
<td>2,602.5</td>
<td>3,917.3</td>
<td>4,795.9</td>
</tr>
<tr>
<td>Total</td>
<td>4,313.3</td>
<td>8,675.0</td>
<td>13,057.7</td>
<td>15,986.3</td>
</tr>
</tbody>
</table>

3. **% Change in Energy Industry Net Output**

   |                                | 4.7 | 8.4 | 11.8 | 14.1 |

4. **% Change in Energy Consumption**

   |                                | -14.2 | -24.1 | -31.4 | -35.4 |
Table 3 (Cont'd)

B. **30% Foreign Ownership of Resource Rents**

<table>
<thead>
<tr>
<th>Counterfactual Domestic Energy Price as % of World Energy Price</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
</table>

1. **Welfare Impacts on Canada**
   ($1980 million)

   - Compensating Variation: 999.1, 579.5, -625.2, -1,733.1
   - Equivalent Variation: 982.8, 562.1, -599.0, -1,647.9

2. **Change in Value of Energy Rents in Canada**
   ($1980 million)

   - Accruing to Foreigners: 1,294.0, 2,602.5, 3,917.3, 4,795.4
   - Accruing to Canadians: 3,019.3, 6,072.5, 9,140.4, 11,190.4
   - Total: 4,313.3, 8,675.0, 13,057.7, 15,986.3

C. **% Change in Energy Industry Net Output**

   - 4.7, 8.4, 11.8, 14.1

D. **% Change in Energy Consumption**

   - -14.2, -24.1, -31.4, -35.4
the welfare loss to Canadians due to the consumer side gain from moving to world prices. Energy output increases by 14% and energy consumption falls by 35%. The net effect is to change Canada from a net importer to a net exporter of energy. Qualitatively similar, but quantitatively smaller impacts occur where prices are increased closer to but still remain below world levels as shown in Table 3.

Results in Table 3 also indicate the impact on results of changing the crucial foreign ownership of Canadian resources parameter. In the base case this parameter is set at 70%. When it is set at 30%, however, a considerably smaller net welfare effect for Canada occurs when price controls are eliminated. In the latter case, the consumer side effect and the rent transfer effect come close to cancelling each other although, on a net basis, the revenue transfer effect still dominates. It is interesting to note that, in the 30% case, moving controlled prices incrementally towards world prices is a nationally welfare gaining change while eliminating price controls is a welfare losing change. This is because the welfare gain from reducing controls is approximately quadratic in the difference between domestic and world prices while the rent transfer effect is approximately linear. For this reason, there will be a nationally welfare maximizing set of price controls where the dead-weight loss of controls and the rent transfer from foreigners offset each other for any given degree of foreign ownership. Results in Table 3 suggest that this occurs when domestic producer prices are between 75% and 90% of world levels in the 30% foreign ownership of resources case.

In Table 4, we report welfare and other impacts of removing energy price controls where the benchmark domestic energy price is set at different levels in relation to the world price. These cases are motivated by the feature that currently controlled energy prices in Canada are much closer to world prices
Table 4

Welfare and Other Impacts of
Removing Energy Price Controls

(Base Case Model Variant)

Case 1: 70% Foreign Ownership of Resource Rents

<table>
<thead>
<tr>
<th>Benchmark Domestic Energy Price as % of World Energy Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
</tr>
</tbody>
</table>

A. Welfare Impacts on Canada
($ 1980 million)

<table>
<thead>
<tr>
<th></th>
<th>Compensating Variation</th>
<th>Equivalent Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>-8,119.9</td>
<td>-5,312.5</td>
</tr>
<tr>
<td>60</td>
<td>-2,992.2</td>
<td>-1,088.7</td>
</tr>
<tr>
<td>75</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>90</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

B. Change in Value of
Energy Rents in Canada
($ 1980 million)

<table>
<thead>
<tr>
<th></th>
<th>Accruing to Foreigners</th>
<th>Accruing to Canadians</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>11,190.4</td>
<td>4,795.9</td>
<td>15,986.3</td>
</tr>
<tr>
<td>60</td>
<td>6,072.5</td>
<td>2,602.5</td>
<td>8,675.0</td>
</tr>
<tr>
<td>75</td>
<td>3,019.3</td>
<td>1,294.0</td>
<td>4,313.3</td>
</tr>
<tr>
<td>90</td>
<td>1,000.1</td>
<td>428.6</td>
<td>1,428.7</td>
</tr>
<tr>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

C. % Change in Energy
Industry Net Output

<table>
<thead>
<tr>
<th>45</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1</td>
<td>8.4</td>
<td>4.7</td>
<td>1.8</td>
<td>0.0</td>
</tr>
</tbody>
</table>

D. % Change in Energy
Consumption

<table>
<thead>
<tr>
<th>45</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>-35.4</td>
<td>-24.8</td>
<td>-15.0</td>
<td>-5.8</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Table 4 (Cont'd)

Case 2: 30% Foreign Ownership of Energy Rents

Benchmark Domestic Energy Price as % of World Energy Price

<table>
<thead>
<tr>
<th></th>
<th>45</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Welfare Impacts on Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>($ 1980 million)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compensating Variation</td>
<td>-1,733.1</td>
<td>-1,849.5</td>
<td>-1,270.6</td>
<td>-518.5</td>
</tr>
<tr>
<td></td>
<td>Equivalent Variation</td>
<td>-1,647.9</td>
<td>-1,794.0</td>
<td>-1,249.9</td>
<td>-515.5</td>
</tr>
<tr>
<td>B. Change in Value of Energy Rents in Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>($ 1980 million)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accruing to Foreigners</td>
<td>4,795.9</td>
<td>2,602.5</td>
<td>1,294.0</td>
<td>428.6</td>
</tr>
<tr>
<td></td>
<td>Accruing to Canadians</td>
<td>11,190.4</td>
<td>6,072.5</td>
<td>3,019.3</td>
<td>1,000.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>15,986.3</td>
<td>8,675.0</td>
<td>4,313.3</td>
<td>1,428.7</td>
</tr>
<tr>
<td>C. % Change in Energy Industry Net Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.1</td>
<td>8.4</td>
<td>4.7</td>
<td>1.8</td>
<td>0.0</td>
</tr>
<tr>
<td>D. % Change in Energy Consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-35.4</td>
<td>-24.8</td>
<td>-15.0</td>
<td>-5.8</td>
<td>0.0</td>
</tr>
</tbody>
</table>
than was true in 1980; currently around 80-90% of world levels. Results indicate that the effects of eliminating energy price controls, while smaller, are still negative in these cases even when foreign ownership of resources is assumed to be 30% rather than 70%.

In Table 5, we report results of moving from the 1980 system of producer and consumer energy price controls to the National Energy Program blended price system (effective January 1981). Since the producer price stays unchanged in this analysis, no changes in rents or production occur and there are no impacts on foreigners. A small welfare gain occurs from the increase in consumer prices but, relative to the preceding system of price controls, this has an insignificant overall impact. Given the sharp reaction against this policy both within Canada and abroad when it was introduced in October 1980, this is a striking finding since at the time it was generally viewed as a major departure from the previous policy. Results in Table 5 clearly suggest that this was not the case, at least in its effect.

In Table 6 we report sensitivity analyses with respect to substitution elasticities for our central case analysis of the impacts of removing energy price controls (Table 3). We vary the elasticity of substitution in consumer demands between 0.2 and 2.0 and change the elasticity of substitution in the production function in energy between 0.05 and 0.1. As previously indicated, this latter parameter needs to be kept small so that the industry-specific nature of energy resources acts as a binding constraint and the energy supply elasticity does not become so large that specialization in production occurs.

These results indicate substantial sensitivity of welfare impacts with respect to elasticity values on the demand side, but more limited sensitivity effects with respect to the production side elasticity.
### Table 5


*(Base Case Model Variant)*

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>Foreign Ownership of Resource Rents = 30%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Welfare Impacts on Canada</strong> ($1980 million)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compensating Variation</td>
<td>18.9</td>
<td>18.9</td>
</tr>
<tr>
<td>Equivalent Variation</td>
<td>18.9</td>
<td>18.9</td>
</tr>
<tr>
<td><strong>B. Change in Value of Energy Rents</strong> ($1980 million)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accrueing to Domestics</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Accrueing to Foreigners</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>C. % Change in Energy Industry Net Output</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>D. % Change in Energy Consumption</strong></td>
<td>-0.11</td>
<td>-0.11</td>
</tr>
</tbody>
</table>
**Table 6**

Sensitivity Analysis for the Central Case Analysis of the Impacts of Removing Energy Price Controls (70% Foreign Ownership)

A. *Welfare Impacts on Canada* ($1980 million)

<table>
<thead>
<tr>
<th>$\sigma_E$</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>0.99</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>CV = -10580.8</td>
<td>CV = -9286.0</td>
<td>CV = -8115.9</td>
<td>CV = -7059.3</td>
<td>CV = -6150.9</td>
<td>CV = -2559.0</td>
</tr>
<tr>
<td>EV = -9974.2</td>
<td>EV = -8793.5</td>
<td>EV = -7717.3</td>
<td>EV = -6737.9</td>
<td>EV = -5890.0</td>
<td>EV = -2482.9</td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>CV = -10460.4</td>
<td>CV = -9165.4</td>
<td>CV = -7995.1</td>
<td>CV = -6938.4</td>
<td>CV = -6029.9</td>
<td>CV = -2437.4</td>
</tr>
<tr>
<td>EV = -9860.8</td>
<td>EV = -8679.3</td>
<td>EV = -7602.4</td>
<td>EV = -6622.4</td>
<td>EV = -5774.1</td>
<td>EV = -2364.9</td>
<td></td>
</tr>
</tbody>
</table>

B. *Change in Value of Energy Rents* ($1980 million)

<table>
<thead>
<tr>
<th>$\sigma_E$</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>0.99</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>D = 4795.9</td>
<td>D = 4795.9</td>
<td>D = 4795.9</td>
<td>D = 4795.9</td>
<td>D = 4795.9</td>
<td>D = 4795.9</td>
</tr>
<tr>
<td>F = 11190.4</td>
<td>F = 11190.4</td>
<td>F = 11190.4</td>
<td>F = 11190.4</td>
<td>F = 11190.4</td>
<td>F = 11190.4</td>
<td>F = 11190.4</td>
</tr>
<tr>
<td>0.1</td>
<td>D = 4911.4</td>
<td>D = 4911.4</td>
<td>D = 4911.4</td>
<td>D = 4911.4</td>
<td>D = 4911.4</td>
<td>D = 4911.4</td>
</tr>
<tr>
<td>F = 11460.1</td>
<td>F = 11460.1</td>
<td>F = 11460.1</td>
<td>F = 11460.1</td>
<td>F = 11460.1</td>
<td>F = 11460.1</td>
<td>F = 11460.1</td>
</tr>
</tbody>
</table>

C. *% Change in Output of Energy Industry*

<table>
<thead>
<tr>
<th>$\sigma_E$</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>0.99</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>14.1</td>
<td>14.1</td>
<td>14.1</td>
<td>14.1</td>
<td>14.1</td>
<td>14.1</td>
</tr>
<tr>
<td>0.1</td>
<td>17.8</td>
<td>17.8</td>
<td>17.8</td>
<td>17.8</td>
<td>17.8</td>
<td>17.8</td>
</tr>
</tbody>
</table>

D. *% Change in Energy Consumption*

<table>
<thead>
<tr>
<th>$\sigma_E$</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>0.99</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>-13.6</td>
<td>-25.2</td>
<td>-35.4</td>
<td>-44.3</td>
<td>-51.7</td>
<td>-77.7</td>
</tr>
<tr>
<td>0.1</td>
<td>-13.4</td>
<td>-25.1</td>
<td>-35.3</td>
<td>-44.2</td>
<td>-51.6</td>
<td>-77.7</td>
</tr>
</tbody>
</table>
Notes to Table 6

1. $\sigma$ represents the elasticity of substitution in demand.
   $\sigma_E$ represents the elasticity of substitution in value added for the energy producing industry.

2. For the base case: $\sigma = 0.6$ and $\sigma_E = 0.05$.

3. $D =$ accruing to domestic residents
   $F =$ accruing to foreigners
variations. Output effects are little affected in either case. The net
domestic welfare effect reflects the consumer surplus gain and the rent
transfer to foreigners; the former is affected substantially by the demand
side elasticity while the latter is left unchanged as this parameter varies.
The important point for policy making is that the sign of the welfare effect
is robust to both sensitivity analyses.

VI. Conclusions

In this paper we describe an applied general equilibrium model for
policy evaluation in the small open price-taking economy case which is
considerably simpler than that currently widely used in the literature.
Provided that there are as many productive factors as goods, and no
difficulties with specialization occur, it is possible to use the zero
profit conditions to solve for factor prices from the given world goods
prices. In this way, it is possible to solve the whole model for a domestic
equilibrium in which factor markets clear and zero-profit conditions hold.
Demand-supply equalities for goods markets are not needed since the large
rest of the world accommodates any excess demands (subject to trade balance).
Computation is dramatically simplified as a result. Extensions of the basic
model to incorporate the distorting effects of price controls, taxes,
tariffs and other policy interventions are relatively straightforward. Ex-
tensions to incorporate non-traded goods can also be accommodated.

We use the approach to analyze the effects of Canadian energy price
policies. The net outcome in terms of national welfare depends on two separate
effects. On the one hand, consumer and producer prices set below world prices
result in over-consumption and under-production of energy, and a welfare loss.
On the other hand, producer prices of energy set below world prices reduce the
factor returns accruing to owners of resources in Canada, many of whom are
foreigners.
Our numerical results portray the rent transfer effect against foreigners as the dominant effect of these policies. Removing price controls is a nationally welfare worsening change, since the increased rents transferred to foreigners more than outweigh the welfare gain.
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