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INDUSTRIAL ORGANISATION FOUNDATIONS OF TRADE POLICY MODELLING*

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General equilibrium models of Canada/US free trade have produced a wide range of predictions of the impact on the Canadian economy. This paper analyses the models from an 'industrial organisation' perspective, focusing on differences in assumptions about market elasticities and pricing behaviour. The approach succeeds in encompassing the range of predictions from the models. The results have implications for agricultural policy modelling.

An exciting recent innovation in trade policy modelling has been the introduction of 'industrial organisation' (IO) assumptions into large-scale computable general equilibrium models. The effect of scale economies and oligopolistic pricing can be to greatly increase the predicted domestic impact of trade liberalisation from the numbers generated by competitive or neoclassical general equilibrium (NGE) simulations.

The IO modellers have focused on the manufacturing sector, where it is believed unexploited scale economies are most likely to be found, and, indeed, have treated primary sectors such as agriculture in a rather rudimentary fashion. In their Canadian applications, all primary sectors are assumed to operate under conditions of constant returns to scale. Nevertheless, the size of the new results is such that they cannot be ignored by agricultural trade economists, since the likely intersectoral feedbacks are substantial. For example, consider the impact of a cut in manufacturing protection. The first-order impact of this on the agricultural sector is beneficial, implying cheaper inputs. However, suppose the lower tariffs force large-scale rationalisations which substantially reduce manufacturing costs, as predicted by the new models. This will increase the demand for manufactured exports, and reduce the demand for imports, leading to an appreciation of the exchange rate, which will not be in the interests of primary exporters. The net effect cannot be signed, *a priori*.

Agricultural economists have a legitimate interest in these developments. They also have a direct interest in the behaviour of food and agricultural processing industries which link final agricultural markets, at home and abroad, with the farm sector.

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General equilibrium models are large and complex, and the publicly available documentation for them is often skimpy or outdated.[1] The contribution of this paper is to set out a relatively small and transparent model which is nevertheless rich enough to encompass both the traditional neoclassical and the new IO approaches to general equilibrium modelling. It is spurred by the debate in Canada on the impact of free trade with the United States, in which context the IO approach was first introduced in the model of Harris and Cox (1984). Applied to Canada/US free trade, this model resulted in the spectacular forecast that free trade would increase Canadian gross national product (GNP) by 9 per cent (Harris 1986). In contrast, a conventional NGE model (Hamilton and Whalley 1985) forecast gains of less than 1 per cent, and two studies have actually predicted losses to Canada from bilateral free trade (Brown and Stern 1987; Wigle 1988).

These large models differ in many respects; this must be expected to contribute to the differences in results.[2] Nevertheless, it will be shown below that changes in IO assumptions embodied in our simple model can generate a range of outcomes that approximately matches the range noted above. This, of course, raises the important question of *which* assumptions are empirically sound. This paper will not attempt to deal comprehensively with this issue, though empirical evidence will be noted where available. It is the author's judgement that while the imperfect competition thrust of the IO approach is sound, the more extreme models are not empirically plausible.

The paper is set out as follows. The next section lists and examines four areas of producer and consumer behaviour on which modellers' assumptions differ. Then, a mathematical model in which these differences can be incorporated is built, and used to give simulation results of the quantitative importance of the assumptions. A final section concludes the paper.

IO Foundations: A Survey

Four major areas are examined where models of market behaviour can differ: on a firm's pricing response to import competition; on the implications of returns to scale in production; on the 'entry threat'; and on the size of import and export demand elasticities.

Pricing

When the tariff on imported widgets is removed, what happens to the price of locally produced ('domestic') widgets? The question really has two parts: what happens to the local or domestic market price of imports, and what then happens to the price of domestic widgets?

The answer to the first part depends on whether the model is partial equilibrium or general equilibrium, and, in the latter case, on whether the rest of the world is modelled explicitly. In partial equilibrium analysis, and in general equilibrium models such as the Harris-Cox model (which adopt the small country assumption), it is customary to assume that 100 per cent of a tariff change is passed on in the price that domestic consumers pay for imported goods. However, in world models (including the other

[1] The important ORANI model, for example, has been much developed since its last full-scale documentation in Dixon *et al.* (1982).

[2] For example, different assumptions are made about international and/or intersectoral capital mobility.

Canadian studies surveyed here), supply and demand must match up across all regions, so that some of a tariff will normally be absorbed in a lower supply price, although the size of this effect is likely to be very small for a country like Canada. In fact, as Baldwin, Mutti and Richardson (1980) note, it is very difficult to reject infinite elasticity on the econometric evidence, even for the largest national economy. However, there are exceptions, such as Japanese automobiles, the supply price of which differs markedly from country to country according to differences in internal market conditions, including trade barriers (Hazledine and Wigington 1987).[3]

The major discrepancies between models, however, concern what happens to domestic prices when competing import prices change. We survey five approaches to this question.

The law-of-one-price (LOOP). This popular answer applies to an industry of perfectly competitive (price taking) firms selling a commodity identical to the imported variety (homogeneous product) under conditions of increasing marginal cost, such that the domestic industry is unwilling to meet all of domestic demand. This model is represented in Figure 1. Elimination of the tariff reduces the domestic market price of imports from $P_w + t$ to P_w, forcing (by consumer arbitrage) an exactly matching change in the price of domestic output from P_{d0} to P_{d1}. Domestic output drops, domestic demand goes up, and, *a fortiori*, imports increase from $D_{d0} - S_{d0}$ to $D_{d1} - S_{d1}$.

The LOOP is standard in partial equilibrium analysis of protection (for example, Magee 1972) and appears in some general equilibrium contexts,

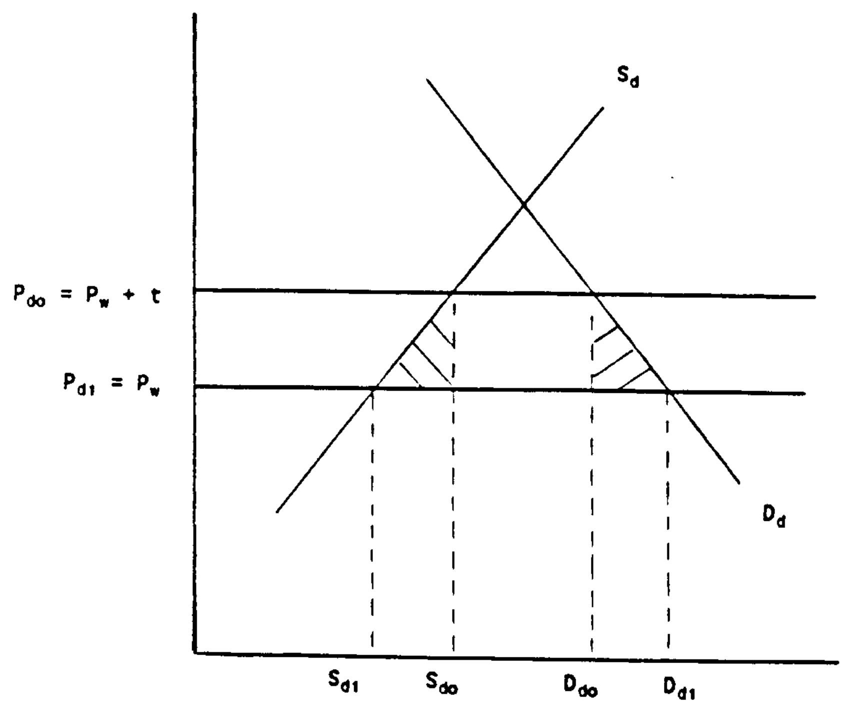

FIGURE 1 – Law-of-One-Price.

[3] See also Caves and Williamson (1985) for some Australian evidence.

especially when agricultural markets are the focus of attention (Trela, Whalley and Wigle 1987; Chisholm and Tyers 1985). It is also virtually standard in international macroeconomic theory (see Dornbusch 1987 for a discussion), and in highly stylised and aggregated models of the links between 'tradeable' and 'non-tradeable' sectors, such as that of Clements and Sjaastad (1984) and Choi and Cumming (1986).

The Eastman-Stykolt hypothesis. A second model leading to the same prediction for the domestic price effect of a tariff change is known as the Eastman-Stykolt hypothesis (ESH), after Eastman and Stykolt's (1967) study of the impact of tariff protection on Canadian manufacturing industries.

Whereas the LOOP features atomistic pricetakers, and ESH assumes a cartel of colluding oligopolists. The homogeneous product case is shown in Figure 2. Below a price equal to the landed, tariff-inclusive price of imports, the cartel operates on the domestic demand curve D_d. At any price higher than this, however, all customers would switch to imports. The demand curve for the cartel therefore has a kink at the import price, so that their marginal revenue curve, MR_{d0} is discontinuous at this point. As long as marginal costs pass through the discontinuous range, price will be set at the kink to just exclude imports. With removal of the tariff, price would drop by the full amount, t_d, from P_{d0} to P_{d1}, as with the LOOP. Unlike the LOOP case, however, domestic output would *increase*, from Q_{d0} to Q_{d1}. Cartel output is demand-constrained, not supply-constrained.

We thus have two quite different market structures leading to the same prediction, that domestic and import prices will move in step, with the

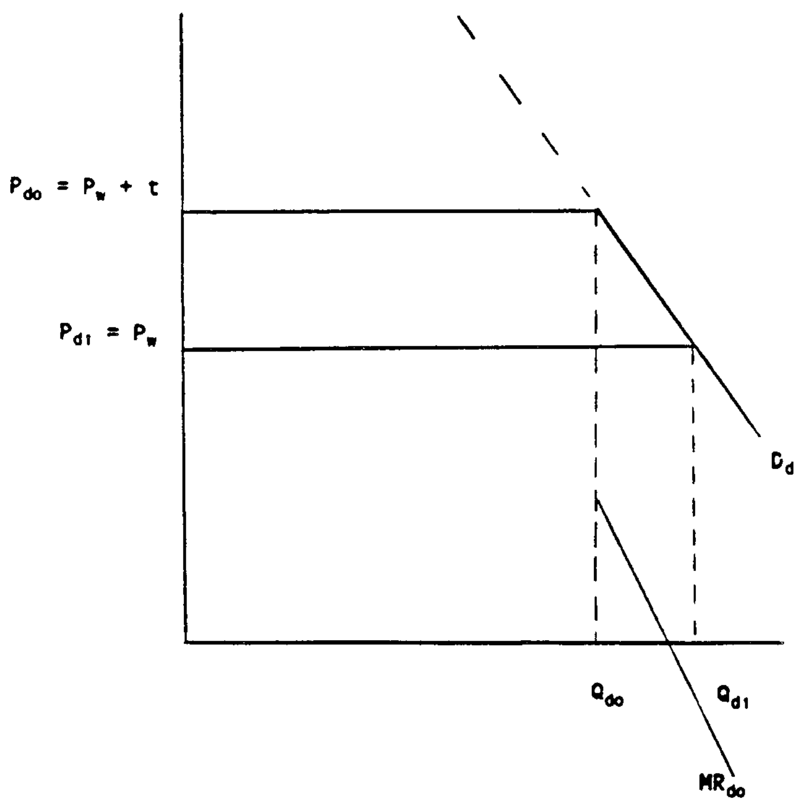

FIGURE 2—Eastman-Stykolt Hypothesis.

latter setting the pace. Note that product homogeneity (domestic output and imports perfectly substitutable) is neither necessary nor sufficient for this. It is not necessary because a cartel faced with costs of coordination could settle on the import price as a natural focal point, even if imports are not perfect substitutes for their output[4] and it is not sufficient because the cartel could choose to price on the downward-sloping part of the curve if this is elastic enough.

Neoclassical general equilibrium pricing. The third class of hypothesis to be considered is the cost-based pricing assumed in mainstream, or neoclassical general equilibrium (NGE) models, as represented in Canada by the work of John Whalley and associates at the University of Western Ontario, and, in Australia, by the well-known ORANI modelling project (Dixon, Parmenter, Sutton and Vincent 1982). An application focusing on agricultural policies in different economies is the OECD's WALRAS model (Burniaux, Delorme, Lienert, Martin and Hoeller 1988). The essence of the NGE model is shown in Figure 3.

The NGE approach offers an interesting contrast to the partial equilibrium LOOP model. Although both are referred to as 'competitive', whereas the LOOP has domestic prices matching one-for-one changes in the local market price of imports, the NGE assumption is that there is *no* direct market price response. Thus, on Figure 3 elimination of a tariff t on competing imports will shift inwards the demand curve but, in the constant returns to scale situation drawn here, have no effect on domestic output price, which may be higher or lower than the import price.[5]

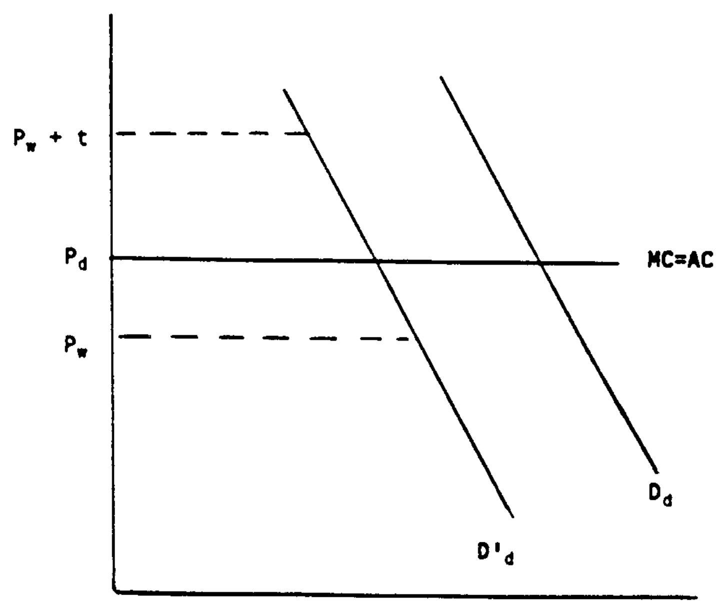

FIGURE 3 – Neoclassical General Equilibrium.

[4] In this case the demand curve would not be perfectly elastic above the kink. See Hazledine (1988*a*) for a discussion of the Eastman–Stykolt model with product heterogeneity.

[5] Shifts in supply curves due to factor price changes may require substantial price changes, especially in the short run when capital stocks are fixed. Thus, Parmenter (1986) reports values of $dP_d/dP_m = 0.4$, approximately, in simulations of across-the-board tariff cuts with the ORANI model.

This is possible because NGE models employ the 'Armington' assumption that domestically produced and imported goods in a market are imperfect substitutes,[6] in keeping with the empirical fact of intra-industry trade (that is, of imports and exports being observed simultaneously, even with highly disaggregated data).

Non-collusive oligopoly pricing. From an industrial organisation perspective it seems unsatisfactory to assume, as in the NGE models, that a change in import prices affects the behaviour of consumers but not that of domestic firms. Surely the local oligopolists will recognise the implications for their market share of failing to respond to the price change? Yet, it is not trivial to write down models in which dP_d/dP_m is much larger than zero. If, following Harris (1984, 1988), we suppose that decision makers set price optimally, given an elasticity of demand (e), we get the 'Lerner markup rule'

$$P_d = [e/(e+1)]C$$

The domestic price (P_d) is a constant markup on unit costs (C). A change in P_m shifts the domestic output demand curve, but it may not cause much change in the perceived elasticity, and thus not P_d. So, it appears to be in the Harris–Cox world. Horridge (1987) in his application of Harris' assumptions to the ORANI model, finds very little difference in results between the complicated Negishi–Lerner perceived elasticity model of Harris–Cox, and an average cost pricing rule, like those found in standard NGE models.

In models with non-constant elasticity demand curves (linear, for example) more substantial domestic pricing responses emerge (Hazledine, 1988*a*) and in collusive models with kinked demand, such as Eastman–Stykolt, oligopolists can be predicted to fully match import prices. However, any of heterogeneous imports and domestic output, imperfect coordination between existing domestic firms, and threats of entry from new firms, can reduce the extent to which domestic and import prices move together.

Mixed pricing. All the above can be summarised as follows: there are two potentially important 'attractors' to domestic output prices: the market price of competing imports and domestic costs of production. At one extreme (LOOP, ESH) the import price attractor dominates; at the other extreme (NGE, Lerner markup rule) it is domestic costs that hold sway. In between, a variety of oligopoly models can be specified in which both attractors have some force.

A priori, it would seem reasonable to adopt an intermediate position, and in fact the empirical evidence supports this. Many econometric studies have failed to confirm the LOOP hypothesis (for example, Milone 1986), even for commodities as apparently homogeneous as wheat (Thursby, Johnson and Grennes 1986). Studies that have examined Canadian and US price data (Hazledine 1980; Karikari 1988) have found that pricing models do need both domestic cost and import prices to fit the data well. This work is given added interest and credibility by its ability to account

[6] Note that homogeneity in a long-run NGE model (no industry-specific factors; constant returns to scale) would result in the number of viable industries being equal to the number of factors.

for *differences* in the relative strength of the two attractors. Hazledine's cross-sectional data reveal that more concentrated (and hence, plausibly, collusive) industries give more weight to the tariff; Karikari's examination of two time periods shows import (US) prices to matter more to Canadian industries when the \$Canadian was high relative to the US\$.

These and other studies that could be cited seem to support the Harris–Cox innovation of 'mixed pricing hypothesis' (MPH), which has the domestic price set as a weighted average of the price that would be set by an industry using the Lerner markup and the focal point Eastman–Stykolt price. Harris and Cox report simulations with different values for the weight in their MPH, but always with the same value for each of their 20 industries. Wigle, however, gets quite different free trade gains from Harris–Cox, from a model in which 'mixed' pricing means some industries are using the ESH and others cost-based pricing. This appears to be an example of the disaggregation of the models extending well beyond the present capabilities of the data.

Technology

As can be seen from Figures 1, 2 and 3, the trade modelling literature contains a full range of assumptions about the technologies available to import-competing industries. In line with standard theoretical general equilibrium practice, NGE models assume long-run constant returns to scale, implying flat average and marginal cost curves, which will shift with changes in factor prices. In the partial equilibrium LOOP model, marginal cost curves must slope upwards to reach equilibrium; this can be achieved with a constant returns technology by assuming that one input is in fixed (inelastic) supply, so that there are diminishing returns in the remaining variable inputs.

Of the Canada/US free trade general equilibrium models, Brown and Stern use this assumption, and it does also appear in earlier work, notably Boadway and Treddenick's (1978) analysis of the impact of unilateral tariff reductions. Upward-sloping cost curves are particularly popular in agricultural trade models, whose builders are reluctant to abandon homogeneous products and price-taking supply as the basis of market behaviour. Examples are the 'Berkeley' models surveyed by de Janvry and Sadoulet (1987), Chisholm and Tyers (1985) and Trela *et al.* (1987).

In manufacturing, however, it is virtually impossible to obtain evidence of upward-sloping marginal costs, and there is a long tradition within Canadian economics that goes back past Eastman and Stykolt (1967), which stresses the assumptions, first, that manufacturing operates with increasing returns to scale, and, second, that inadequate exploitation of scale economics is a major factor in explaining Canada/US productivity differences.[7] It is possible that the statistical studies, on which Harris–Cox and others have come to rely, tend to overestimate the size of unexploited scale economies.[8] On the other hand, other sources of cost changes, for

[7] The importance of scale economies has also been long recognised in the even smaller Australasian economies. See, for example, Dixon's (1978) pioneering demonstration of the productivity gains from reducing protection in a model incorporating scale economies.

[8] This is because they omit factors (managerial excellence, superior location, luck) which will cause the most successful firms in an industry to be both relatively larger and relatively low cost. If these factors are important, overall production efficiency could be reduced by inducing smaller firms to expand.

example 'X-inefficiency', may also be responsive to changes in competitive pressure due to tariff cuts. The basic thrust of the 'Canadian school' of endogenous-cost models is the idea that production costs are to some extent responsive to the price received, which in turn is affected by the tariff.

Entry

From the industrial organisation perspective, behaviour in markets cannot be fully specified unless we know what assumptions firms already in a market make about the possibility of new firms entering. Both neoclassical and Harris–Cox general equilibrium models assume free entry, that is, new firms have access to the same technology as incumbents, and will continue to enter an industry as long as price exceeds costs.

However, the effects of the entry process are quite different in the two approaches. In NGE models, entry keeps prices down to the level of cost,[9] whereas in Harris–Cox it drags costs up to price. The NGE story is textbook-perfect competition, whereas Harris–Cox is heterodox, and worth examining further. Beginning with the imposition of a tariff on imports, under the mixed pricing hypothesis, existing domestic firms raise their prices, so that profit margins are greater than zero. This attracts other firms who enter, reducing average firm size. Constant returns technologies are infinitely divisible, so that firm size is unimportant, but this is not so under increasing returns. In this case, the new entrants 'crowd' the industry, pushing all firms up their average cost curves until the rents are all dissipated. Now, if the tariff is removed, price falls, all firms make losses, and rationalisation (exit) occurs until output per surviving firm has

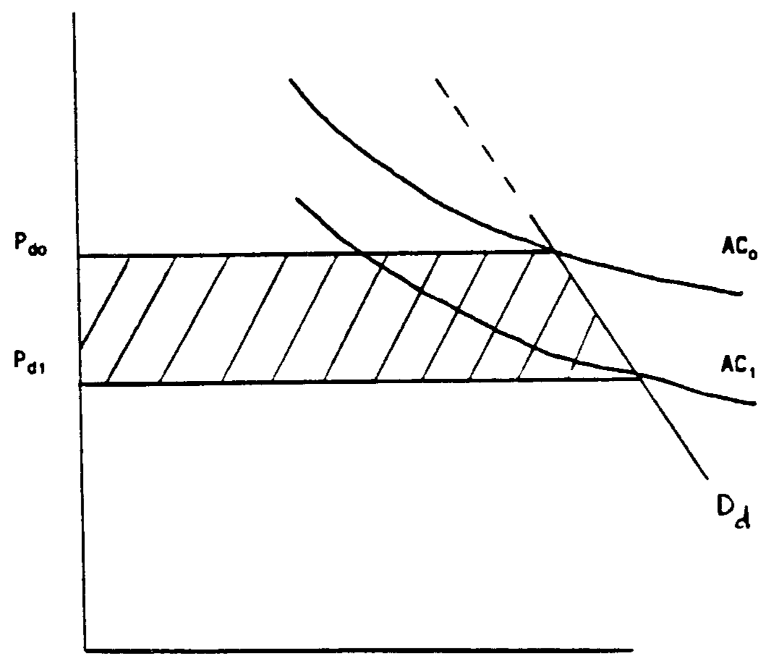

FIGURE 4 – Scale Economies Model.

[9] In fact, the process of preserving $P = AC$ is not spelled out; just the equilibrium outcome is modelled.

increased enough to reduce average costs to the new price level. The situation is shown in Figure 4, with industry average cost curves AC_0 and AC_1 for the tariff and no-tariff situations respectively.[10]

The implications for efficiency gains are readily seen. Whereas in the LOOP and NGE models tariffs cause only marginal distortions of output and consumption, resulting in small 'triangle' efficiency losses, as shown by the shaded area in Figure 1, in Harris–Cox *all* units of production are affected, generating a larger trapezoid (the shaded area in Figure 4) of waste to be recovered by tariff reductions.

The Harris–Cox model does seem idiosyncratic. If firms are able to collude on pricing, why are they not able to collude to repel entry or rationalise production? On the other hand, if they cannot stop entry, would it not pay them to set a lower price in the first place, to at least maintain market share? Scepticism on either of these questions leads to predictions of lower efficiency losses from tariffs, either because firms are able to pocket the tariff rents rather than seeing them dissipated, or because they take less advantage of the tariff in the first place, and so induce less production inefficiency. In the simulation analysis, we will experiment with less-extreme rent dissipation assumptions.

To complete the taxonomy, note that the upward-sloping supply curves of the LOOP model (Figure 1) imply that entry is impeded in the sense that at least one essential input to production is not in perfectly elastic supply.

Elasticities

All the above concerns the behaviour of firms, the selling side of the market. The buying side also matters. All the models assume price-taking consumers, whose behaviour can be summarised by price elasticities. General equilibrium modellers have to rely on existing studies for their demand elasticities, and the quality of these is perhaps the most readily admitted weakness in the empirical soundness of their models (Shoven and Whalley 1984, pp. 1042–4). A general concern seems to be that the available econometric estimates are too small. Hamilton, Mohammad and Whalley (1984) report 'central tendency' estimates from a literature survey of aggregate elasticities ranging from −0.78 (Japan) to −1.66 (US) for import price elasticities, and −0.79 (Canada) to −1.41 (US) for exports. Harris and Cox, requiring two-digit SIC Canadian elasticities, apparently derive them from a study by Hazledine (1981), though these were no more than an informal synthesis of another survey, by Stern, Francis and Schumacher (1976).

It will be seen that the results of trade liberalisation are quite sensitive to the demand elasticities assumed, through the terms of trade changes needed to maintain external balance when imports become cheaper. This is particularly so in the NGE world, in which domestic prices do not change much, so that the *relative* price of imports falls by the amount of tariff reduction, inducing the largest possible shift in market shares. In his 'Comment' on the Brown and Stern (1987) paper, Harris blames these terms of trade effects for reducing Canada's welfare in their BFT simulations, given that existing Canadian tariffs are higher than US levels.

[10] These curves show the average cost that would be associated with different levels of industry output if changes in the latter were effected by all the firms in an industry at a particular time expanding or contracting in proportion (constant market shares).

A Framework Model

In this section, we set out a relatively small (eight variable) model of the tradeable goods sector. For simplicity, it will be assumed that this sector is small enough compared to the rest of the economy such that changes in tradeable output do not affect prices of factor inputs, or output prices in the non-tradeables sector.

The demand for real imports is a function of their price and the price of domestically produced tradeables:

(1)′ $$M = M(P_d,\ P_m)$$

Upper case letters represent variables in levels; lower case will be used for their proportional rates of change, thus:

$$x \equiv \mathrm{d}X/X$$

for some variable X. Our model will be in rate of change form throughout. Thus, (1)′ becomes

(1) $$m = \beta p_m + \alpha p_d \qquad \beta < 0,\ \alpha > 0$$

where β and α are the own- and cross-price elasticities of demand for imports.

Similarly, the demand for the economy's exports in the world market is

(2) $$x = \delta p'_x \qquad \delta < 0$$

with δ the own-price elasticity of demand for exports, and the assumption that competing world prices do not change.

Domestic prices of tradeable goods change according to the formula

(3) $$p_d = (1 - \tau)c + \tau p_m \qquad 0 \leq \tau \leq 1$$

This formula allows for the extremes of cost-based pricing ($\tau = 0$) or LOOP ($\tau = 1$), as well as intermediate hypotheses which allow both domestic costs and competing imports to affect domestic prices.

The domestic market price of imports satisfies

(4)′ $$P_m = P'_m T_d R$$

their supply price on the world market multiplied by the domestic tariff actually defined as:

$$T_d = 1 + \text{ rate of tariff duty}$$

multiplied by the domestic currency price of a unit of foreign or 'world' currency. The world price of imports will be taken as constant, so that

(4) $$p_m = t_d + r$$

The price at which the economy offers its exports on the world market is, analogous to (4)′:

(5)′ $$P'_x = P_x T_f / R$$

the domestic currency supply price multiplied by world or foreign tariffs, divided by the domestic currency exchange rate. Then

(5) $$p'_x = p_x + t_f - r$$

The export supply price is set by

(6) $$p_x = \theta p_d + (1 - \theta)c \qquad 0 \leq \theta \leq 1$$

Values of θ less than 1 can be interpreted either as price discrimination or as reflecting the split of the tradeable goods sector into separate exporting and importing-competing industries.

Average domestic costs of production:

$$c = \eta p_d \qquad 1 \geq \eta \geq 0 \tag{7}$$

If $\eta = 1$ we have the extreme Harris–Cox model of productivity changes fully compensating for changes in the prices received for domestic output. $\eta = 0$ corresponds to the standard neoclassical constant returns to scale, fixed technology assumption (given that there are no factor price changes here). A value for η slightly larger than zero matches the partial equilibrium perfect competition model (or the general equilibrium models with a fixed input), which have higher price inducing higher output at a higher marginal cost, resulting in a small increase in average costs.

Finally, trade balance requires

$$P_x' X / T_f = P_m' M \tag{8$'$}$$

World currency export receipts (net of any foreign tariff payments) must equal the domestic economy's expenditures on imports. In rate of change form, (8)′ becomes

$$p_x' + x - t_f = m \tag{8}$$

given that world prices of imports do not change.

We now have eight equations in the eight variables m, x, p_d, p_m, p_x', r, p_x and c, which are solved in the Appendix.

Analysis of the Model

We are interested in the welfare impact of tariff cuts under various industrial organisation and demand elasticity scenarios. Since we are chasing some rather big numbers, we will not complicate welfare calculations with 'triangle' allocative effects, which are generally found to be of second-order importance. The measured welfare impact is thus simply the sum of the change in imports net of the change in exports required to pay for them (the terms of trade effect) and the change in the quantity of resources needed to produce the base period output of the tradeables sector (the productivity effect). Changes in the domestic consumption of domestically produced output have no welfare effect, since they are assumed to be fully offset by changes in non-tradeables output and consumption.

The terms of trade effect is given by

$$ToT = \sigma(p_x - r) \tag{9}$$

where σ (set at 0.3 in the simulations) is the proportion of pre-free-trade imports or exports to tradeables' value added, and $(p_x - r)$ is the change in domestic supply price of exports minus the change in the exchange rate, which is the domestic currency supply price of imports.

Results for Different Pricing and Cost Responses

Table 1 shows the results of varying pricing and cost response parameters, holding constant export and import price elasticities at −2.0, approximately in line with the estimates from the econometric literature.

The event simulated is abolition of both domestic and foreign tariffs with the latter being lower originally, in line with the Canada/US tariff structure. The results are given for five variables: the exchange rate (r), the price of domestic tradeable sector output (p_d), the terms of trade effect (ToT), productivity improvement ($-c$) and the net welfare effect (net)

Results are shown for nine combinations of pricing and cost response parameters. Consider first the top row, corresponding to the constant returns or no cost response ($\eta=0$) case. With $\tau=0$ as well (cell 1) we have the standard long-run NGE situation, that is tariffs have no direct effect on prices, and costs are constant, under which there should be only a terms of trade effect on welfare (given that second-order allocative improvements are ignored here). Such is indeed the case: with domestic tariffs falling from higher levels than foreign, the exchange rate depreciates (r rises) by 3.33 per cent, resulting in a welfare loss equal to the terms of trade loss of 1 per cent of tradeables' value added. Since costs do not change and imports do not affect domestic prices, the latter do not change.

With some direct domestic price response to the fall in import prices on the domestic market (cell 2) the exchange rate still depreciates, but by less, and terms of trade and thus net welfare losses are correspondingly smaller. The reason is that the fall in domestic prices reduces the relative price change of imports and so reduces the increase in demand for imports, and thus the increase in exports required to pay for them. This trend continues when the pricing response is increased to 1.0 (cell 3), so that the price of imports relative to competing domestic output does not change, and it is only the lower price relative to non-tradeables that induces any increase in demand.

Now bring in some responsiveness on the costs side by assuming that each 1 per cent fall in domestic prices induces a 0.5 per cent improvement in productivity, through lower X-inefficiency, increased scale efficiency, or whatever ($\eta=0.5$). In the cost-based pricing case (cell 4) results are identical to the cell above. The reason is that, with domestic prices unresponsive to imports, they do not change when trade is liberalised; thus, there is nothing to induce domestic firms to improve productivity.

With partial price response (cell 5), however, the exchange rate now appreciates compared with cell 2, boosting the effect of tariff cuts on landed import prices, so that domestic output prices fall by 8.7 per cent, and costs by 4.3 per cent. Lower costs mean lower export prices, which worsens the terms of trade, despite the favourable implication of the higher exchange rate on the price of imports relative to exports. However, the productivity improvements are big enough to easily compensate for terms of trade losses, and the net effect on the economy's welfare is a 3.3 per cent increase (as a proportion of tradeable GNP).

All of this is exaggerated if domestic prices are solely determined by imports (cell 6). Domestic prices end up falling by more than 17 per cent, which is well above the original domestic tariff of 12 per cent, and welfare gains are nearly 8 per cent of tradeable value added.

Assuming 100 per cent cost response to domestic price changes ($\eta=1.0$) should be equivalent to the Harris-Cox assumptions of scale economies and zero profit equilibrium. For the cost-plus pricing case (cell 7) the model will not solve. The problem is that equations (3) and (7) are now identical, that is, price equals cost and cost equals price; thus, we have, in effect, lost an equation, and the model is undetermined. This is remedied by having a direct response to tariff changes, as in cells 8 and 9. Note, though, that results in these two cells are identical. It is easily seen why this must be so. With $\eta=1$, equation (7) is

TABLE 1

Sensitivity Analysis of Pricing and Costs Parameters with Import and Export Price Elasticities Set at −2.0[a]

			Pricing parameter (γ) 0.0	0.5	1.0
			1	2	3
		r	0.033	0.016	−0.010
		p_d	0.000	−0.052	−0.130
	0.0	ToT	−0.010	−0.005	−0.003
		$-c$	0.000	0.000	0.000
		net	−0.010	−0.005	−0.003
			4	5	6
		r	0.033	−0.010	−0.053
Cost		p_d	0.000	−0.087	−0.173
response	0.5	ToT	−0.010	−0.010	−0.010
		$-c$	0.000	0.043	0.087
(η)		*net*	−0.010	0.033	0.077
			7	8	9
		r		−0.140	−0.140
		p_d	No	−0.260	−0.260
	1.0	ToT	solution	−0.036	−0.036
		$-c$		0.260	0.260
		net		0.224	0.224

[a] r is rate of change of real exchange rate, domestic currency per unit of foreign currency; p_d is rate of change of domestic price of tradeables; ToT is rate of change of terms of trade; $-c$ is rate of change of production efficiency (negative of rate of change of unit costs); *net* is net welfare effect of bilateral free trade ($= ToT - c$). Event is elimination of 12 per cent domestic and 7 per cent foreign tariff duties on all imports and exports.

$$c = p_d \tag{10}$$

Substituting this into equation (3):

$$p_d = (1-\tau)p_d + \tau p_m = p_m \tag{11}$$

Domestic prices end up falling by as much as import prices, whatever the value of τ. The value of $p_d = c = p_m$ is always a solution for any τ, and when $\eta = 1$, it is the only solution.

Note the very large numbers that result from trade liberalisation when costs are fully endogenous to price. The exchange rate appreciates by 14 per cent, domestic tradeables prices drop by 26 per cent and the net welfare gain is more than 22 per cent of tradeables value added. This number is roughly equivalent to the Harris-Cox figure of welfare gains around 8 or 9 per cent of the economy's total GNP.

However, in another respect, our results do not match those of Harris and Cox, since, with fully responsive costs the pricing parameter does not matter in our model, whereas Harris-Cox show simulations (Cox and Harris 1985, p. 137) with welfare gains increasing as domestic prices respond relatively more to lower tariffs. This discrepancy remains to be explored in future work.

Results for Different Import and Export Elasticities

Table 2 examines the sensitivity of the results to differences in demand elasticities, using 'middle-of-the-road' ($\tau = \eta = 0.5$) assumptions about

TABLE 2

Sensitivity Analysis of Import and Export Price Elasticities with Pricing and Costs Parameters Set at 0.5[a]

			Import own-price elasticity (α)		
			−1.0	−2.0	−3.0
			1	2	3
	−1.0	r	−0.090	0.068	0.090
		p_d	−0.140	−0.035	−0.020
		ToT	0.006	−0.025	−0.030
		$-c$	0.070	0.018	0.010
		net	0.076	−0.008	−0.020
			4	5	6
Export own-price elasticity (δ)	−2.0	r	−0.140	−0.010	0.033
		p_d	−0.173	−0.087	−0.058
		ToT	0.016	−0.010	−0.019
		$-c$	0.087	0.043	0.029
		net	0.103	0.033	0.010
			7	8	9
	−3.0	r	−0.150	−0.049	−0.003
		p_d	−0.180	−0.113	−0.082
		ToT	0.018	−0.002	−0.011
		$-c$	0.090	0.056	0.041
		net	0.108	0.054	0.029

[a] r is rate of change of real exchange rate, domestic currency per unit of foreign currency; p_d is rate of change of domestic price of tradeables; ToT is rate of change of terms of trade; $-c$ is rate of change of production efficiency (negative of rate of change of unit costs); *net* is net welfare effect of bilateral free trade ($= ToT - c$). Event is elimination of 12 per cent domestic and 7 per cent foreign tariff duties on all imports and exports.

pricing and cost response. Own-price elasticities range from −1 to −3. The cross-price elasticity of demand for imports with respect to domestic tradeables price is held at +1.

When both the import, and export demand elasticities are small (cell 1), free trade results in a sharp appreciation of the exchange rate (9 per cent), a small improvement in the terms of trade, and a worthwhile improvement in net welfare (7.6 per cent). However, doubling the import elasticity changes this (cell 2). The domestic consumers' greater responsiveness to cheaper imports has to be checked by a depreciation of nearly 7 per cent to maintain trade balance. As a result, domestic tradeable prices do not drop by as much, and cost improvements are only just sufficient to compensate (in net welfare) for the deterioration in the terms of trade. With an even larger import elasticity (cell 3), the end result is a 2 per cent fall in net welfare as a proportion of tradeables value added.

Moving to the second row, we expect an improvement throughout in the outcome from the domestic economy's point of view, as foreigners are now assumed to be more responsive to lower export prices. Such turns out to be the case. Even with the biggest import elasticity (cell 6), the depreciation of the exchange rate is small enough both to dilute to a lesser extent the domestic price change and thus cost rationalisation, and to diminish the unfavourable terms of trade impact, so that the domestic economy registers a small gain in net welfare. Note that cell 5 in this table is the same scenario as cell 5 in Table 1.

The bottom row, with the most elastic export demand, shows further improvements, especially for the more elastic import demand scenarios (cells 8 and 9). Overall, the sensitivity analysis does reveal the importance of terms of trade effects driven by differences in demand elasticities (and by differences in the height of the tariff barriers that are liberalised). Within the range of parameters explored in Table 2, net welfare changes from trade liberalisation range from a 2 per cent fall to a more than 10 per cent improvement. Even greater extremes could be achieved, of course, by combining 'pessimistic' demand elasticities with small price and cost response parameters, and 'optimistic' elasticities with large values of τ and η.

Conclusion

This paper set out to make sense of the big differences in free trade gains predicted by the large general equilibrium models that have been used to analyse the Canada/US bilateral free trade agreement. Our working hypothesis was that differences in assumptions about 'industrial organisation', the behaviour of firms and consumers in markets, would account for differences in outcomes in a quite simple model that approximately match the differences in outcomes from large general equilibrium models.

The results seem to be at least consistent with this hypothesis. Orthodox NGE assumptions of constant returns to scale and perfect competition in input markets (easy entry and exit) allow little direct impact of tariff changes; domestic prices and costs are unchanged, leaving room only for triangle efficiency gains as market prices of imports are brought into line with supply prices. In these models, it is consumers, not firms, who have the decisive say in the impact of trade liberalisation, through their responsiveness, at home and abroad, to the price changes and thus to the changes in the terms of trade needed to maintain macroeconomic balance on the trade account. For an economy like Canada which starts with higher tariffs on imports than are levied on its exports, the terms of trade effect of abolishing tariffs can easily result in welfare losses, as in the Brown–Stern simulations.

To counter such terms of trade effects, we require that tariffs have some direct microeconomic impact on prices and costs. Such is provided in the Harris–Cox model, in which domestic prices respond directly to changes in competing import prices, forcing firms to enter or exit industries to maintain (as in the neoclassical models) zero profits. Zero profits with changing prices require changing costs and these are achieved by the assumption of increasing returns to scale technologies. Thus, trade liberalisation leads to lower domestic prices, which forces 'rationalisation' (through exit) until average firm size is increased enough to bring costs down far enough to restore zero-profit equilibrium.

Macro terms of trade effects are also important in the Harris–Cox world. Lower domestic prices boost exports and discourage imports, requiring an appreciation of the exchange rate to maintain trade balance. This in turn further reduces the domestic market price of imports, forcing down competing domestic output and thus inducing a further reduction in production costs, and so on. The economy is pushed into a virtuous circle of self-reinforcing productivity improvements, with an ultimate impact on welfare that can be several times larger than the original cut in tariffs.

What is the non-specialist to make of all this? From the perspective of mainstream industrial organisation economics, both models are extreme. The neoclassical approach permits no oligopolistic interdependence, leading to the implausible prediction that a change in the price of an imported commodity has no direct impact on the price of the domestically produced substitute. Harris–Cox have domestic oligopolists able to respond to import price changes due to tariffs, but then grant them no power to defend any resulting rents from entry, resulting in inefficient high-price high-cost industrial structures.

More moderate assumptions about pricing and entry, as represented by the middle cell in the tables of the previous section, generate less extreme results. However, the matter cannot be settled by an appeal to the innate reasonableness of middle-of-the-road assumptions. These matters should be addressed directly. The contribution offered by this paper is to point to where the gaps in our knowledge are most important and thus suggest an appropriate research agenda. This could include the following:

(a) An obvious central issue is the pricing behaviour of domestic oligopolists, which must be linked to the threat of competition from new entrants. There is a vast theoretical and empirical IO literature on this topic, and general equilibrium modellers may be faulted for not showing more interest. However, it has been clear, at least since Eastman and Stykolt (1967), that open-economy IO has some special twists to it (for example, to the concept of the 'entry-limiting price' we must add the 'import-barring price' as a possible important focal point for oligopolists) and useful research remains to be done. Recent work in this area includes Hazledine (1980, 1985, 1988*a*), Karikari (1988) and Ross (1988). Caves (1985) gives a survey of what standard structure-performance IO research has to offer the open-economy modeller.

It seems likely that something akin to the MPH of Harris and Cox may turn out to be empirically plausible, on average. However, there are likely to be differences in the pricing behaviour of different types of industries, and these differences could be important to the result, as Wigle (1988) found.

(b) Better, econometrically based, pricing models will require better measures of protection itself. Another way of putting this is to ask: 'how big is the import-competing tradeable goods sector?' Except in a world of single-commodity industries, the answer to this question is not trivial. In the typical Canadian manufacturing industry a number of commodity classifications exist. In some of these, imports are dutiable, in others imports enter duty free, and in others there are no imports at all. It seems likely that the usual method of calculating 'the' tariff for an industry (dividing the value of duties collected by the f.o.b. value of dutiable imports) will overstate, in general, the impact of tariff protection. Though, in a sense, this is just a data problem stemming from too-highly aggregated industry classifications, it is a data problem we have to live with and therefore fashion some means of dealing with.

(c) Most general equilibrium practitioners worry about their demand elasticity estimates (for example, Whalley 1985, p. 27), which are usually borrowed, often from Australian studies, and which usually seem 'too small' to be plausible. We have seen the impact of low elasticities on terms of trade effects.

The IO perspective gives an insight into why the numbers may be underestimates. To the extent that domestic prices do follow import prices, econometric specifications of demand functions that only include one of the prices will be biased, and those that include both as though they were independent variables will suffer from multicollinearity. The solution is to estimate demand elasticities *jointly* with the pricing model, as demonstrated by Slade (1987).

(d) The potential for productivity improvements needs further scrutiny. Harris has focused on unexploited scale economies as the source of these, and there are other avenues whereby increased competitive pressure, such as from cheaper imports, may reduce costs, for example, through a general reduction in monopoly slack or X-inefficiency. Empirical work has lagged in using historical data to test these hypotheses about the response of costs to market conditions.

To conclude, the general equilibrium model builders themselves have often admitted the shakiness of their empirical foundations, but the matter is perhaps even more serious than they realise. Whalley has expressed a wish for 'empirical estimation rather than more hypothesis testing' (1985, p. 35), but the differences noted in this paper stem from fundamental disagreement about the true models or hypotheses, not just weak econometrics. Truly, 'more research is needed' and, in the meantime, economists should be scrupulous, as they perhaps have not been in Canada,[11] in educating policy makers about the limitations of their models.

APPENDIX

The system solves as follows: substituting equation (7) into equation (3) and rearranging:

$$p_d = \tau p_m / [1 - (1-\tau)\eta] \qquad \text{(A1)}$$

Substituting equation (A1), (7) and (6) into equation (5):

$$\begin{aligned} p_x' &= \{p_m \tau[\theta + (1-\theta)\eta]/[1-(1-\tau)\eta]\} + t_f - r \\ &= a p_m + t_f - r \\ &= a(t_d + r) + t_f - r \qquad \text{from equation (4)} \qquad \text{(A2)} \end{aligned}$$

with $a = \tau[\theta + (1-\theta)\eta]/[1-(1-\tau)\eta]$

Equation (1) becomes

$$\begin{aligned} m &= b p_m \text{ where } b = \{\tau\alpha/[1-(1-\tau)\eta]\} + \beta \qquad \text{(A3)} \\ &= b(t_d + r) \text{ from equation (4)} \end{aligned}$$

and equation (2) becomes

$$\begin{aligned} x &= \delta a p_m + \delta t_f - \delta r \qquad \text{(A4)} \\ &= \delta a(t_d + r) + \delta t_f - \delta r \qquad \text{from equation (4)} \end{aligned}$$

Substituting equations (A2), (A3) and (A4) into equation (8):

$$(1+\delta)[a(t_d + r) + t_f - r] - t_f = b(t_d + r) \qquad \text{(A5)}$$

Collecting terms and rearranging:

$$r = \{[b - (1+\delta)a]t_d - \delta t_f\}/[(1+\delta)(a-1) - b] \qquad \text{(A6)}$$

[11] See Hazledine (1988*b*) for a discussion of the role of general equilibrium models in the Canadian debate over free trade.

Substituting back for a and b:

$$\text{(A7)} \quad r = (t_d\{\tau\alpha + \beta[1-(1-\tau)\eta] - (1+\delta)\tau[\theta + (1-\theta)\eta]\}/ \{(1+\delta)(1-\eta)(\tau\theta - 1) - \tau\alpha - \beta[1-(1-\tau)\eta]\})$$
$$- (t_f\delta[1-(1-\tau)\eta]/\{(1+\delta)(1-\eta)(\tau\theta-1) - \tau\alpha - \beta[1-\tau(1-\eta)]\})$$
$$= (ft_d - gt_f)/h$$

where

$$\text{(A8)} \quad f = \alpha\tau + \beta[1-(1-\tau)\eta] - (1+\delta)\tau[\theta + (1-\theta)\eta]$$

$$\text{(A9)} \quad g = \delta[1-(1-\tau)\eta]$$

$$\text{(A10)} \quad h = (1+\delta)(1-\eta)(\tau\theta-1) - \tau\alpha - \beta[1-(1-\tau)\eta]$$

With a solution for r we can substitute back into equations (A3) and (A4) to get m and x; into equation (8) to get p'_x; into equation (4) to get p_m; into equation (1) to get p_d; into equation (7) to get c; and into equation (6) to get p_x.

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