On Measuring the Social Opportunity Cost of Foreign Exchange

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Abstract

In this paper a multi-sector general equilibrium model is developed to measure the social opportunity cost of foreign exchange. The model allows one to evaluate this parameter and take explicit account of the combined impact of the change in the demand for imports and the impact of the method of financing used by the government to pay for them. Three alternative ways of financing and increasing the demand for foreign exchange have been evaluated using this model. These results indicate that the social value of foreign exchange is approximately 6.5 per cent greater than the market exchange rate in Canada.

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Abstract. In this paper a multi-sector general equilibrium model is developed to measure the social opportunity cost of foreign exchange. The model allows one to evaluate this parameter and take explicit account of the combined impact of the change in the demand for imports and the impact of the method of financing used by the government to pay for them. Three alternative ways of financing and increasing the demand for foreign exchange have been evaluated using this model. These results indicate that the social value of foreign exchange is approximately 6.5 per cent greater than the market exchange rate in Canada.

Sur la mesure du coût social d'opportunité des devises étrangères. Dans ce mémoire, les auteurs développent un modèle multisectoriel d'équilibre général pour mesurer le coût social d'opportunité des devises étrangères. Le modèle permet de calibrer ce paramètre et de tenir compte explicitement de l'effet combiné du changement dans la demande pour les importations et de la méthode de financement utilisée par le gouvernement pour l'achat de ces devises. On évalue de façon comparative trois manières différentes de financer et d'accroître la demande de devises étrangères grâce à ce modèle. Les résultats indiquent que la valeur sociale des devises étrangères est à peu près 6.5 pourcent plus élevée que le taux de change sur le marché au Canada.

INTRODUCTION

The purpose of this paper is to develop a multi-sector general equilibrium model that will enable us to estimate the social opportunity cost of foreign exchange. A number of theoretical papers on this topic have clarified the nature of the distortions that create a divergence between the market and the shadow exchange rate. Recently, this

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work has been extended to include an analysis of the effect of the method used to finance the purchase of foreign exchange.[1]

This paper follows the general theoretical approach outlined by Blitzer, Dasgupta, and Stiglitz (1981), where the shadow price of foreign exchange is a function of both the types of distortions in the economy as well as the mechanism that the government uses to close the trade deficit created when additional imports are required by an investment project. Here we attempt to take the issue beyond a theoretical analysis and towards the specification of a model that can be evaluated empirically while integrating most of the tax, tariff, and subsidy distortions found in an economy. By testing this model with Canadian data, we can determine how sensitive the value of the shadow price of foreign exchange is both to the various trade and domestic fiscal distortions and to alternative policies used by the government to bring about an equilibrium in the foreign exchange market.

In a competitive trade equilibrium and in the absence of all distortions in the economy, the social value of foreign exchange earned from or spent on in a given project is determined by the net amount of foreign exchange multiplied by the market exchange rate. For most countries, however, trade distortions such as import duties and subsidies as well as export taxes and subsidies are frequently imposed on a variety of commodities. In such circumstances the market exchange rate will generally not reflect the social value of foreign exchange.

In deriving the resource costs of supply or the willingness to pay for consumption forgone, market distortions play a central role in driving a wedge between market prices and economic values. This analysis assumes that such market distortions are likely to remain unchanged over the period of time that the estimated value of the parameter is to be used.

A GENERAL EQUILIBRIUM MODEL

To evaluate the social opportunity cost of foreign exchange a multi-sector general equilibrium model is developed consisting of production and demand functions, tax and subsidy distortions, and a set of constraints on the quantities of resources available to the economy.

Production functions

This model is developed with the structure of the Canadian economy in mind. It contains two distinct sets of industries: a primary industry group and a non-primary set of industries. This division reflects the relatively greater importance of resource-based exports in the Canadian economy when compared with most other developed countries. The primary industries group consists of six sectors: agriculture, forestry, fishing (including hunting and trapping), metal mines, coal mines, and petroleum

1 See Harberger (1965, 1972); Bacha and Taylor (1971); Dasgupta, Sen, and Marglin (1972); Balassa (1974a, 1974b); Batra and Guisinger (1974); Bertrand (1974); Scott (1974); Boadway (1978); and Blitzer, Dasgupta, and Stiglitz (1981). An excellent description of how this parameter is practically used in cost-benefit analysis can be found in Roemer and Stern (1975).

and gas. Each produces its product (X_i in the ith sector) by using three primary factors, capital (K_i), labour (L_i), and its specific natural resource (N_i), along with a variety of intermediate inputs (X_{ji}) in fixed proportions. The non-primary industry group is made up of forty-four sectors.[2] The product of each of these sectors is produced by two primary factors, capital and labour, along with intermediate inputs that are used in fixed proportions to output.

All production functions are assumed to take the CES form. Intermediate inputs of the jth type (X_{ji}) are used to produce output in the ith sector (X_i) and are broken down into domestically produced (X_{ji}^{d}) and imported goods (X_{ji}^{m}) with constant input-output coefficients (a_{ji}^{d}) and (a_{ji}^{m}).[3] The production functions are written as follows:

$$\begin{aligned} X_i &= \lambda_i \left(\alpha_{ki} K_i^{-\rho_i} + \alpha_{li} L_i^{-\rho_i} + \alpha_{ni} N_i^{-\rho_i}\right)^{-(1/\rho_i)} \\ &= X_{ji}^{d}/a_{ji}^{d}/ = X_{ji}^{m}/a_{ji}^{m}, \\ i,j &= 1, 2, \ldots, 50 \\ N_i &= 0 \text{ if } i = 7, 8, \ldots, 50 \end{aligned} \tag{1}$$

where λ_i is a scale factor, ρ_i is a parameter such that the elasticity of substitution (σ_i) is constant, where $\sigma_i = 1/(1 + \rho_i)$, and α_{ki}, α_{li} and α_{ni} are distribution coefficients.

Under perfect competition, no firm is able to make surplus profits, which implies that the producer's price of each commodity equals its unit cost. Such costs from the firm's point of view include various taxes and trade margins associated with input requirements for production. For example, tariffs are imposed on imported goods, commodity taxes are paid on both intermediate and final demands, and payroll and corporate income taxes are levied on the factors of production. Firms also pay for some government goods and services and receive some direct subsidies from the government. For sectors that qualify for production subsidies, it is assumed that the subsidy is a fixed proportion of the producer's value of total output. The same assumption is applied to 'other value-added,' which is defined to include purchases of goods and services produced by the government.

It should be noted that with respect to the margins of the wholesale and retail trade and the transport industry, they can sometimes be produced by other industrial sectors. This arises because the classification of industries in the Canadian input-output table

2 These sectors are listed in the statistical appendix to the paper available from the authors.

3 This model has a number of similarities to the one developed by Boadway and Treddenick (1978). However, it also has several differences beyond the fact that this model is developed with 1977 data, while the Boadway and Treddenick model employed 1966 data. This model attempts to capture the nature of the major natural resource sectors in Canada by introducing a fixed factor in each of the sectors. In addition, rather than assume that Canada is facing a less than perfectly elastic world supply for goods it imports, this model specifies that imports are less than perfect substitutes for domestically produced goods. The treatment of exports is similar to that of Boadway and Treddenick in that it assumes that the demand for Canadian exports is less than perfectly elastic. The asymmetry in treatment of imports and exports in this model was introduced because Canada's exports tend to be concentrated in products such as forest and mineral products where it seems likely that the quantity of Canada's exports would affect the price at which they can be sold. On the other hand, Canada imports a wide variety of goods where the quantity it consumes is unlikely to have a significant impact on their world prices.

is based on their principal activity, and some sectors will contain trading or transportation activities.[4]

The producer's price of the ith domestically produced commodity (P_i^d) can be then expressed as the sum of payments to primary factors, intermediate inputs, subsidies on production, and other value-added:

$$P_i^d = r(1 + t_{ki} + t_{mi} + t_{si})a_{ki} + w(1 + t_{1i})a_{1i} + r_{ni}(1 + t_{ni})a_{ni} + \sum_J a_{ji}^d P_j^d (1 + t_{ji}^d + h_{ji}^d + k_{ji}^d) + \sum_J a_{ji}^m P_j^m (1 + t_{ji}^m + h_{ji}^m + k_{ji}^m) + v_i P_i^d + u_i P_i^d. \quad (2)$$

$i,j = 1, 2, \ldots, 50$

$a_{ni} = 0$ if $i = 7, 8, \ldots, 50$

The return to capital net of capital and municipal taxes and capital subsidies but gross of depreciation is denoted by r,[5] the wage rate net of payroll taxes is w, and r_{ni} is the net return to the ith specific natural resource. For the ith sector the effective corporate income tax rate is shown as t_{ki}, t_{mi} is the municipal property tax rate, and t_{si} defined negatively is the subsidy rate on capital. Payroll tax rates are shown as t_{1i} where payroll taxes include the Canada Pension Plan, unemployment insurance premiums, medical/hospital care premiums, and workmen's compensation paid by firms. The tax rate paid on the ith specific natural resource is denoted as t_{ni}, while the commodity tax rates on X_{ji}^d and X_{ji}^m are shown as t_{ji}^d and t_{ji}^m, respectively. Wholesale margins on X_{ji}^d and X_{ji}^m are expressed as rates h_{ji}^d and h_{ji}^m, respectively, while k_{ji}^d and k_{ji}^m are the retail trade plus the transport margins on the consumption of domestic and imported goods. The unit physical requirements of capital, labour, and the specific natural resource used in production by the ith sector are shown as a_{ki}, a_{li}, and a_{ni}, respectively. The rate of production subsidy is expressed as v_i defined negatively, u_i is the other value-added coefficient, and p_j^m is the producer's price of the jth imported good inclusive of custom duties.

If r_i^*, w_i^*, and r_{ni}^* stand for the unit cost of capital, labour, and the services of the ith resource gross of taxes and subsidies, and if a_{ji}^{d*} and a_{ji}^{m*} denote the domestic and imported intermediate inputs gross of taxes and margins, (2) can be rewritten as

$$P_i^d = r_i^* a_{ki} + w_i^* a_{1i} + r_{ni}^* a_{ni} + \sum_J a_{ji}^{d*} P_j^d + \sum_J a_{ji}^{m*} P_j^m + v_i P_i^d + u_i P_i^d. \quad (3)$$

Since firms would select the optimal combination of primary factor input requirements so as to minimize the unit value-added cost of good i, (D_i), which is equal to ($r_i^* a_{ki} + w_i^* a_{1i} + r_{ni}^* a_{ni}$), we obtain[6]

$$a_{1i}/a_{ki} = [(\alpha_{1i}/\alpha_{ki})/(r_i^*/w_i^*)]\ \sigma_i \quad (4)$$

4 Statistics Canada (1979).

5 The implicit assumption is that depreciation rates are the same across sectors.

6 The CES production function can be expressed in unit form:

$$1 = (\lambda_i)^{-\rho_i} (\alpha_{ki}\, a_{ki}^{-\rho_i} + \alpha_{1i}\, a_{1i}^{-\rho_i} + \alpha_{ni}\, a_{ni}^{-\rho_i}).$$

The problem becomes one of minimizing the unit value-added cost of the ith good subject to the above constraint of the unit production function. The results can be easily derived by using the Lagrange multiplier and setting the first-order conditions with respect to a_{ki}, a_{1i}, and a_{ni}.

$$a_{ni}/a_{ki} = [(\alpha_{ni}/\alpha_{ki})\ (r_i^*/r_{ni}^*)]^{\sigma_i}. \tag{5}$$

The unit capital requirements can be expressed[7]

$$a_{ki} = \lambda_i^{-1}\ (\alpha_{ki})^{\sigma_i/(1-\sigma_i)}\ [1 + (\alpha_{1i}/\alpha_{ki})^{\sigma_i}\ (r_i^*/w_i^*)^{\sigma_i - 1} + (\alpha_{ni}/\alpha_{ki})^{\sigma_i} (r_i^*/r_{ni}^*)^{\sigma_i - 1}]^{\sigma_i/(1-\sigma_i)}, \tag{6}$$

where the last term within the bracket disappears for all non-primary sectors.

Substituting (4) and (5) into D_i yields[8]

$$\begin{aligned} D_i &= r_i^* a_{ki}\ [1 + (w_i^* a_{1i}/r_i^* a_{ki}) + (r_{ni}^* a_{ni}/r_i^* a_{ki})] \\ &= \lambda_i^{-1} r_i^*\ (\alpha_{ki})^{\sigma_i/(1-\sigma_i)}\ [1 + (\alpha_{ki})^{-\sigma_i}\ (r_i^*)^{\sigma_i - 1} \\ &\qquad \cdot \{(\alpha_{1i})^{\sigma_i}(w_i^*)^{1-\sigma_i} + (\alpha_{ni})^{\sigma_i}\ (r_{ni}^*)^{1-\sigma_i}\}]^{1/(1-\sigma_i)}, \end{aligned} \tag{7}$$

where the term $(\alpha_{ni})^{\sigma_i}(r_{ni}^*)^{1-\sigma_i}$ is again absent from all non-primary sectors. From (7), D_i can be seen as a function of primary factor prices (r, w, and r_{ni}).

If we generalize equation (3) into simultaneous equations for the economy, we obtain

$$\begin{aligned} &[I - ((A^*)^d)' - V - U]P^d \\ &= r^* a_k + w^* a_1 + r_n^* a_n + ((A^*)^m)'P^m \\ &\equiv D + ((A^*)^m)'P^m, \end{aligned} \tag{8}$$

where P^d, P^m, a_k, a_1, a_n, and D are all column vectors of domestic and imported producers' prices, primary inputs of capital, labour and specific natural resources, respectively, and unit value-added costs; r^*, w^* and r_n^* are, respectively, the diagonal matrices of unit costs of capital, labour, and specific resources gross of taxes and subsidies; $(A^*)^d$ and $(A^*)^m$ are the matrices of domestic and imported input-output coefficients inclusive of commodity taxes, trade, and transport margins.

The producers' prices of fifty sectors can be solved from the simultaneous equations (8) and are expressed as follows:

$$P^d = [I - ((A^{*d})' - V - U]^{-1}\ [D + ((A^*)^m)'P^m]. \tag{9}$$

Since the input-output coefficients, commodity tax rates, wholesale margins, retail and transport margins, subsidy rates on output, and other value-added coefficients

7 The production function in unit form can be rewritten

$$1 = (\lambda_i)^{-\rho_i}\ \alpha_{ki}\ (a_{ki})^{-\rho_i}\ [1 + (\alpha_{1i}/\alpha_{ki})\ (a_{1i}/a_{ki})^{-\rho_i} + (\alpha_{ni}/\alpha_{ki})\ (a_{ni}/a_{ki})^{-\rho_i}].$$

Substituting (4) and (5) into the above equation and utilizing the relationship $\sigma_i = 1/(1 + \rho_i)$ yields

$$1 = (\lambda_i)^{-\rho_i}\alpha_{ki}\ (a_{ki})^{-\rho_i}\ [1 + (\alpha_{1i})^{\sigma_i}(\alpha_{ki})^{-\sigma_i}(r_i^*)^{\sigma_i - 1}(w_i^*)^{1-\sigma_i} + (\alpha_{ni})^{\sigma_i}(\alpha_{ki})^{-\sigma_i}(r_i^*)^{\sigma_i - 1}(r_{ni}^*)^{1-\sigma_i}].$$

Equation (6) can be obtained by removing $(a_{ki})^{-\rho_i}$ to the left-hand side and then taking the root. For the special case where $\rho_i = 0$, the term a_{ki} can be expressed as

$$a_{ki} = \lambda_i^{-1}[(\alpha_{ki}/\alpha_{1i})(w_i^*/r_i^*)]^{\alpha_{1i}}\ [(\alpha_{ki}/\alpha_{ni})(r_{ni}^*/r_i^*)]^{\alpha_{ni}}.$$

8 For the cases where $\sigma_i = 1.0$, the unit value-added cost becomes

$$D_i = r_i^* \lambda_i^{-1}\ \alpha_{ki}^{-1}\ [(\alpha_{ki}/\alpha_{1i})\ (w_i^*/r_i^*)]^{\alpha_{1i}}\ [(\alpha_{ki}/\alpha_{ni})(r_{ni}^*/r_i^*)]^{\alpha_{ni}}.$$

are all given, the producers' prices of commodities in the economy become functions of primary input prices and the prices of imported goods, which in turn depend upon international prices and the exchange rate.

Demand functions

Goods and services are produced to meet demand for intermediate input and final demand. The latter consists of private consumption and investment, government expenditures, and exports. In equilibrium, all product markets should clear. The sum of domestic production (X_i) and imports (M_i) of each commodity is equal to the sum of intermediate inputs (X_{ij}) and final demands by households (C_i), governments (G_i) and exports (E_i), and changes in inventories (ΔI_i):

$$X_i + M_i \equiv \sum_J X_{ij} + C_i + G_i + E_i + \Delta I_i$$
$$= \sum_J (a_{ij}{}^d + a_{ij}{}^m) X_j + C_i + G_i + E_i + \Delta I_i.$$

For the economy as a whole, these equations can be written in matrix form:

$$X = [I - A^d - A^m]^{-1} (C + G + E - M + \Delta I), \tag{10}$$

where C, G, E, M and ΔI are the column matrices of C_i, G_i, E_i, M_i and ΔI_i, and A^d and A^m are the domestic and imported input-output coefficient matrices. Since households, governments, and foreign sectors have different utility functions, each will be discussed separately below.

The household sector

Households are assumed to consume both capital and consumption goods. They select their consumption bundles so as to maximize their welfare function subject to their budget constraint. The households' welfare function (WH) is assumed for this model to take the form of a CES function:

$$\text{WH} = (\sum_i e_i C_i{}^{-\beta})^{-(1/\beta)}, \tag{11}$$

where e_i is the distribution coefficient, C_i is the household consumption of the ith commodity, and β is a parameter that gives the function the property of having a CES among commodities.

Households' disposable income (Y) is defined here as total personal income net of income tax and government borrowing (B_g):

$$Y = (1 - t_y)(r\bar{K} + w\bar{L} + \sum_i r_{ni}\bar{N}_i + T_r) - B_g, \tag{12}$$

where t_y is the average personal income tax rate; $\bar{K}$, $\bar{L}$, and $\bar{N}_i$ are total factor endowments of capital, labour, and the ith specific natural resource; and T_r is the government transfer payments to households including unemployment insurance benefits, family allowance, and all social assistance. For simplicity, all total disposable income is spent on various commodities and services:

$$\sum_i q_i C_i = Y, \tag{13}$$

where q_i is the purchaser's price of the ith commodity.

Following Armington (1969), we consider it realistic to assume that domestically produced goods and imports of the same type are less than perfect substitutes. The degree of their substitutability is likely to be higher than that between commodities. Therefore, C_i is viewed as the consumption of the ith composite commodity that is determined by both domestic and imported goods and is specified in the form of a CES function:

$$C_i = \mu_i[b_i^d(C_i^d)^{-\delta_i} + b_i^m(C_i^m)^{\delta i}]^{-(1/\delta_i)}, \tag{14}$$

where μ_i is a scale factor; b_i^d and b_i^m are distribution coefficients; and δ_i is a parameter with the property of CES between domestic and imported goods.

The demand for C_i^d and C_i^m is derived in two steps. Households first select composite consumption bundles by maximizing their welfare function and then select the domestic-foreign mix for each ith composite commodity that minimizes the cost of purchasing the volume of C_i. The optimal demand function for C_i is:[9]

$$C_i = Y/[e_i^{-s}(q_i)^s \sum_J e_j^s (q_j)^{1-s}], \tag{15}$$

where s stands for the elasticity of substitution among commodities such that $s = 1/(1 + \beta)$.

The minimization of the cost of C_i yields:[10]

$$C_i^m/C_i^d = [(b_i^m/b_i^d)(q_i^d/q_i^m)]^{si}, \tag{16}$$

where q_i^d and q_i^m are purchasers' prices of the domestic and imported ith commodity, and s_i is the CES between the domestic and imported goods of the ith commodity such that $s_i = 1/(1+\delta_i)$.

Purchasers' prices are normally producers' prices augmented by commodity taxes on final demand. However, as the data obtained from input-output tables are often constructed on an industry basis, certain of these industries also undertake wholesale, retail or transportation services in addition to their principal activity. Purchasers' prices are, therefore, producers' prices augmented by wholesale margins (h_i^d), retail and transportation margins (k_i^d), provincial sales taxes (t_{pi}^d), and all other commodity taxes (t_i^d), including the federal excise tax; it is expressed as follows:

$$q_i^d = P_i^d(1 + t_i^d + h_i^d + k_i^d)(1 + t_{pi}^d). \tag{17}$$

Imported commodities are subject to the same commodity taxes and trade margins. The relationship between q_i^m and p_i^m can be written as

$$q_i^m = p_i^m(1 + t_i^m + h_i^m + k_i^m)(1 + t_{pi}^m). \tag{18}$$

9 This equation is obtained by first maximizing the welfare function (11) subject to the constraint of disposable income (13). The first-order conditions with respect to C_i and C_j *yield* $C_i/C_j = [(e_i/q_i)/(e_j/q_j)]^s$.

Substituting this relationship into $C_i = C_i \cdot Y/\sum_J q_j C_j = Y/\sum_J q_j (C_j/C_i)$ gives us equation (15).

10 This equation is obtained by minimizing the cost of purchasing the domestic-imported mix of the ith goods subject to the constraint of a fixed amount of expenditure on the ith goods (i.e., equation (14)).

Substituting (16) into (14) yields demand functions for C_i^d and C_i^m:[11]

$$C_i^d = C_i\mu_i^{-1}\,(b_i^d)^{s_i/(1-s_i)}\,[1 + (b_i^m/b_i^d)^{s_i}(q_i^m/q_i^d)^{1-s_i}]^{s_i/(1-s_i)} \tag{19}$$

$$C_i^m = C_i\mu_i^{-1}\,(b_i^m)^{s_i/(1-s_i)}\,[1 + (b_i^d/b_i^m)^{s_i}(q_i^d/q_i^m)^{1-s_i}]^{s_i/(1-s_i)}. \tag{20}$$

The price of the composite commodity that is required to determine C_i may be derived by setting the value of the marginal contribution of C_i^d equal to its price, q_i^d:[12]

$$\begin{aligned} q_i &= q_i^d/(\partial C_i/\partial C_i^d) \\ &= q_i^d\,(\mu_i)^{(1-s_i)/s_i}\,(C_i)^{-(1/s_i)}\,(b_i^d)^{-1}\,(C_i^d)^{1/s_i}. \end{aligned}$$

Substituting (19) into the above equation yields:[13]

$$q_i = (\mu_i)^{-1}(q_i^d)(b_i^d)^{s_i/(1-s_i)}\,[1 + (b_i^m/b_i^d)^{s_i}(q_i^m/q_i^d)^{1-s_i}]^{1/(1-s_i)}. \tag{21}$$

If we substitute (21) into (15), C_i can be viewed in terms of q_i^d and q_i^m. The demand for the ith domestic commodity from (19) becomes a function of the same basic purchasers' price of domestic and imported commodities and of disposable income. According to (17), purchasers' prices of domestically produced goods are tied to their producers' prices, which are, in turn, expressed in terms of the primary input prices, world prices and the exchange rate. Therefore, the demand for the ith domestic commodity is also expressed in terms of primary input prices, world prices, the exchange rate, direct and indirect taxes, as well as trade and transport margins.

If the country is small relative to the rest of the world its demand for imports, the c.i.f. prices of imported goods expressed in units of foreign exchange (P_i^w) will be exogenously given. The producer's price of an import becomes a function of its world price, the exchange rate, and its tariff rate. That is,

$$p_i^m = zP_i^w\,(1 + \tau_i), \tag{22}$$

where z is the foreign exchange rate expressed in the price of foreign currency and τ_i is the tariff rate of the ith commodity. The final demand for goods and services in the household sector can then be fully expressed in terms of the initial factor endowments, tax and tariff rates, primary input prices, world prices, and the exchange rate.

The government sector

The government hires labour, purchases goods and services, and uses its own capital

11 For the cases where $\delta_i = 0$, both C_i^d and C_i^m can be expressed

$$C_i^d = C_i\mu_i^{-1}\,[(b_i^d/b_i^m)\,(q_i^m/q_i^d)]^{b_i^m}$$

$$C_i^m = C_i\mu_i^{-1}\,[(b_i^m/b_i^d)\,(q_i^d/q_i^m)]^{b_i^d}.$$

12 See, for example, Armington (1969).

13 For the cases where $\delta_i = 0$, the term q_i can be expressed as

$$q_i = \mu_i^{-1}q_i^d\,(b_i^d)^{-1}\,[(b_i^d/b_i^m)\,(q_i^m/q_i^m)]^{b_i^m}.$$

endowment to produce services. All expenditures are financed through taxation (R_g) and borrowing (B_g):

$$\sum_i (q_i^d G_i^d + q_i^m G_i^m) + wL_g + T_r = R_g + B_g \tag{23}$$

where G_i^d and G_i^m are the government consumption of the ith domestic and imported goods, respectively; L_g is the physical requirements of labour employed in the government sector; and T_r is the government transfer payments.

Net government revenue can be expressed as the sum of tariffs, federal and provincial commodity taxes, export taxes, capital and natural resource taxes net of capital and production subsidies, personal income taxes, and payroll taxes:

$$\begin{aligned} R_g = {} & \sum_i z P_i^w M_i \tau_i + \sum_i \{P_i(C_i + G_i)t_i + \sum_j P_j X_{ji} t_{ji}\} \\ & + \sum_i P_i (C_i + G_i)(1 + t_i + h_i + k_i)t_{pi} + \sum_i P_i (t_i^e E_i + v_i X_i) \\ & + \sum_i ra_{ki} X_i (t_{ki} + t_{mi} + t_{si}) + \sum_i r_{ni} a_{ni} X_i t_{ni} \\ & + (r\bar{K} + w\bar{L} + \sum_i r_{ni} \bar{N}_i + T_r)t_y + w(L_g t_{1g} + \sum_i a_{1i} X_i t_{1i}), \end{aligned} \tag{24}$$

where t_i^e is the export tax rate of the ith commodity, and t_{1g} is the payroll tax rate in the public sector. The rest of the variables used in (24) have been previously defined. Since the domestic and imported components of the variables are not explicitly expressed in the equation, the distinction between superscripts 'd' and 'm' is not shown.

The level of government expenditurers is assumed to be exogenous, where spending on each category is given in this model and expressed as follows:

$$G_i^d = \bar{G}_i^d \tag{25}$$

$$G_i^m = G_{0i}^m + \bar{G}_i^m \tag{26}$$

$$L_g = \bar{L}_g \tag{27}$$

$$T_r = \bar{T}_r \tag{28}$$

where G_{0i}^m is a constant term that can be viewed as the autonomous expenditure on the ith imported goods. As a result, the government will borrow to the extent the government undertakes expenditures in excess of its net revenues.

The foreign sector

As was previously discussed, the demand for the ith imported commodity used for intermediate inputs depends upon the given imported input-output coefficients and outputs in the ith sector which are in turn a function of all primary inputs employed in that sector. Primary input demand can be expressed in terms of primary input prices. The final demand for household consumption of an imported commodity can also be expressed in terms of various tax parameters and its producer's price, with the producer's price again being a function of primary input prices, tariff rates, world prices, and the exchange rate.

It is assumed that in its demand for imports Canada faces given world prices. On the other hand, because Canada's exports tend to be concentrated in relatively few natural resource based commodities, it is assumed that the demand for its exports depends upon the export commodity's own price demand elasticity (η_i) in the world market:

$$E_i = E_{0i} (q_i^d/z)^{\eta_i}, \tag{29}$$

where E_{0i} is a scale factor. It should be noted that all exports from Canada are exempt from manufacturing and retail sales tax, but certain commodities may be subject to export taxes.

Since the model we deal with is an open economy, net capital inflows are a source of purchasing power. Assuming that the net capital inflow (F) is exogenously given, the condition for the balance of payments to be in equilibrium requires

$$z\sum_i P_i^w M_i = F + \sum_i q_i^d E_i. \tag{30}$$

Equation (30) can be solved iteratively for the value of z that clears the balance of payments.

Full employment

To reflect the importance of natural resources to Canada the economy is assumed to have eight primary factors: labour, capital, and six specific natural resources. The system with the full employment condition requires

$$a_{ni}X_i = \bar{N}_i \qquad i = 1, 2, \ldots, 6 \tag{31}$$

$$\sum_i a_{ki}X_i = \bar{K} \tag{32}$$

where X_i is the total demand for the domestically produced ith commodity. It can be expressed as

$$X_i = \sum_j a_{ij}^d X_j + C_i^d + G_i^d + E_i + \Delta I_i$$

or in matrix form as

$$X = [I - A^d]^{-1} (C^d + G^d + E + \Delta I),$$

where C^d and G^d are the column vectors of final demand for domestically produced commodities by households and governments; A^d, E and ΔI are as previously defined. These X_i are indeed the same as the X_i in (1).

The description of the multi-sector model in an open economy is now complete. Equations (30)–(32) describe the generalized model in equilibrium. By Walras's law, the labour market is necessarily cleared when all income earned is spent and all other markets are cleared. One can use the wage rate (w) as the numéraire and eliminate the labour market equilibrium equation. The variables to be solved in the system are r, z, and r_{ni} ($i = 1, 2, \ldots, 6$).

The numerical procedure to solve the system is to start with a set of arbitrary values for all variables. Since a_{ki} can be expressed in terms of the independent variable r, Newton's iteration method is used to determine a value of r that satisfies

equation (32).[14] Once the value of r is determined, a new foreign exchange rate (z) is solved from equation (30), and the domestic outputs of all sectors are calculated based on the values of r and z derived from the previous iteration. Given total factor endowments of capital and natural resources, the a_{ni} and the r_{ni} are now recalculated and a new value of r is again estimated. The iteration process is continued until a covergence criterion is satisfied. At that stage, the system of eight non-linear equations (30)–(32) is solved for the eight unknown relative prices (r, z, and r_{ni}, $i = 1$ to 6). Consequently, the value of all other variables such as output, import, export and consumption by sector, factor requirements by sector, and commodity prices can also be derived from the eight relative prices.

To measure the social cost of foreign exchange we must take into consideration both the market value of the foreign exchange and the net change that arises in the value of all the distortions in the economy as a consequence of the action that either generates or uses the foreign exchange. This approach, initiated by Harberger (1965, 1972) and further generalized by Boadway (1978), measures the change in economic welfare arising from an action that reallocates resources as the sum of the value of the change in allocation of inputs and outputs measured at domestic producers prices and the net increases in tax and tariff revenues and the value of other distortions. When applied to the measurement of the social cost of foreign exchange (SOCFE), the value of this parameter will be equal to the market value of foreign exchange (z) times an expression that measures the changes in values of all distortions in the economy that arise because of the use or production of one more unit of foreign exchange. This is expressed in equation (33) as

$$\text{SOCFE} = z\,[1 + (\phi/\Delta\text{FE})], \tag{33}$$

where $\phi = -\sum_i \bar{P}_i^d \{(1 + t_i^d)(1 + t_{pi}^d) - 1\}\,\Delta C_i^d$

$$-\sum_i z\,P_i^w \{(1 + \tau_i^c)[(1 + t_i^m)(1 + t_{pi}^m) + (h_i^m + k_i^m)\,t_{pi}^m] - 1\}\,\Delta C_i^m$$

$$-\sum_i \{\bar{P}_i^d (v_i + t_i^e)\,\Delta X_i\} - \sum_i \{\bar{r}(t_{si} + t_{ki} + t_{mi})\,\Delta(a_{ki}X_i) + t_{1i}\,\Delta(a_{1i}x_i)\}.$$

14 The numerical problem of this model is to solve a set of eight non-linear equations (30) to (32) for eight unknown variables r, z, and r_{ni} ($i = 1,2, \ldots, 6$). To simplify the model, let $\text{CR}_i = [\alpha_{ni}^{-1}\,(a_{ni}\lambda_i)^{(1-\sigma_i)/\sigma_i} - 1]^{-1}$. Substituting (5) into (6) and re-grouping the terms, one can rewrite (6) as a relationship between the unit physical requirements of capital for production and the relative prices and shares of primary factors:

$$a_{ki} = \lambda_i^{-1}\,\{\alpha_{ki}\,(1 + \text{CR}_i)\,[1 + (\alpha_{1i}/\alpha_{ki})^{\sigma_i}\,(r_i^*/w_i^*)^{\sigma_i - 1}]\}^{\sigma_i/(1-\sigma_i)}$$

Since a_{ki} can be expressed in terms of one independent variable r, Newton's method can be used to determine a value of r that satisfies equation (32). According to (32), let us define $F(r) = \sum_i a_{ki}X_i - \bar{K}_i$. Assuming that r_0 is an approximation to the root of $F(r) = 0$, Newton's method would give the value of $(r_0 + h)$ as an even better approximation if the value of h is estimated by $h = F(r_0)/F'(r_0)$, where $F'(r) = \sum a'_{ki}X_i$. At this stage, a new exchange rate (z) is determined from equation (30) and the domestic production X_i are calculated based on the most up-to-date values of r and z. Meanwhile, equation (31) is used to estimate a_{ni} and CR_i and then a_{ki}. Newton's method is again used to determine a new estimate of r, then z and r_{ni}. Since r and z are the central variables in the system, the iteration process continues until a convergence criteria is satisfied. The convergence criterion used was that the square root of $(r^2 + z^2)$ from one iteration to another be the same to three decimal points.

The parameter τ_i^c denotes the tariff rate of the ith good used by household sector. Also, Δ indicates the change in the equilibrium value of a variable. ΔFE refers to either the change in foreign exchange required to purchase additional imports (i.e., $\sum_i \Delta G_{0i}^m$) or from a change in capital outflow (i.e., ΔF). The variables with a '-' sign stand for the mean value of the equilibriums before and after the additional imports by the government.

The first term of ϕ measures the change in the value of commodity taxes paid that result from the change in expenditures made on domestically produced goods and services. By the same token, the second term measures the change in tariffs and sales tax revenues arising from the change in imports by households. The third term measures the change in the value of production subsidies net of export taxes. The last set of terms measure the net change in the value of subsidies and taxes that apply to the factors of production.

From equation (33) we find that if the use of additional foreign exhange causes the net value of taxes and subsidies paid in the product and factor markets to fall, then the social opportunity cost of foreign exchange will be greater than its market price. The opposite result arises if the use of foreign exchange causes net government revenues to increase.

The value of SOCFE will be dependent on the actual source or use of foreign exchange and the particular way the economy finances or raises the foreign exchange. In this paper, two basic different situations will be evaluated. First, we will consider the case of the government purchasing additional imports. In order to make this purchase it must reduce domestic expenditures through alternative financing, so that resources will be released from the economy to finance this purchase. In this case we shall assume that the government finances the additional purchase of imports by increasing personal income tax revenues. The simultaneous purchase of imports and reduction in domestic expenditures will cause the private demand for all goods to fall while at the same time causing the domestic currency to depreciate, hence, increasing the relative prices of traded goods. This, in turn, leads to a movement of variable factors towards the production of traded goods and away from the non-traded sector until factor returns across sectors in the economy are again equalized. This movement in the quantities of goods produced and consumed will change the value of the taxes and subsidies associated with these goods and hence create a divergence between the financial cost (z) and the social cost to the economy of a unit of foreign exchange used to purchase imports.

The second case for which the shadow price of foreign exchange is evaluated is the situation where foreign exchange is used up through an increase in capital outflows, for example, to repay foreign debt. In this case the adjustment comes about through a fall in the value of domestic currency. This will cause relative prices to change, so that a shift in resources is induced towards the production of traded goods that will substitute for and / or finance imports that would otherwise have been financed by the foreign exchange. The reallocation of resources in the economy would occur until factor price equalization is established among sectors. This case corresponds to the traditional approach of measuring the social opportunity cost of foreign exchange

where the welfare implications of any direct action the government might take to finance a purchase of foreign exchange are not considered.

EMPIRICAL ANALYSIS

All coefficients and parameters in the model were estimated from the 1977 benchmark data for Canada.[15] When the exogenous variables, such as the quantity of factor available, are substituted into the model, a set of equilibrium values are generated with the wage rate as a numéraire for the market exchange rate, the primary factor prices, and the levels of output and consumption of all sectors.

In the first case we assume that the government increases its purchase imported goods and that these purchases are proportionally distributed among sectors according to the normal consumption patterns of imported goods and services. If the purchase of imports is accompanied by an increase of the same amount in personal income tax revenue, their combined impact on the national economy is obtained by solving the multi-sector non-linear model for the two actions simultaneously. When an equilibrium is re-established, we obtain a set of values for all other endogenous variables. For example, the price of foreign exchange rises by 0.31 per cent and the rental price for capital falls by 0.17 per cent. The net change of all distortions in the economy can be calculated according to (33). The major distortions are due to forgone tariffs and commodity taxes. We find that the social opportunity cost of foreign exchange for 1977 would be approximately 8.20 per cent higher than the market rate.

In the second case we increase the level of capital outflows without any direct reduction of domestic expenditures through increased taxation. Again, a new set of equilibrium values for all endogenous variables is obtained from solving the model. For example, the price of foreign exchange rises by 0.87 per cent and the rental price rises by 1.90 per cent. As a result, the social cost of foreign exchange in this case is 7.81 per cent greater than the market price of foreign exchange.

Since 1977 a number of Canada's trade restrictions and other market distortions have changed. The changes in the size of the distortions are likely to affect the social value of foreign exchange and therefore should be incorporated into the simulation of the model.

First, the manufacturing sales tax has been reduced from 12 per cent to 9 per cent since November 1978 (with the exception of alcohol and tobacco).

Secondly, according to the multilateral trade negotiations under the General Agreement on Tariffs and Trade, there has been a decrease of approximately 10 per cent on tariff rates (with the exception of the clothing and textile sectors) since January 1980.

Thirdly, since January 1979 the Canadian government has imposed a bilateral quota agreement with the low-cost exporting countries on the clothing, textiles, and knitting mills sectors. In addition, the non-leather footwear sector has been commit-

15 A statistical appendix outlining the estimation of the parameters used to evaluate the model is available from the authors on request.

ted to the global quota system since December 1977. The bilateral quota system (and to a lesser extent, the global quota system) provides a very effective constraint on imports and should be incorporated to the model by using the tariff equivalent of such restrictions. The additional protection provided by quotas has been estimated by Jenkins (1983) and ranges from 2 per cent of pyjamas / sleepwear to 54 per cent of shirts with tailored collars, with an average of approximately 17.5 per cent, which is used in this paper.

Fourthly, the world price of crude oil has been considerably higher than the domestic price in the past few years. This was a result of substantial production subsidies provided to the petroleum refinery sector by the Canadian government. Based on the National Energy Program, the domestic price of oil used in this paper has been assumed to be 85 per cent of the world price.

Finally, the capital subsidy rate of the Regional Development Incentives Program is recalculated, and an annual average from 1968 to 1979 is used.

We assume that these trade distortions in Canada will remain unchanged over the life of the project under evaluation. With these modifications, the values of the input variables have been adjusted and substituted into the multi-sector model. A new set of general equilibrium values for all endogenous variables in the economy are determined.

Now, assume the government increases its purchase of imported goods financed simultaneously by an increase in personal income tax revenue. The model will generate new equilibrium values for all variables in the economy. The estimated social opportunity cost of foreign exchange is now approximately 6.98 per cent higher than the market rate. The reason for the fall in the social foreign exchange premium from 8.20 per cent for 1977 is mainly the reduction in the rates of manufacturing sales tax and tariffs combined with the offsetting effect of the increase in the non-tariff restraints in the clothing, textile, and footwear sectors.

It should be noted that the social cost of foreign exchange is more sensitive to the assumptions on the price elasticity of exported goods than the elasticity of substitution of production functions. For example, if the own price elasticities of exports is increased by 10 per cent for all sectors, the shadow price of foreign exchange would be about 6.72 per cent (instead of 6.98 per cent) greater than the market rate. If a Cobb-Douglas function is assumed for all sectors, the shadow price of foreign exchange is only slightly altered (6.92 per cent).

The model was also used to evaluate a case where the government increased its purchase of imports but financed these expenditures by increasing the corporate income tax. In this situation the social value of foreign exchange was estimated to be 6.56 per cent greater than its market value.

On the other hand, if we evaluate the social cost of foreign exchange from an exogeneous increase in capital outflows, the social value of foreign exchange would be about 6.16 per cent higher than the market rate in 1982.

These estimates of the shadow price of foreign exchange represent two basic different ways in which the economy is required to adjust to an additional use of foreign exchange. In the first case the government assists the movement to a new equilibrium

in the economy by reducing the demand for both traded and domestic goods through an increase in either personal or corporate income taxes. In the case of increased capital outflows the entire adjustment is brought about through changes in the exchange rate and relative prices. This analysis would indicate that, as compared with case where the financing of the increased demand for foreign exchange is done indirectly through changes in the exchange rate and relative prices, the social cost of foreign exchange is somewhat higher when the government simultaneously increases its purchase of imports and increases taxes to pay for them.

According to GATT, a gradual 40 per cent reduction in tariff rates will be achieved by 1987. If this occurs, the foreign exchange premium would be further reduced by 0.35 per cent. However, this reduction of foreign exchange premium will be more than offset (an increase of 0.50 per cent) by the 1 percentage point increase of the manufacturing sales tax rate (from 9 to 10 per cent) that was implemented in October 1984.[16]

From these experiments we find that the premium on foreign exchange ranges from 6.16 to 6.98 per cent. Although further cases could be evaluated, we believe that a 6 to 7 per cent range for the foreign exchange premium is likely to cover most of the realistic cases for Canada. If for practical reasons one needs to use a single value for this parameter in the evaluation of a set of projects in Canada which use or generate foreign exchange, the social value of the foreign exchange would be greater than the market rate by approximately 6.5 per cent.

CONCLUDING REMARKS

In this paper a multi-sector general equilibrium model has been developed to measure the social opportunity cost of foreign exchange. The model incorporates not only import tariffs and commodity taxes but also takes into account production and capital subsidies in the Canadian economy. The model takes explicit account of the way additional imports by the government are financed. Therefore, the evaluation of the shadow price of foreign exchange can be made up of the combined impact of the method of financing and the change in demand for imports in all other sectors of the economy. Very few fully general equilibrium estimations of this parameter have been carried out to date and none, that we are aware of, has been able to incorporate the level of detail of sector distortions presented here.

Because of tariffs, non-tariff barriers, commodities taxes, and production and capital subsidies in Canada, we find that there is approximately a 6.5 per cent differential between the market price and the social value of foreign exchange. Viewed in the context of the appraisal of investment projects that either use or generate foreign exchange, this adjustment could be one of the key determinants in estimating their net economic value to Canada.

16 Department of Finance, *Budget Papers* (19 April 1983)

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