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Volume Title: Trade Policies for International Competitiveness

Volume Author/Editor: Robert C. Feenstra, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-23949-7

Volume URL: <http://www.nber.org/books/feen89-1>

Conference Date: April 29-30, 1988

Publication Date: 1989

Chapter Title: U.S.-Canada Bilateral Tariff Elimination: The Role of Product Differentiation and Market Structure

Chapter Author: Drusilla K. Brown, Robert M. Stern

Chapter URL: <http://www.nber.org/chapters/c6181>

Chapter pages in book: (p. 217 - 254)

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## U.S.-Canada Bilateral Tariff Elimination: The Role of Product Differentiation and Market Structure

Drusilla K. Brown and Robert M. Stern

Recent empirical literature evaluating the trade and welfare effects of the proposed U.S.-Canada free trade area (FTA) has emphasized the significant gains associated with tariff removal on trade in differentiated products. In this connection, there are two welfare conclusions concerning U.S.-Canada bilateral tariff elimination that tend to dominate the public discussion of the trade initiative. The first conclusion emphasized by the proponents of a U.S.-Canada FTA relates to the mutual gains from capturing scale economies and increased product variety that access to each other's market will make possible. Moreover, the influx of tariff-free imports will improve the competitive environment for firms selling domestically, with the result that these firms must either exit or reduce cost. Free trade, then, is expected to rationalize the production process by increasing output per firm and lowering average total cost.

The predicted gains from liberalization draw heavily from the literature that compares autarky and free trade (e.g., Krugman 1979; and Markusen 1981). However, from a theoretical perspective, the question of whether there are gains from liberalization is distinct from the question of whether there are gains from trade. U.S. and Canadian firms already enjoy substantial access to each other's markets. Post-Tokyo Round bilateral tariffs on U.S.-Canada trade are quite low, averaging less than 2 percent. Furthermore, Canadian firms are subjected to the efficiency-stimulating experience of competing with U.S. firms in the U.S. market. Whether small tariff changes lead to rationalization depends on certain characteristics of the input markets, as

Drusilla K. Brown is assistant professor of economics at Tufts University Robert M. Stern is professor of economics at the University of Michigan and Brandeis University.

Financial assistance was provided in part by a grant from the Ford Foundation to support a program of research in trade policy at the University of Michigan. The authors would like to thank Chris Jackson for his assistance in assembling and editing data.

Flam and Helpman (1987) have shown, as well as the procompetitive effects emphasized in the gains-from-trade literature.

Second, the emphasis on trade in differentiated products in evaluating liberalization leads to the conclusion that increased trade will be primarily intraindustry. Interindustry resource reallocation necessary under an FTA is therefore presumed to be minimal. On the other hand, the policy debate has tended to downplay the terms-of-trade changes typically associated with tariffs, resource movements due to interindustry trade, or the second-best nature of bilateral tariff reductions.

Aside from the theoretical welfare issues, there are some basic modeling choices that arise in evaluating the bilateral tariff elimination using computable general equilibrium techniques. In particular, U.S.-Canada bilateral trade flows that are the subject of tariff removal must be identifiable.

There are four basic approaches to this problem. First, there is the textbook model that examines the case in which each good is homogeneous across firms and countries. The implication of this framework is that some bilateral trade flows will cease with bilateral tariff elimination. Typically, the smaller country in the FTA will trade within the FTA only.

In order to avoid this particular pattern of trade in which some bilateral trade flows disappear, it is common to adopt some form of product or market differentiation. One popular approach has been to assume that products are differentiated by place of production, embodied in the Armington (1969) assumptions.<sup>1</sup> Alternatively, there are two other modeling approaches that draw on the behavior of imperfectly competitive firms. The first is to assume that there is product differentiation at the firm level rather than at the national level. The second alternative is to assume that all firms supply a homogeneous product but that national markets are segmented, as in Venables (1985). Thus, firms make separate price and supply decisions for each national market based on the perceived elasticity of demand.

The purpose of this paper is to analyze some important issues that arise in the modeling of bilateral tariff removal and to assess these issues computationally in the context of the U.S.-Canada FTA. Our paper is structured as follows. The differentiated products models are discussed in the following section, and the theoretical relation between tariff liberalization and firm output is developed. We also comment on the demand structure adopted in some previous modeling efforts. In particular we will discuss the practice of assuming both firm and national product differentiation and the implications for the debate concerning intra- versus interindustry trade, rationalization of the production process, and the gains from trade.

In section 7.2, we present a market segmentation model and discuss the likely welfare implications of bilateral tariff removal. The issues raised are then illustrated using a computational model designed to analyze U.S.-Canada bilateral tariff removal. The model is discussed in section 7.3, and computational results are presented in section 7.4. Conclusions follow.

## 7.1 The Differentiated Products Models

The earliest versions of the differentiated products models involved differentiating by country of origin using the Armington assumptions. “Love of variety” in the utility function guarantees that all bilateral trade flows will continue following the formation of the preferential trading club as long as industries are not eliminated in any country. Models of this type tend to assume that production is characterized by constant returns to scale and that firms are perfectly competitive.

There is an important difficulty, however, with the national product differentiation (NPD) model insofar as it means that each country will have a monopoly in the supply of its own characteristic variety.<sup>2</sup> Consequently, optimal tariffs tend to be large, even for small countries. Terms-of-trade changes, rather than efficiency gains, therefore dominate the welfare predictions of NPD models.

National product differentiation is the approach adopted by Brown and Stern (1987), who find that Canada’s welfare declines by 0.3 percent as the result of bilateral tariff removal. This result appears to emerge because removal of the relatively high tariffs currently in place in Canada leads to deterioration in the terms of trade. On the other hand, Hamilton and Whalley (1985) consider nontariff barrier (NTB) removal as well as bilateral tariff removal and find that Canada enjoys a 0.7 percent increase of GDP from the formation of an FTA, presumably because of the relatively high NTBs in the United States.

An alternative is to differentiate products at the firm level, using the Dixit-Stiglitz-Spence form of the utility function. Love of variety will again guarantee the existence of all bilateral trade flows since no two firms in the world sell the same variety. In this model, firms are typically assumed to have downward-sloping average total cost curves and to be monopolistically competitive.

Harris (1984) developed the imperfectly competitive approach, computationally, incorporating a variety of different assumptions concerning a firm’s price-setting behavior. The Harris approach yielded startling results. Multilateral pre-Tokyo Round tariff removal was shown to increase Canada’s welfare by up to 9 percent of GDP, depending on the precise assumptions concerning firm behavior. Increasing firm output, thereby reducing average total cost, is a key source of welfare gain in the imperfectly competitive computational trade models. Subsequent revisions of tariff data and parameters of the model, however, place the welfare gain for Canada in the Harris model closer to 2.5 percent of GDP.<sup>3</sup>

In this section, we will first describe a typical monopolistically competitive (MC) trade model and evaluate the effects of tariff liberalization on firm output. The NPD model and the MC model are then compared in terms of the implications of a tariff for the terms of trade and intra- versus interindustry trade.

Assume a model consisting of  $n$  traded goods that are produced by  $m$  countries. Good  $j$  produced by each firm in each of the  $m$  countries is aggregated using a linearly homogeneous aggregation function to form a composite good  $j$ . Following Spence (1976) and Dixit and Stiglitz (1977), modelers have typically chosen the constant elasticity of substitution (CES) function to aggregate different varieties into a single aggregate. The conditional demand in country  $i$  for the product of a representative firm in country  $r$  that produces good  $j$  for a CES aggregation function is

$$(1) \quad D_{ij}^r = \frac{E_{ij}(P_{ij}^r)^{-\sigma}}{\sum_{s=1}^m n_{sj}(P_{ij}^s)^{1-\sigma}}$$

where  $P_{ij}^r$  is the price paid in country  $i$  for good  $j$  produced by a representative firm in country  $r$ ,  $E_{ij}$  is expenditure in country  $i$  on the aggregate good  $j$ ,  $n_{sj}$  is the number of firms in industry  $j$  in country  $s$ , and  $\sigma > 1$  is the elasticity of substitution among the different varieties.

Firms set price as a markup over marginal cost according to

$$(2) \quad P_{rj}^* = MC_{rj}(1 + 1/\eta_{rj})^{-1},$$

where  $P_{rj}^*$  is the price received by a representative producer of  $j$  in country  $r$ ,  $\eta_{rj} < -1$  is the firm's perceived elasticity of demand, and  $MC_{rj}$  is marginal cost. The firm's perceived elasticity of demand is a sales-weighted average of the elasticities of demand in each national market. The elasticity of demand in country  $i$  for the product of a representative firm in country  $r$  is obtained from equation (1) above to be

$$(3) \quad \eta_{rj}^i = -\sigma + (\sigma - 1) \frac{P_{ij}^r D_{ij}^r}{E_{ij}},$$

or

$$(3') \quad \eta_{rj}^i = -\sigma + (\sigma - 1) \frac{\theta_{ij}^r}{n_{rj}},$$

where  $\theta_{ij}^r$  is country  $r$ 's share of the market in country  $i$  for good  $j$ .

The firm's production function requires a fixed input of capital plus variable capital and labor inputs that are characterized by constant returns to scale. Thus, the average total cost (ATC) curve is downward sloping, and marginal cost is constant. Entry occurs until profits are eliminated, requiring the firm's price to equal ATC:

$$(4) \quad P_{rj}^* = P_r^K \left( \frac{K^F}{q_{rj}} + a_j^K \right) + w_r a_j^L,$$

where  $P_r^K$  is the price of capital in country  $r$ ,  $w_r$  is the return to labor,  $a_j^K$  is the variable capital unit input requirement in industry  $j$ ,  $a_j^L$  is the unit labor

requirement,  $K^F$  is the fixed capital requirement, and  $q_{rj}$  is output of a typical firm in industry  $j$  in country  $r$ .

Capital and labor are assumed to be mobile between sectors. The return to each factor is determined to equate demand to a fixed supply.

Finally, tariff policy serves to link the price received by the seller to the price paid by the buyer. Thus,

$$(5) \quad P_{ij}^r = P_{ij}^*(1 + t_{ij}^r),$$

where  $t_{ij}^r$  is the ad valorem tariff that country  $i$  imposes on imports of good  $j$  from country  $r$ .

### 7.1.1 Rationalization

We now examine the conditions under which tariff liberalization will lead to rationalization of production in this model. That is, will a tariff reduction increase output per firm and lower ATC? There are several considerations that determine the effect of liberalization on rationalization, such as differing factor intensities across industries and the effect of liberalization of the elasticity of demand.

Turning first to the production side, suppose that there are two industries and that industry 1's fixed capital input requirement is zero. Throughout this exercise, we will hold the shape of the demand curve fixed so as to focus on technological determinants of firm output.

Equilibrium in the labor market requires that

$$(6) \quad L = a_1^L Q_1 + a_2^L n_2 q_2,$$

where  $L$  is the endowment of labor,  $Q_1$  is the output of industry 1, and  $n_2 q_2$  is output of industry 2. Proportionate differentiation yields

$$(6') \quad \lambda_{L1} \hat{Q}_1 + \lambda_{L2} (\hat{q}_2 + \hat{n}_2) = \delta_L (\hat{w} - \hat{p}^K),$$

where  $\delta_L = \lambda_{L1} \theta_{K1} \sigma_1 + \lambda_{L2} \theta_{K2}^V \sigma_2$ ,  $\lambda_{fj}$  is industry  $j$ 's share of the employment of factor  $f$ ,  $\theta_{fj}$  is factor  $f$ 's share of total cost in industry  $j$ ,  $\theta_{fj}^V$  is variable factor  $f$ 's share of variable cost in industry  $j$ , and  $\sigma_j$  is the elasticity of substitution between capital and labor in industry  $j$ .

Similarly, capital market equilibrium requires

$$(7) \quad K = a_1^K Q_1 + a_2^K n_2 q_2 + n_2 K^F,$$

which, when proportionately differentiated, yields

$$(7') \quad \lambda_{K1} \hat{Q}_1 + \lambda_{K2}^V (\hat{q}_2 + \hat{n}_2) + \lambda_{K2}^F \hat{n}_2 = -\delta_K (\hat{w} - \hat{p}^K),$$

where  $\delta_K = \lambda_{K1} \theta_{L1} \sigma_1 + \lambda_{K2}^V \theta_{L2}^V \sigma_2$ ,  $\lambda_{K2}^V$  is variable capital in industry 2's share of capital employment,  $\lambda_{K2}^F$  is fixed capital in industry 2's share of capital employment, and  $\lambda_{K2}^V + \lambda_{K2}^F = \lambda_{K2}$  is industry 2's share of capital employment.

A tariff reduction will lower demand for the domestically produced good, yielding negative profits for domestic firms. The question is whether output per firm in industry 2 will rise or fall as firms exit. Suppose first that  $q_2$  is held constant as  $n_2$  falls so that firms neither rationalize nor derationalize. The markup pricing rule used by firms requires that the percentage change in price be equal to the percentage change in marginal cost if the elasticity of demand is held constant. Therefore,

$$(8) \quad \hat{P}_2 = \theta_{L2}^V \hat{w} + \theta_{K2}^V \hat{P}^K.$$

On the other hand, the zero-profit condition requires that the percentage change in price be equal to the percent change in ATC. Therefore,

$$(9) \quad \hat{P}_2 = \theta_{L2} \hat{w} + \theta_{K2} \hat{P}^K - \theta_{K2}^F \hat{q}_2.$$

Now, as industry 2 contracts and industry 1 expands, relative factor prices must also be adjusting. As a result, equations (8) and (9) cannot be satisfied simultaneously if output per firm is held constant. This conclusion follows from the assumption that capital is the only fixed factor, which implies that labor's share of variable cost must be greater than labor's share of total cost and that capital's share of variable cost must be smaller than capital's share of total cost.

The necessary change in firm output will depend on the relative factor intensity ranking of the two industries. It can be demonstrated using equations (6') and (7') that, if industry 2 is the capital-intensive industry ranked according to its variable inputs, then  $\hat{w} - \hat{P}^K > 0$  as resources are transferred from industry 2 to industry 1. On the other hand, if industry 2 is the labor-intensive industry, then  $\hat{w} - \hat{P}^K < 0$ . That is,

$$\hat{w} \geq \hat{P}^K \text{ as } \lambda_{L1} \lambda_{K2}^V \geq \lambda_{K1} \lambda_{L2}.$$

For the case in which industry 2 is relatively labor intensive, so that  $\hat{w} - \hat{P}^K < 0$ , marginal cost has fallen relative to ATC, requiring output per firm to rise. However, if industry 2 is relatively capital intensive, then marginal cost has risen relative to ATC, requiring output per firm to fall.

As a general rule, if an industry's intensively used factor has a greater share in variable cost than in total cost, then a policy that lowers price will also lead to rationalization. On the other hand, if an industry's intensive factor has a smaller share in variable cost than in total cost, then derationalization will occur.<sup>4</sup> It should also be noted that, if technological considerations are leading to rationalization of the domestic industry, derationalization will be occurring in the foreign industry.

There are, of course, several demand side considerations that will also help determine firm output. An increase in the absolute value of the firm's perceived elasticity of demand will lower the markup over marginal cost, and

firm output will therefore rise. To the extent that liberalization increases the number of firms in the industry worldwide, reducing individual firm market share, the second term on the right-hand side of equation (3) will become smaller, and the absolute value of the elasticity will therefore rise.

On the other hand, as noted by Horstmann and Markusen (1986), ad valorem tariff reductions tend to steepen the demand curve facing the foreign firm, lowering the elasticity of demand and lowering output per firm. This point can be seen by differentiating equation (3) with respect to  $t'_{ij}$ , using equation (5).

### 7.1.2 Tariff Liberalization and the Terms of Trade

It is reasonable to presume that a tariff reduction on imports of the monopolistically competitive good 2 will tend to lower the price received by domestic producers,  $P_2^d$ , relative to the price paid for imports,  $P_2^m$ , thus worsening the terms of trade for the liberalizing country. The terms of trade for the competitive good will also deteriorate. The tariff reduction will shift production in the home country toward good 1 and away from good 2. Thus,  $P_1/P_2^d$  will rise. If the home country is a net exporter of good 2 and an importer of good 1, then the increase in  $P_1/P_2^d$  constitutes a fall in the price of exports. The tariff reduction will also shift production in the foreign country toward good 2 and away from good 1. Thus,  $P_1/P_2^m$  will fall. If the home country is a net importer of good 2 and an exporter of good 1, then the fall in  $P_1/P_2^m$  also constitutes a deterioration in the home country's terms of trade.

The welfare implications of the relative price changes for the home country should nonetheless be smaller than in the more conventional Armington model, in which goods are differentiated at the national level and individual firms are price takers. This will be the case for two reasons.

First, the powerful terms-of-trade gain from a tariff in the NPD model stems from the fact that firms, as price takers, do not internalize the market power attendant on national product differentiation. Thus, a tariff that reduces national supply to the world market exploits monopoly power ignored by the firms. However, if product differentiation exists at the firm level rather than at the national level, there is little market power associated with product differentiation that can be perceived by the government that is not already exercised by the firm.

Second, the number of differentiated products in an NPD model equals the number of countries. On the other hand, the number of products in an MC model is significantly larger and equal to the sum over the number of firms in each country. By increasing the number of products, the market power of the seller of an individual product is reduced, leaving less room to increase welfare by reducing supply.

The terms-of-trade loss of the home country may be further mitigated if rationalization occurs in the foreign country. An increase in output per firm is



associated with a reduction in the markup over marginal cost, offsetting some of the original increase in price by foreign firms.

### 7.1.3 Increasing Returns to Scale and National Product Differentiation

Implementation of the differentiated products model computationally does not require national product differentiation. Nonetheless, the tendency has been to preserve both national and firm product differentiation. In this context, a third level is added to the utility function. Expenditure on imports is allocated among competing sources following the decision concerning allocation between an import aggregate and a domestic aggregate. For example, Wigle (1988) adopts this approach and finds that bilateral tariff removal would reduce welfare in Canada by 0.1 percent of GDP.

National product differentiation is not necessary to explain cross-hauling in models with firm product differentiation. It may nonetheless seem plausible to retain a preference for the domestically produced good in the utility function. However, if perfect aggregation is used to form separate domestic and import aggregates, then domestic firms are insulated from changes in the composition of the import aggregate with the consequence of introducing a new equilibrating mechanism that has questionable economic content.

Adding a third stage to the budgeting process will have three implications for the computational results. First, the model will be predisposed toward the conclusion that free trade will stimulate intraindustry trade, thus minimizing the necessary intersectoral adjustment. To see this point, consider the extreme case in which consumers distinguish between the import and the domestic variety of good  $j$ ,  $D_j$ , but all firms within a country produce perfect substitutes. That is,

$$(10) \quad D_j = [(D_j^d)^\rho + (D_j^m)^\rho]^{1/\rho},$$

where the domestic variety,  $D_j^d$ , and the imported variety,  $D_j^m$ , are given by

$$(11) \quad D_j^d = \sum_{i=1}^{n_{dj}} X_{ij}^d$$

and

$$D_j^m = \sum_{i=1}^{n_{mj}} X_{ij}^m,$$

where  $n_{dj}$  is the number of domestic firms,  $n_{mj}$  is the number of foreign firms in industry  $j$ , and  $X_i$  denotes the output of the  $i$ th firm. This is the case analyzed by Horstmann and Markusen (1986).<sup>5</sup> A key assumption in this framework is that the number of firms in the domestic industry does not affect demand facing an individual foreign firm, nor does the number of firms in the foreign industry affect the demand facing an individual domestic firm.

A tariff on imports will stimulate demand for the domestic variety and reduce demand for the foreign variety, leaving domestic firms with positive profits and foreign firms with negative profits. To restore the zero-profit condition, entry occurs domestically while foreign firms exit. Since domestic firm demand does not depend on the number of foreign firms, entry in the domestic industry reduces individual firm demand until profits are once again zero. The opposite occurs for foreign firms. The essential equilibrating mechanism here is that local entry dissipates positive profits by dividing the market among a larger number of firms, thereby reducing firm output and raising average fixed cost. Indeed, Horstmann and Markusen conclude that the tariff change has no effect on domestic firm output.<sup>6</sup>

In comparison, consider the model outlined above, in which consumers distinguish between the output of different firms but not between imports and the domestic good. In this case, the level of firm demand depends not on whether there is local entry or exit but rather on whether there is global entry or exit. If the increase in the number of domestic firms is smaller than the fall in the number of foreign firms, then all firms in the industry, both domestic and foreign, will experience an increase in demand. As a result, positive profits for domestic firms will increase even further.

Entry in the domestic industry restores the zero-profit condition by raising the return to the factor used intensively in the expanding sector, which raises total cost. The effect of local entry on firm demand, which occurs in the Horstmann-Markusen model, is absent here. Thus, restoring the zero-profit condition depends entirely on intersectoral factor movements.

The second implication of adding a third stage to the budgeting process is that reducing the change in factor prices necessary to restore equilibrium will also weaken the forces leading to rationalization or derationalization associated with differing factor intensities. The third implication is that reintroducing national product differentiation increases national market power that is not perceived by firms, thus raising the optimal tariff.

#### 7.1.4 Summary

There are a few lessons that we can draw in comparing the likely welfare and trade conclusions of each approach for a U.S.-Canada bilateral tariff elimination that will be relevant for the computational results presented below. Welfare conclusions from a model assuming perfect competition and national product differentiation will be dominated by changes in the terms of trade. The average level of tariffs currently in place in Canada is somewhat higher than in the United States. This implies that tariff elimination will tend to worsen Canada's terms of trade, resulting in a welfare loss. In addition, the intersectoral trade pattern will not be particularly affected by tariff liberalization. Rather, increased trade will be primarily intraindustry.

In contrast, if industries are monopolistically competitive, then product differentiation is removed to the firm, and firms incorporate market power

associated with product differentiation into their pricing decisions. Therefore, welfare-reducing changes in the terms of trade as the result of liberalization will be confined primarily to large countries and are not likely to play a dominant role in the welfare conclusions of bilateral tariff removal. Consequently, welfare gains for Canada are more likely than in the NPD model. Further, more distinctive changes in the intersectoral pattern of specialization will emerge in view of the fact that each variety of a good is not nationally specific. Production can be relocated in the country where the cost of production is lowest.

Rationalization of the production process will depend on the general equilibrium effects of tariff liberalization on the return to capital, which in turn depends on the relative factor-intensity ranking of industries. If the protected sector is labor intensive and liberalization therefore causes the return to capital to rise, output per firm will tend to rise. However, if the protected sector is capital intensive, then the return to capital is likely to fall. Consequently, firm output may fall as well.

## 7.2 A Market Segmentation Model

Another alternative to modeling bilateral tariff elimination is to assume that all firms sell a homogeneous product but that national markets are segmented. Thus, all firms selling to a single national market must charge the same price, but price may vary across countries. This approach has not been used previously in the context of U.S.-Canada bilateral tariff removal but has been applied to the European Community by Smith and Venables (1988). Here we extend the model of Venables (1985) to three countries.

The market demand in country  $j$  is

$$(12) \quad D_j = S_j(D - p_j), \quad j = 1, 2, 3,$$

where  $p_j$  is the price paid by consumers in country  $j$  and  $S_j$  is a parameter indicating the size of market  $j$ . Firms are assumed to behave as Cournot followers, so that the perceived demand is the market demand net of supply by other firms. Therefore, a typical firm in country  $i$  perceives the demand for its exports to country  $j$  to be

$$(13) \quad x_i^j = S_j(D - p_j) - Q_j, \quad j \neq i$$

where  $Q_j$  is supply by other firms, and demand in the local market to be

$$(14) \quad y_i = S_i(D - p_i) - Q_i.$$

As above, each firm in country  $i$  faces a fixed cost,  $f_i$ , and constant marginal cost,  $c_i$ , yielding profits of

$$(15) \quad \pi_i = \sum_{j \neq i} (p_j - c_i - t_j)x_i^j + (p_i - c_i)y_i - f_i,$$

where  $t_j$  is the tariff imposed by country  $j$  on imports. The first-order conditions for profit maximization are

$$(16) \quad x_i^j = S_j(p_j - c_i - t_j) \quad i \neq j$$

and

$$(17) \quad y_i = S_i(p_i - c_i).$$

Free entry guarantees that profits will be zero, which, when making use of the first-order conditions for profit maximization, equations (16) and (17), implies that

$$(18) \quad \sum_{j \neq i} (p_j - c_i - t_j)^2 S_j + (p_i - c_i)^2 S_i - f_i = 0.$$

Consider now the effect of a tariff change by country 2 on imports from country 1. Totally differentiating equation (18) for each  $i$  yields

$$(19) \quad \begin{bmatrix} y_1 & x_1^2 & x_1^3 \\ x_2^1 & y_2 & x_2^3 \\ x_3^1 & x_3^2 & y_3 \end{bmatrix} \begin{bmatrix} dp_1 \\ dp_2 \\ dp_3 \end{bmatrix} = \begin{bmatrix} x_1^2 dt_2 \\ 0 \\ 0 \end{bmatrix}.$$

Solving for the equilibrium price changes yields

$$(20) \quad \begin{bmatrix} dp_1 \\ dp_2 \\ dp_3 \end{bmatrix} = \frac{-x_1^2 dt_2}{A} \begin{bmatrix} -y_2 y_3 + x_3^2 x_2^3 \\ y_3 x_2^1 - x_3^1 x_2^3 \\ y_2 x_3^1 - x_2^1 x_3^2 \end{bmatrix},$$

where  $A = y_1(y_2 y_3 - x_3^2 x_2^3) - x_1^2(y_3 x_2^1 - x_3^1 x_2^3) - x_1^3(y_2 x_3^1 - x_2^1 x_3^2)$ .

If  $A$  is positive<sup>7</sup> and  $c_i < c_j + t_i$ , then it can be shown that  $dp_1/dt_2 > 0$ . The restriction on marginal cost implies that a typical domestic firm sells more to the domestic market than a typical foreign firm. In this case, the tariff imposed by country 2 raises the price paid by consumers in country 1, thus lowering welfare in country 1. If, in addition,  $y_3 x_2^1 > x_3^1 x_2^3$ , then it follows that  $dp_2/dt_2 < 0$ . The tariff lowers the price to consumers in country 2, raising welfare in country 2.<sup>8</sup>

The effect of a tariff imposed by country 2 in this model is to lower the price net of tariff that country 1 firms receive for their exports to country 2. In order to restore the zero-profit condition, country 1 firms must increase price in other markets, such as the domestic. However, the higher price in country 1's market raises profitability for country 2 firms, leading to a reduction in price on sales to domestic consumers. The price increase to country 1 consumers lowers welfare in country 1, and the price reduction in country 2 raises consumer welfare in country 2.

This outcome, of course, is not inevitable. Negative profits for country 1 firms are eliminated by raising the price in countries in which country 1 firms have a relatively large market share. The change in relative price, then, will depend closely on the pattern of trade and preexisting market share.

In the U.S.-Canada case, the volume of trade between the United States and Canada is large, while trade between Canada and the rest of the world is comparatively small. A tariff reduction by Canada will raise the profitability of U.S. firms. A price reduction in the United States that lowers profits of U.S. firms and a price increase in Canada and the rest of the world that offsets the price reduction in the U.S. market are likely.

### 7.3 The Computational Model

Sections 7.1 and 7.2 leave us with a set of propositions concerning the implications of modeling choices that we would like to illustrate computationally. There are three variants of the model. The perfect competition (PC) version is characterized by national product differentiation, perfect competition, and constant returns to scale. The monopolistic competition (MC) version differs in that product differentiation exists only at the firm level, there are increasing returns to scale, and firms set price as a markup over marginal cost. In the market segmentation (MS) version, there are economies of scale as well, but each product is homogeneous across firms and countries. Firms behave as Cournot followers and perceive national markets as segmented.<sup>9</sup>

Canada, the United States, and a group of thirty-two other countries are modeled explicitly, and the rest of the world constitutes an abbreviated fourth region. Our sectoral coverage includes twenty-two tradable product categories based on three-digit ISIC industries and seven nontradable categories based on one-digit ISIC industries.<sup>10</sup>

In all three models, consumers initially allocate final demand and producers allocate intermediate demand across sectors without regard to the location of production. Bilateral trade flows are identified in the PC model by assuming that consumers and producers aggregate the variety produced by each country using a CES aggregation function. Thus, the demand in country  $i$  for the output of country  $r$ 's production of good  $j$ , conditional on expenditure on the aggregate good  $j$ ,  $E_{ij}$ , is

$$(21) \quad D_{ij}^r = \frac{E_{ij}(P_{ij}^r)^{-\sigma}}{\sum_{s=1}^m (P_{ij}^s)^{1-\sigma}},$$

where  $P_{ij}^r$  is the price consumers in  $i$  pay for good  $j$  produced in country  $r$ . This price differs from the price received by the seller in country  $r$  by any tariffs imposed by country  $i$ .

Bilateral trade flows in the MC model are similarly identified, though product differentiation exists at the firm level only. Monopolistically competitive firms set price as a markup over marginal cost according to equation (2), and the firm's perceived elasticity of demand is given by equation (3).

In the MS model, consumers do not distinguish between the output of various firms or countries. Rather, firms perceive national markets as segmented. The firm set price and supply in each market to maximize firm profits. That is,

$$\max_{\{P_{ij}^1, \dots, P_{ij}^m\}} \sum_{i=1}^m D_{ij}^r (P_{ij}^i - MC_{rj}) - FC_{rj},$$

where MC and FC are marginal and fixed costs and  $P_{ij}^i$  is the price a typical firm in country  $r$  receives for sales in country  $i$ . This price differs from the price paid by consumers in country  $i$  by any tariffs imposed. Firms behave as Cournot followers. Therefore, the firm's perceived demand,  $D_{ij}^r$ , is the market demand in country  $i$  for good  $j$ ,  $D_{ij}$ , less output by other firms,  $Q$ . The underlying utility function determining industry demand is Cobb-Douglas. Under this assumption, it can be shown that the supply to country  $i$  by a representative firm in country  $r$  is

$$(22) \quad S_{rj}^i = D_{ij} \frac{(P_{rj}^i - MC_{rj})}{P_{rj}^i}.$$

The production function in all three models requires intermediate and primary inputs. Intermediate inputs and a primary input aggregate are employed in fixed proportion to output. The primary input aggregate is a CES function of capital and labor employed. Capital and labor demand are determined by minimizing the cost of attaining the level of the primary input aggregate required by the upper level of the production function. In addition to variable capital and labor inputs, a fixed input of capital is necessary in the MC and MS models.

Capital and labor are mobile between sectors but not countries. The return to capital is determined to equate demand to a fixed supply of capital. The return to labor is held constant. National income is adjusted to maintain total employment at the base level.

Freedom of entry is assumed, and, therefore, firm profits are zero. This implies that PC firms must set price equal to marginal cost. MC firms must set price equal to ATC, and MS firms must set average price equal to ATC.

Equilibrium prices are determined in global markets to equate supply and demand. In the PC model, one price is determined for each national variety of each good. In the MC model, one price is determined for each firm. However, firms within each country face identical costs and technology, and demand is symmetric. Therefore, all firms within an industry and country charge the same price. In the MS model, one price is determined for each national market. Thus, all firms selling in a single market must charge the same price.

The base year for data on production, employment, and trade for the United States, Canada, and other countries and the rest of the world is 1976.

Input-output coefficients for the production function were derived from the U.S. input-output table for 1972 and the Canadian table for 1976.

The key parameters in the base period for the MC model are obtained in the following manner.<sup>11</sup> The firm's perceived demand in the base period is calculated according to equation (3), assuming that the elasticity of substitution among varieties of each good is 15.0.

Once the elasticity of demand is determined, it is straightforward to calculate the variable input share of total cost. The variable cost share is equal to the ratio of marginal cost and average total cost,  $\theta^{VC} = MC/ATC$ . Since profits are zero, average total cost is equal to price. The ratio of marginal cost and price is determined by the markup pricing rule in equation (2). Therefore,  $\theta^{VC} = 1 + 1/\eta$ .

The share of total capital that is variable is implied by the variable cost share, capital's primary input cost share,  $\theta^K$ , and the primary input share of total cost,  $b_0$ . Capital is assumed to be the only fixed factor. Therefore, the share of capital that is fixed is equal to the ratio of fixed cost's share of total cost to capital's share of total cost. That is,

$$(23) \quad \frac{1 - \theta^{VC}}{\theta^K b_0} = \frac{P^K K^F / TC}{P^K (K^F + K^V) / TC} = \frac{K^F}{K^F + K^V}.$$

The distribution of primary input cost between capital and labor is available from industry data, and primary input share of total cost is obtainable from input-output data.

The relation between fixed capital's share of total capital and the elasticity of substitution in the aggregation function places restrictions on the size of the elasticity of substitution. A small value for  $\sigma$  can imply a fixed capital share that does not lie between zero and one. Setting  $\sigma = 15$  was the smallest value for this parameter consistent with the restrictions on the fixed capital share.

Structural equations of the MS model also imply base period values for the parameters. The markup over marginal cost,  $(P - MC)/MC$ , for each of the three national markets is derived from equation (22) to be

$$(24) \quad M_r^i = \frac{\theta_r^i / n_r}{1 - \theta_r^i / n_r},$$

where  $M_r^i$  is the markup over marginal cost by producers in country  $r$  on their sales to country  $i$  and  $\theta_r^i$  is country  $r$ 's share of the market in country  $i$ .

This procedure tended to lead to very small markups for many industries, which caused instability in the computational model. Therefore, the markups are bounded from below by 5 percent. Utility functions other than Cobb-Douglas may produce larger markups. However, it may also be the case that this model is unsuitable for modeling sectors that are not highly concentrated.

The variable cost share for the MS model can be obtained in a manner similar to the method employed with the MC model. Variable cost share is

equal to the ratio of marginal cost to average cost. The zero-profit condition implies that the average price received by the firm for its sales in each market must equal ATC. Therefore,

$$(25) \quad \theta_r^{\text{VC}} = \frac{\text{MC}_r}{\sum_i \delta_r^i p_r^i},$$

where  $\delta_r^i$  is the share of country  $r$ 's output that is sold to country  $i$ . Equation (22) can be used to find that

$$(26) \quad \theta_r^{\text{VC}} = \left[ \sum_i \frac{\delta_r^i}{1 - \theta_i/n_r} \right]^{-1}.$$

#### 7.4 Computational Results of U.S.-Canada Bilateral Tariff Elimination

The models described in section 7.3 have been used to analyze computationally the effects of bilateral tariff removal by the United States and Canada. Our purpose here is to illustrate the implications of various modeling choices for the trade and welfare conclusions of U.S.-Canada bilateral tariff removal. The model was run three times, employing each of the three different market structures in all industries: perfect competition, monopolistic competition, and market segmentation. It is of course more plausible to assume that market structure will vary across industries. Results reflecting our best judgment concerning the proper market structure for each industry can be found in Brown and Stern (1989).

Tariffs removed are those prevailing in both countries subsequent to full implementation of the Tokyo Round tariff reductions, which was completed in 1987. The last column of each of tables 7.2 and 7.3 below list the bilateral trade weighted ad valorem tariff equivalents on U.S.-Canada trade. Notice that U.S. tariffs on Canadian exports are somewhat lower than Canadian tariffs on the United States. Nevertheless, U.S. tariffs on Canadian exports on some products such as clothing and footwear remain quite high.

The results for imports, exports, the exchange rate, terms of trade, and welfare are summarized in table 7.1. Panel A of table 7.1 reports the change in trade and welfare under perfect competition. U.S. and Canadian trade increases by close to \$7 billion, while rest-of-world trade falls by nearly \$2 billion. The welfare and terms-of-trade changes are similar to those obtained elsewhere using such a model,<sup>12</sup> and the role of national product differentiation is clearly evident. The comparatively deep tariff reductions by Canada worsen its terms of trade by 0.7 percent, leading to a trivial decline in welfare. U.S. terms of trade, on the other hand, improve by 0.3 percent, raising U.S. welfare by \$781 million on the basis of 1976 trade. Rest-of-world welfare declines as well.



**Table 7.1** Summary Results of a U.S.-Canada Free Trade Area: Changes in Country Imports, Exports, Exchange Rates, Terms of Trade, and Welfare (trade and welfare in millions of U.S. dollars)

Country	Imports <sup>a</sup>	Exports <sup>a</sup>	Exchange Rate <sup>b</sup>	Terms-of-Trade Percentage Change	Equivalent Variation
A. Perfect Competition: National Product Differentiation:					
United States	6,981.3	6,643.4	.0	.3	780.9
Other	-1,758.1	-1,611.2	.2	-.1	-145.4
Canada	6,254.8	6,546.8	.6	-.7	-28.5
B. Monopolistic Competition: Firm Product Differentiation:					
United States	9,194.2	9,051.7	.0	.1	476.1
Other	-1,882.1	-1,762.7	.1	-.1	-116.1
Canada	9,366.3	9,557.0	-1.0	-.5	2,304.0
C. Market Segmentation Model: Homogeneous Products:					
United States	12,947.9	12,624.5	-.0	.2	-1,175.3
Other	-1,547.3	-1,620.2	-.0	-.1	-240.0
Canada	10,668.0	10,754.2	.0	-.3	-1,389.1
D. Sensitivity Analysis: Perfect Competition: <sup>c</sup>					
United States	14,689.2	14,372.4	-.0	.2	657.1
Other	-2,991.2	-2,871.0	.2	-.1	-267.8
Canada	13,190.4	13,462.4	.6	-.7	-163.9
E. Sensitivity Analysis: Monopolistic Competition: <sup>c</sup>					
United States	19,107.9	19,024.4	.0	.1	-1,002.8
Other	-3,181.4	-3,101.0	.0	-.0	-55.9
Canada	18,875.5	18,890.3	-1.4	-.3	2,797.2

<sup>a</sup>Dollar value of change in trade volume.

<sup>b</sup>(+) indicates depreciation of currency.

<sup>c</sup>Elasticity of substitution between varieties increased above base run.

The outcome is somewhat different if industry structure is taken to be monopolistically competitive. These results are presented in panel B of table 7.1. U.S. and Canadian trade increases by about \$9 billion. The U.S. terms-of-trade gain is now only one-third as large (0.1 percent), and Canada's terms-of-trade loss is about 30 percent smaller (-0.5 percent). This result was expected. The move from products differentiated at the national level to products differentiated at the firm level significantly increases the number of products, thereby increasing the elasticity of demand for each individual variety. In addition, rationalization occurs in the United States as a result of liberalization, forcing U.S. firms to reduce the markup over marginal cost.

The U.S. welfare gain is accordingly reduced to \$476 million, but Canada's welfare gain rises to \$2.3 billion, which is 1.2 percent of Canadian GDP in 1976. There are several possible explanations for the welfare improvement for Canada. First, a smaller deterioration in Canada's terms of trade will reduce the welfare loss. Second, as discussed above, internalizing market power by differentiating products at the firm level, rather than at the national level, lowers Canada's optimal tariff. Thus, despite the deterioration in the terms of

trade, Canadian welfare still rises owing to efficiency gains. Third, Canada may be gaining from rationalizing production.

In order to illustrate the sensitivity of the model to the choice of the elasticity of substitution, the PC and MC versions of the model were rerun after increasing the elasticity of substitution. Values for this parameter ranged from seventeen to forty-five across industries, compared to fifteen in the base run. These results are summarized in panels D and E of table 7.1.

In the case of perfect competition, the most notable effect of increasing the elasticity of substitution is to increase the change in the volume of trade. The effects on the terms of trade and welfare are trivial. This is not the case, however, if firms are monopolistically competitive. The terms-of-trade changes are further weakened as the elasticity of substitution increases. In particular, Canada's terms of trade deteriorate by only 0.3 percent, as compared to 0.5 percent in the base run and 0.7 percent under national product differentiation. Canada's welfare gain rises to 1.4 percent of GDP.

Panel C of table 7.1 summarizes the effects of liberalization in the MS model. The trade effect is significantly larger than for the other two market structures, with U.S. and Canadian trade increasing by about \$11–\$13 billion. The terms-of-trade effects are similar to those obtained in the MC model, but welfare for all three country groups declines. It should be noted at the outset that the MS model is a poor approximation of firm behavior in unconcentrated industries. Results presented for this version of the model should therefore be considered illustrative only. Little weight should be attached accordingly to the aggregate measures such as the terms of trade and welfare.

#### 7.4.1 Sectoral Results: Perfect Competition and Monopolistic Competition

Sectoral results for each experiment are presented in tables 7.2–7.7. Tables 7.2 and 7.3 report the percentage change in exports, imports, bilateral trade, output, capital employment, the return to capital, and labor employment due to bilateral liberalization under perfect competition for the United States and Canada, respectively. Tables 7.4 and 7.5 report similar values for the MC model. The percentage changes in the number of firms and in the firm's perceived elasticity of demand are also included.

The most notable feature of the PC model is the strong tendency toward increased intraindustry trade. Bilateral trade increases in virtually every sector. The only exception is that Canadian imports of transportation equipment from the United States fall by 3.2 percent. Total trade for both countries generally increases as well. U.S. imports increase in every sector, and Canada's imports decline only in petroleum products and transportation equipment.

Employment effects are equally small. The largest decline in employment in the United States is 1.3 percent in nonferrous metals. Significantly more

**Table 7.2 Sectoral Effects on the United States of U.S.-Canada Free Trade, Tariffs Only, Post-Tokyo Round: Perfect Competition (percentage change)**

Sector	Exports	Imports from:		Output	Capital	Rental Rate	Employment	Tariff on Canada Exports
		World	Canada					
Agriculture	-.2	4.2	30.9	-.3	-.3	-.1	-.4	1.6
Food	7.0	7.5	64.4	-.0	.0	-.1	-.1	3.8
Textiles	30.7	5.8	125.0	3.4	3.4	-.1	3.3	7.2
Clothing	47.8	3.8	255.8	.6	.7	-.1	.6	18.4
Leather products	2.7	4.8	49.7	-.3	-.3	-.1	-.4	2.5
Footwear	80.5	3.0	141.3	-.1	.0	-.1	-.1	9.0
Wood products	2.0	8.7	12.4	-.7	-.7	-.1	-.8	.2
Furniture, fixtures	77.4	31.8	80.0	.2	.3	-.1	.2	4.6
Paper products	11.6	10.2	10.9	.1	.2	-.1	.1	.0
Printing, publishing	2.2	5.2	15.0	.0	.1	-.1	.0	.3
Chemicals	9.4	7.4	23.5	1.0	1.1	-.1	1.0	.6
Petroleum products	-.9	1.2	6.4	-.6	-.5	-.1	-.7	.0
Rubber products	22.5	13.2	62.3	-.2	-.11	-.1	-.2	3.2
Nonmetal mineral products	11.2	5.5	14.7	.2	.2	-.1	.2	.3
Glass products	22.0	18.9	93.1	.6	.6	-.1	.5	5.7
Iron & steel	8.7	6.9	48.4	-.3	-.3	-.1	-.4	2.7
Nonferrous metals	4.6	7.4	19.3	-1.3	-1.2	-.1	-1.3	.5
Metal products	25.1	14.2	69.7	.4	.4	-.1	.4	4.0
Nonelectrical machinery	4.2	13.2	45.1	-.2	-.1	-.1	-.2	2.2
Electrical machinery	11.3	5.9	81.3	.7	.7	-.1	.7	4.5
Transport equipment	-2.1	5.7	10.8	-1.1	-1.1	-.1	-1.1	.0
Miscellaneous manufacturers	5.4	4.5	29.2	.1	.1	-.1	.0	.9
Mining & quarrying				-.4	-.3	-.1	-.4	
Utilities				.0	.0	-.1	-.1	
Construction				.0	.1	-.1	-.0	
Wholesale trade				.0	.1	-.1	-.1	
Transportation				.0	.1	-.1	-.0	
Financial services				.0	.0	-.1	-.1	
Personal services				-.0	.0	-.1	-.0	

**Table 7.3 Sectoral Effects on Canada of U.S.-Canada Free Trade, Tariffs Only, Post-Tokyo Round:  
Perfect Competition (percentage change)**

Sector	Exports	Imports from:		Output	Capital	Rental Rate	Employment	Tariff on U.S. Exports
		World	United States					
Agriculture	8.0	13.3	23.6	.5	.5	.4	.8	2.2
Food	31.8	22.2	65.4	-.3	-.5	.4	-.1	5.4
Textiles	34.7	67.9	165.5	-25.1	-25.4	.4	-25.0	16.9
Clothing	99.9	15.3	260.7	-1.5	-2.0	.4	-1.3	23.7
Leather products	22.9	4.5	27.8	17.3	16.9	.4	17.4	4.0
Footwear	99.1	4.6	245.7	4.4	4.0	.4	4.5	21.5
Wood products	11.2	17.7	24.2	3.4	3.2	.4	3.5	2.5
Furniture, fixtures	79.0	99.7	160.6	.8	.5	.4	.9	14.3
Paper products	9.8	68.1	74.3	.9	.7	.4	1.0	6.6
Printing, publishing	13.8	3.9	6.4	.9	.6	.4	1.0	1.1
Chemicals	20.8	48.9	72.9	-13.3	-13.7	.4	-13.1	7.9
Petroleum products	6.1	-.7	3.4	5.7	5.1	.4	6.4	.4
Rubber products	58.7	36.6	76.4	3.6	1.9	.4	4.0	7.3
Nonmetal mineral products	9.5	24.6	46.8	-.4	-.7	.4	-.2	4.4
Glass products	73.8	40.4	60.6	-6.5	-6.9	.4	-6.4	6.9
Iron & steel	33.9	26.8	63.3	5.7	5.6	.4	5.8	5.1
Nonferrous metals	14.0	4.3	25.8	18.7	18.6	.4	18.8	3.3
Metal products	45.2	66.2	97.3	-4.6	-4.8	.4	-4.5	8.6
Nonelectrical machinery	34.5	12.2	22.9	7.3	6.8	.4	7.5	4.6
Electrical machinery	47.4	40.9	75.1	-6.5	-6.6	.4	-6.4	7.5
Transport equipment	10.0	-3.0	-3.2	9.1	9.0	.4	9.2	.0
Miscellaneous manufacturers	27.1	12.4	38.6	3.4	3.0	.4	3.6	5.0
Mining & quarrying				3.5	3.3	.4	4.0	
Utilities				-.4	-.7	.4	.3	
Construction				-.1	-.4	.4	.1	
Wholesale trade				-.3	-1.0	.4	.0	
Transportation				-.1	-.6	.4	.1	
Financial services				-.3	-.5	.4	.2	
Personal services				-.5	-.8	.4	-.3	

**Table 7.4 Sectoral Effects on the United States of U.S.-Canada Free Trade, Tariffs Only, Post-Tokyo Round: Monopolistic Competition (percentage change)**

Sector	Exports	Imports from:		Output	No. of Firms		Elasticity	Capital	Rental Rate	Employment
		World	Canada		United States	World				
Agriculture	.4	3.2	17.7	-.1	-.1	-.2	.0	-.1	.1	-.0
Food	8.8	5.7	50.5	.0	-.1	-.1	.0	-.1	.1	.0
Textiles	43.7	-1.0	72.0	5.0	4.8	4.6	.1	4.8	.1	5.0
Clothing	52.1	1.9	234.2	.9	.7	.6	.0	.8	.1	.9
Leather products	2.7	5.8	72.2	-.5	-.6	.3	.0	-.7	.1	-.5
Footwear	84.1	1.9	131.6	.2	-.1	-.1	.2	-.0	.1	.2
Wood products	6.6	-5.8	-9.2	1.5	.7	.2	.7	1.1	.1	1.5
Furniture, fixtures	85.9	24.5	63.4	.5	-.8	-1.0	1.1	-.6	.1	.5
Paper products	19.4	-21.3	-23.3	3.5	2.0	.8	1.3	2.5	.1	3.5
Printing, publishing	11.6	-.2	-6.7	.2	.0	.0	.1	.0	.1	.2
Chemicals	19.6	-11.5	-48.3	3.9	1.0	.5	2.6	2.8	.1	3.9
Petroleum products	1.6	-1.0	-12.0	.7	.5	.0	.1	.5	.1	.7
Rubber products	27.6	12.4	63.8	-.7	-.8	-.4	.0	-.8	.1	-.6
Nonmetal mineral products	17.7	-1.3	-8.9	.7	.6	.5	.0	.6	.1	.7
Glass products	32.6	10.6	57.9	1.1	1.0	.8	.0	1.0	.1	1.1
Iron & steel	9.3	7.8	63.8	-1.6	-1.7	-1.5	.0	-1.8	.1	-1.6
Nonferrous metals	5.2	28.4	76.9	-6.5	-6.6	-2.9	.0	-6.6	.1	-6.5
Metal products	30.6	9.8	52.6	-.1	-.2	-.2	.0	-.2	.1	-.1
Nonelectrical machinery	7.4	5.8	22.6	.7	.6	.2	.0	.6	.1	.7
Electrical machinery	15.9	2.5	60.1	1.2	-.2	-.3	1.2	.1	.1	1.2
Transport equipment	-11.0	44.6	96.0	-7.6	-15.8	-11.3	7.5	-13.1	.1	-7.5
Miscellaneous manufactures	10.0	-.3	-1.3	2.0	2.3	1.1	-.4	2.1	.1	2.0
Mining & quarrying				.1	.1		.0	.1	.1	.2
Utilities				.0	-.0		-.0	-.0	.1	.1
Construction				-.1	-.1		-.0	-.2	.1	-.1
Wholesale trade				-.1	-.2		-.0	-.2	.1	-.1
Transportation				.0	-.1		-.0	-.1	.1	.0
Financial services				-.0	-.0		-.0	-.1	.1	.0
Personal services				-.1	-.2		-.0	-.2	.1	-.1

**Table 7.5 Sectoral Effects on Canada of U.S.-Canada Free Trade, Tariffs Only, Post-Tokyo Round: Monopolistic Competition (percentage change)**

Sector	Exports	Imports from:		Output	No. of Firms		Elasticity	Capital	Rental Rate	Employment
		World	United States		Canada	World				
Agriculture	-1.2	22.1	32.4	-4.8	-4.6	-4.2	.1	-4.5	-1.1	-5.4
Food	20.8	34.7	78.1	-1.8	-1.8	-1.7	.2	-.9	-1.1	-2.0
Textiles	5.1	112.3	212.9	-32.5	-33.6	-24.6	.5	-32.8	-1.1	-32.6
Clothing	86.5	31.9	279.0	-5.1	-6.0	-4.8	.4	-4.5	-1.1	-5.1
Leather products	42.8	1.7	25.4	37.2	36.1	4.0	1.0	37.4	-1.1	37.2
Footwear	91.6	12.2	254.4	2.8	.9	.6	1.3	3.2	-1.1	2.7
Wood products	-10.4	34.8	41.7	-9.0	-6.5	-5.5	-2.2	-6.8	-1.1	-9.1
Furniture, fixtures	62.4	116.2	177.6	-1.2	-13.1	-11.7	11.1	-9.1	-1.1	-1.3
Paper products	-22.6	93.9	100.4	-20.4	-19.3	-17.4	-.9	-19.4	-1.1	-20.5
Printing, publishing	-7.2	20.0	22.7	-4.9	-3.0	-2.6	-1.4	-3.0	-1.1	-5.1
Chemicals	-50.4	91.0	116.1	-52.4	-38.2	-27.4	-13.1	-44.0	-1.1	-52.7
Petroleum products	-12.0	12.1	17.2	-9.6	-9.9	-2.5	.5	-6.9	-1.1	-9.7
Rubber products	60.2	52.1	92.2	18.7	18.1	13.9	.5	23.1	-1.1	18.4
Nonmetal mineral products	-11.8	44.0	66.6	-10.6	-10.4	-8.2	-.0	-9.7	-1.1	-10.9
Glass products	39.1	65.8	86.5	-20.1	-22.3	-14.0	2.1	-20.2	-1.1	-20.3
Iron & steel	48.3	33.5	69.7	27.4	27.0	22.6	.6	27.5	-1.1	27.4
Nonferrous metals	68.0	24.6	44.7	68.1	67.7	-4.1	.2	68.2	-1.1	68.1
Metal products	32.7	85.3	116.6	-3.0	-3.8	-3.3	.8	-2.8	-1.1	-3.0
Nonelectrical machinery	15.1	21.1	32.2	-9.6	-13.1	-3.1	3.1	-11.2	-1.1	-9.7
Electrical machinery	31.5	58.6	93.6	-10.4	-16.7	-12.7	5.4	-15.1	-1.1	-10.5
Transport equipment	89.4	-20.7	-21.4	85.1	48.6	18.3	33.2	50.1	-1.1	85.1
Miscellaneous manufactures	-3.2	27.5	55.0	-18.8	-33.5	-12.8	13.3	-27.4	-1.1	-18.9
Mining & quarrying				-2.2	-2.0		-.1	-1.6	-1.1	-3.3
Utilities				-1.5	-1.0		-.1	-.4	-1.1	-2.9
Construction				.7	.8		.1	1.6	-1.1	.4
Wholesale trade				.9	1.4		.2	3.0	-1.1	.4
Transportation				.6	1.0		.1	2.0	-1.1	.3
Financial services				1.1	1.3		.1	1.9	-1.1	.1
Personal services				.3	.9		.1	1.2	-1.1	-.1

labor adjustment is required in Canada. For example, employment in textiles falls by 25.0 percent.

In comparison, the interindustry effect of liberalization is much more pronounced under monopolistic competition. While liberalization causes U.S. imports from Canada to rise in every sector in the PC model, U.S. imports from Canada in the MC model fall in wood products (−9.2 percent), paper products (−23.3 percent), printing and publishing (−6.7 percent), chemicals (−48.3 percent), petroleum products (−12.0 percent), nonmetallic mineral products (−8.9 percent), and miscellaneous manufactures (−1.3 percent).

Interindustry specialization in production, particularly for Canada, follows a similar pattern. Under the MC model, output in Canada declines in sixteen of the twenty-two tradable sectors, as compared to eight sectors that decline in the PC model. The expanding sectors are leather products (37.2 percent), footwear (2.8 percent), rubber products (18.7 percent), iron and steel (27.4 percent), nonferrous metals (68.1 percent), and transportation equipment (85.1 percent). On the other hand, U.S. output declines in several of these sectors, such as leather products (−0.5 percent), rubber products (−0.7 percent), iron and steel (−1.6 percent), nonferrous metals (−6.5 percent), and transportation equipment (−7.6 percent).

The degree to which firms rationalize or derationalize can be determined by comparing industry output to the number of firms. If the percentage change in industry output exceeds the percentage change in the number of firms, then output per firm must have risen. In the case of the United States, rationalization occurs in every sector except miscellaneous manufactures. In that industry, output rises by 2.0 percent, but the number of firms increases by 2.3 percent.

This is not a particularly surprising result. The return to capital in the United States rises by 0.1 percent, causing ATC to increase. Firms return to the zero-profit position by increasing output.

On the demand side, the reduction in Canada's tariffs was expected to reduce the perceived demand elasticity of U.S. firms, while the fall in the U.S. tariff should have raised the firm's perceived elasticity of demand. Overall, the demand elasticity increased, reducing markup overall marginal cost and further raising firm output. Miscellaneous manufactures is the only industry in the United States for which the firm's perceived elasticity of demand falls. The increased market power attendant to a fall in elasticity induces profit-maximizing firms to reduce output and increase the markup of price over marginal cost. Thus, as noted above, output per firm in the industry also falls.

Rationalization effects for Canada are mixed. The comparatively deep tariff reductions by Canada would have been expected to increase the elasticity of demand and increase firm output. However, the return to capital fell in Canada by 1.1 percent, which tends to lower firm output. Rationalization occurred in fifteen of the twenty-two tradable industries in Canada, but derationalization occurred in all the nontradable industries.

The tradable industries in which firm output declined are agriculture, wood products, paper products, printing and publishing, chemicals, and nonmetallic mineral products. These tend to be the industries in which Canadian tariffs are already quite low. (Canadian average tariffs on U.S. exports are 2.2 percent on agricultural products, 2.5 percent on wood products, 1.1 percent on printing and publishing, and 4.4 percent on nonmetallic mineral products.) Consequently, tariff reductions did little to increase the perceived elasticity of demand of Canadian firms.

We conclude, then, that the relatively large increase in welfare for Canada may in part be due to realized economies of scale. However, the U.S. welfare gain is distinctly smaller even though rationalization occurs much more consistently across all U.S. industries. Therefore, it is likely that intersectoral specialization is playing an important role as well.

#### 7.4.2 Sector Results: Market Segmentation

Sectoral results for U.S.-Canada bilateral tariff removal in the MS model are presented in table 7.6 for the United States and table 7.7 for Canada. The special characteristics of the MS model are most readily apparent when examining the production and price changes in the United States. The reduction in Canadian tariffs on U.S. exports raises the after-tariff price received by U.S. exporters, thus increasing firm profits. The zero-profit condition is restored by a reduction in the price received for sales to the domestic market. As can be seen from column 7 of table 7.6, the price paid by U.S. consumers for tradable goods generally declines. The only exceptions are leather products, iron and steel, and transportation equipment.

In addition, entry occurs in most U.S. industries. The number of U.S. firms declines only in leather products (−42.2 percent), petroleum products (−4.4 percent), rubber products (−0.4 percent), iron and steel (−1.8 percent), metal products (−0.1 percent), and transportation equipment (−18.0 percent).

The tariff reductions by the United States increase the profits of Canadian firms as well. However, the adjustment is dominated by intersectoral resource shifts. Interestingly, sectoral specialization in Canada in the MS model occurs in many of the same industries as in the MC model. Output in Canada increases in only six tradable sectors: leather products, footwear, petroleum products, rubber products, nonelectrical machinery, and transport equipment. Owing to increased specialization in Canada, U.S. imports from Canada decline in several sectors, such as wood products (−17.2 percent), paper products (−43.1 percent), printing and publishing (−6.0 percent), chemicals (−62.9 percent), nonmetallic mineral products (−5.1 percent), nonferrous metals (−185.9 percent), and miscellaneous manufactures (−68.1 percent). On the other hand, Canada's imports from the United States increase in all categories except leather products (−73.2 percent) and transportation equipment (−42.2 percent).



**Table 7.6 Sectoral Effects on the United States of U.S.-Canada Free Trade, Tariffs Only, Post-Tokyo Round:  
Market Segmentation (percentage change)**

Sector	Exports	Imports from:		Output	U.S. Firms	Price	Marginal Cost	Capital	Rental Rate	Employment
		World	Canada							
Agriculture	5.3	.6	13.2	1.2	1.0	-.0	-.0	1.1	.1	1.3
Food	15.3	4.5	59.6	.2	.1	-.0	-.0	.0	.1	.2
Textiles	67.9	-7.1	81.6	8.1	6.9	-.5	-.2	7.2	.1	8.1
Clothing	77.3	-4.2	303.0	2.5	2.1	-.3	-.2	2.3	.1	2.5
Leather products	-45.8	92.9	1150.9	-42.1	-42.2	.2	-.0	-42.3	.1	-42.1
Footwear	104.4	-1.4	219.4	1.4	1.4	-.1	-.0	1.2	.1	1.4
Wood products	12.1	-11.8	-17.2	2.9	2.4	-.1	-.0	2.8	.1	3.0
Furniture, fixtures	114.5	27.4	76.6	.4	.5	-.2	-.1	.4	.1	.4
Paper products	31.9	-39.6	-43.1	6.2	5.3	-.2	-.1	5.5	.1	6.3
Printing, publishing	17.0	-2.0	-6.0	.4	.3	-.0	-.0	.3	.1	.4
Chemicals	30.8	-17.3	-62.9	6.3	5.5	-.3	-.0	5.8	.1	6.3
Petroleum products	-1.1	10.4	72.2	-4.5	-4.4	.0	.0	-4.6	.1	-4.3
Rubber products	45.3	11.1	69.1	-.8	-.4	-.1	-.1	-.8	.1	-.8
Nonmetal mineral products	24.2	-2.3	-5.1	.8	.9	-.0	.0	.7	.1	.8
Glass products	39.3	12.4	81.7	.6	.9	-.1	-.0	.6	.1	.6
Iron & steel	12.2	3.1	40.9	-3.0	-1.8	.1	.0	-2.2	.1	-3.0
Nonferrous metals	21.2	-67.0	-185.9	14.7	10.8	-.1	-.0	14.1	.1	14.7
Metal products	42.4	9.8	64.7	-.9	-.1	-.0	.0	-.5	.1	-.9
Nonelectrical machinery	10.2	10.8	48.4	.5	.6	-.1	-.0	.5	.1	.5
Electrical machinery	24.5	.2	72.6	1.8	2.0	-.1	-.0	1.9	.1	1.8
Transport equipment	-28.6	88.3	185.6	-17.6	-18.0	.3	.0	-17.9	.1	-17.6
Miscellaneous manufactures	25.0	-11.8	-68.1	7.4	7.2	-.2	-.0	7.3	.1	7.5
Mining & quarrying				-2.0	-.2	.1	.0	-2.0	.1	-1.9
Utilities				.1	.0	.1	.1	.0	.1	.2
Construction				-.2	-.0	-.0	-.0	-.2	.1	-.1
Wholesale trade				-.2	-.0	.0	.0	-.4	.1	-.1
Transportation				-.1	-.0	.0	.0	-.2	.1	-.0
Financial services				-.1	-.0	.1	.1	-.1	.1	.0
Personal services				-.2	-.0	.0	.0	-.3	.1	-.2

**Table 7.7 Sectoral Effects on Canada of U.S.-Canada Free Trade, Tariffs Only, Post-Tokyo Round:  
Market Segmentation (percentage change)**

Sector	Exports	Imports from:		Output	Canada Firms	Price	Marginal Cost	Capital	Rental Rate	Employment
		World	United States							
Agriculture	-11.5	38.7	55.3	-11.2	-7.8	.9	.5	-11.0	1.3	-10.5
Food	20.7	49.9	110.5	-4.2	-4.0	.5	.5	-5.2	1.3	-4.1
Textiles	-16.3	160.1	297.6	-39.8	-46.8	-.6	-.1	-46.1	1.3	-39.7
Clothing	111.0	42.1	378.1	-10.9	-11.3	-.4	-.4	-13.0	1.3	-10.9
Leather products	1,116.8	-93.6	-73.2	1,098.2	1,094.5	-7.6	-.3	1,095.4	1.3	1,098.3
Footwear	170.0	-21.6	304.8	20.6	15.6	-2.6	-2.0	15.3	1.3	20.7
Wood products	-18.0	48.8	58.7	-15.4	-13.9	.7	.4	-15.8	1.3	-15.3
Furniture, fixtures	75.4	151.1	233.7	-5.4	-9.2	-.9	-.0	-9.3	1.3	-5.4
Paper products	-42.3	134.6	143.5	-34.9	-31.8	1.4	.5	-34.7	1.3	-34.7
Printing, publishing	-6.6	26.4	30.5	-4.1	-4.5	.5	.4	-5.6	1.3	-4.1
Chemicals	-64.9	127.1	161.6	-72.5	-64.2	1.4	.4	-69.4	1.3	-72.1
Petroleum products	72.2	-5.4	17.2	75.3	72.0	-.2	.1	72.4	1.3	77.0
Rubber products	64.8	84.8	140.7	35.3	14.0	-1.9	.2	16.3	1.3	35.8
Nonmetal mineral products	-8.1	52.0	83.2	-7.9	-10.5	-.3	.0	-10.5	1.3	-7.6
Glass products	57.4	72.1	99.4	-14.1	-23.4	-1.9	.0	-20.8	1.3	-13.9
Iron & steel	23.9	34.5	82.8	-19.3	-11.7	.3	-.0	-12.5	1.3	-19.3
Nonferrous metals	-191.6	21.4	50.1	-191.9	-195.0	.5	.2	-192.6	1.3	-191.8
Metal products	37.9	113.9	156.2	-4.0	-8.9	-.4	.1	-7.5	1.3	-3.9
Nonelectrical machinery	37.6	22.6	37.6	5.3	2.5	-2.8	-.2	1.2	1.3	5.5
Electrical machinery	35.0	80.0	127.7	-14.7	-19.0	-.9	-.4	-18.1	1.3	-14.6
Transport equipment	185.3	-40.3	-42.2	170.6	153.3	-4.3	-1.4	156.8	1.3	170.7
Miscellaneous manufactures	-70.0	60.5	100.2	-76.7	-78.7	-.2	.2	-78.7	1.3	-76.3
Mining & quarrying				33.1	14.1	-.0	.7	31.3	1.3	34.6
Utilities				-3.3	-1.9	.8	.6	-4.3	1.3	-1.6
Construction				-.9	-1.0	.2	.1	-2.0	1.3	-.5
Wholesale trade				-.4	-.7	.3	.3	-3.0	1.3	.1
Transportation				.1	-.5	.1	.1	-1.7	1.3	.5
Financial services				1.2	.2	.5	.6	.1	1.3	2.4
Personal services				-1.8	-1.3	.5	.4	-2.6	1.3	-1.3

Exit accompanies the decline in output in most Canadian industries. The number of Canadian firms increases only in leather products (1,094.5 percent), footwear (15.6 percent), petroleum products (72.0 percent), rubber products (14.0 percent), nonelectrical machinery (2.5 percent), and transportation equipment (153.3 percent).

Though the MS and MC models yield similar intersectoral results, they differ in one important respect. Rationalization is much more prevalent for Canadian firms and much less prevalent for U.S. firms in the MS model than in the MC model. A comparison of the percentage change in industry output and number of firms in Canada shows that output per firm rises in sixteen of the twenty-two tradable sectors. This result is similar to that obtained with the MC model. However, rationalization also occurs in five of the seven nontradable sectors, whereas all the nontradable Canadian industries derationalized in the MC model.

In the United States, derationalization occurs in furniture and fixtures, petroleum products, rubber products, nonmetallic mineral products, glass products, iron and steel, metal products, nonelectrical machinery, and electrical machinery. In comparison, all U.S. industries increase output per firm in the MC model, except miscellaneous manufactures. In the nontradable industries, six of seven sectors derationalize in the MS model, compared to none in the MC model.

The relative return to capital in Canada increases by 1.3 percent, raising firm fixed costs. In order to maintain zero profits, firm output in Canada tends to rise. The return to capital in the U.S. increases as well, but by a much smaller 0.1 percent. This result suggests that the rationalization effects in the model may be quite sensitive to the method used for calculating the variable cost share, though demand side considerations are also affecting firm behavior.

## 7.5 Summary and Conclusions

Our purpose in this paper has been to review the important modeling issues involved in analyzing the economic effects of bilateral tariff removal between the United States and Canada. The major modeling issues identified include (1) improving modeling techniques for identifying the bilateral trade that will be subject to tariff removal, (2) whether liberalization would lead firms to increase output and capture scale economies in production, (3) whether the gains from the agreement would stem from increased intraindustry or interindustry trade, and (4) whether terms-of-trade effects or efficiency gains would dominate the welfare outcome of liberalization.

Three classes of models were identified as suitable for studying bilateral tariff removal. These are models in which products are differentiated at the national level, models in which products are differentiated at the firm level, and models in which markets are segmented at the national level.

In all three cases, markets may be imperfectly competitive as the result of increasing returns to scale in production. Reaping economies of scale provides an additional source of potential gain from trade liberalization, which is thought to be especially important in the Canadian case because of the small size of its national market. The determination of the scale of production for each firm in an MC market was shown theoretically to depend on the factor-intensity ranking of the industries most heavily protected. If liberalization raises the return to capital, thereby increasing ATC relative to marginal cost, firm output must rise to satisfy the zero-profit and maximum-profit conditions. The opposite occurs if the return to capital falls. Though the power of rationalization effects may depend on country size, the direction does not.

Previous studies of the U.S.-Canada FTA have exhibited a strong tendency toward the conclusions that increased trade will be primarily intraindustry, that rationalization will occur in most Canadian industries, but that Canada's terms of trade will deteriorate. These results were shown in section 7.1 to be influenced by the assumption of national product differentiation. In particular, national product differentiation and strong terms-of-trade effects appear to lie behind most negative welfare conclusions found for Canada.

Differentiating products by place of production is a convenient and popular procedure for identifying bilateral trade flows. However, the development of computational models with imperfectly competitive firms offers an attractive alternative. We have not provided empirical evidence that product differentiation is more likely to exist at the firm level than at the national level. However, given the artificial nature of the assumption of national product differentiation and its strong welfare, trade, and terms-of-trade implications, it should be used sparingly and only on the condition that this assumption is convincingly justified in each case. This is especially the case in view of the fact that differentiating products at the firm level sidesteps many of the problems associated with differentiation at the national level.

The theoretical results were illustrated using a general equilibrium computational model. Three market structures were adopted: perfect competition with national product differentiation; monopolistic competition with firm product differentiation; and a national market segmentation model with homogeneous products.

The computational results from the MC model *without* national product differentiation indicate that rationalization depends on the change in the return to capital, with the United States more likely to experience rationalization than Canada. Strong interindustry specialization occurs, particularly in Canada, with output in Canada declining in sixteen of the twenty-two tradable sectors and exports declining in eight tradable sectors. Intersectoral specialization gains are in part responsible for an increase in Canadian welfare by 1.2 percent of GDP, despite the deterioration in Canada's terms of trade. The U.S. welfare gain is also positive but smaller in absolute terms.

## Notes

1. The Armington assumptions are that the utility function is weakly separable in goods and that the function used to aggregate the import and the domestically produced good is linearly homogeneous. That is, the utility function can be written as a function of the  $n$  goods,  $U = U(X_1, \dots, X_n)$ , and each good is an aggregate of the domestic and imported varieties,  $X_i = f(X_i^H, X_i^M)$ . These are simply the assumptions necessary for perfect aggregation as demonstrated by Green (1964).

2. National product differentiation and the terms of trade effects of a tariff are discussed in detail in Hamilton and Whalley (1983) and Brown (1987).

3. For a summary and analysis of the various studies of the U.S.-Canada FTA, see Brown and Stern (1989).

4. Flam and Helpman (1987, p. 87) explore a similar model but cast their results somewhat differently. They conclude that the utilization rate in industry 2 depends on whether the absolute value of the elasticity of supply of 2 with respect to the price of 1 is larger or smaller than the absolute value of the elasticity of research and development with respect to the price of 1.

5. Horstmann and Markusen make the additional assumption that there is a single factor of production.

6. This strong result depends on two assumptions. First, there is only one factor of production. As a result, the industry can expand without changing relative factor prices. This implies that the slope of the ATC curve does not change during the adjustment. Second, the demand for the domestic good is assumed to shift in a parallel fashion in response to changes in the price of imports. Thus, the slope of the demand curve is also unaffected. Together, these two assumptions imply that the point of tangency between the ATC curve and domestic demand will always occur at the same level of output.

7. Sufficient conditions for  $A > 0$  are that all countries of the model are identical and that all countries impose a positive tariff. This implies that  $y_i = y_j$ ,  $x_i^k = x_j^k$ , and  $y_i > x_j^i$ . An alternative is that  $y_i > x_i^i + x_i^k$  and that  $y_i > x_j^i$ . That is, a typical firm sells more domestically than it exports, and a domestic firm sells more to the domestic market than a foreign firm.

8. This condition requires that a country 3 firm's sales to the domestic market add more to profits than exports to country 1 as compared to a typical firm in country 2. As a result, an increase in  $p_1$  and a fall in  $p_3$  that hold country 3 firm profits at zero will imply positive profits for country 2 firms. Thus,  $dp_2$  must be less than zero.

9. For the proportionately differentiated equations of the model, see the appendix to Brown and Stern (1989).

10. The thirty-two countries are sixteen industrialized countries (Australia, Austria, Belgium-Luxembourg, Denmark, the Federal Republic of Germany, Finland, France, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom) and sixteen newly industrializing countries (Argentina, Brazil, Chile, Colombia, Greece, Hong Kong, India, Israel, Mexico, Portugal, Singapore, South Korea, Spain, Taiwan, Turkey, and Yugoslavia).

11. Values for these parameters can be obtained from the authors on request.

12. See Brown and Stern (1987) and Boadway and Treddenick (1978).

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## Comment      Robert W. Staiger

I found the paper by Brown and Stern to be extremely interesting. The authors consider a timely topic and use the opportunity to produce some suggestive numbers on the likely magnitude of the gains from the U.S.-Canada free trade agreement as well as to tackle some important methodological issues in computable general equilibrium (CGE) modeling in the presence of noncompetitive markets. The authors compare the gains from trade liberalization between the United States and Canada under three model scenarios corresponding to three different characterizations of market structure: that markets are competitive but the Armington assumption holds, that markets are monopolistically competitive, and that markets are segmented. As might be expected from the work of Harris (1984), and as the authors illustrate here, market structure can have a profound effect on the nature and magnitude of the gains from trade liberalization.

The results described by the authors under the three market structure alternatives are suggestive of the contributions to the overall gains from trade liberalization that each kind of industry will make. Nevertheless, no single market structure will characterize all industries, and the assumption made by the authors that all industries are either perfectly competitive, monopolistically competitive, or segmented must be viewed as artificial. Thus, while I find the quantitative results intriguing, for this and other reasons outlined below I interpret the main contribution of the paper as methodological rather than empirical.

In this regard, I found the discussion of the monopolistically competitive model most interesting but, at the same time, least transparent. I will therefore focus my comments on what I view as the paper's main methodological insight with regard to the monopolistically competitive model: that is, the link between protection and output per firm in the monopolistically competitive sector, or the issue of "rationalization." After summarizing the authors' methodological points, I will then comment on their attempt to implement these insights in the CGE modeling experiment of the paper.

### Rationalization

In my view, the main contribution of the paper involves formalizing the general equilibrium relation between "rationalization" and changes in factor prices that accompany a change in the level of protection in a two-factor setting. Here, I will attempt to summarize the main argument.

The free-entry (symmetric) equilibrium conditions for a monopolistically competitive industry are given by the profit-maximizing markup equation and the free-entry zero-profit condition

$$(1) \quad \frac{P - C_q(r, w, q)}{P} = 1/\eta,$$

$$(2) \quad P = C(r, w, q)/q,$$

where firm subscripts can be dropped owing to symmetry and where  $P$ ,  $C(\cdot)$ , and  $C_q(\cdot)$  are price, total cost, and marginal cost, respectively, of the monopolistically competitive good,  $r$  and  $w$  are rental and wage rates,  $q$  is the output level of a representative firm in the industry, and  $\eta$  is the elasticity of demand as perceived by the firm with the sign reversed. Expressions (1) and (2) can be combined to yield

$$(3) \quad 1 - \frac{1}{\eta} = \frac{C_q(r, w, q)}{C(r, w, q)/q}.$$

Under the assumption of constant marginal costs, (3) can be rewritten as

$$(4) \quad 1 - \frac{1}{\eta} = \frac{C_q(\omega)}{C(\omega, q)/q} \equiv \theta(\omega, q),$$

where  $\omega$  is the wage-to-rental ratio  $w/r$ . The variable  $\theta(\omega, q)$  is the elasticity of cost with respect to output, the inverse of which is used as an index of scale economies by Helpman and Krugman (1985).

Expression (4) implicitly defines equilibrium output per firm as a function of  $\omega$  and  $\eta$ , or

$$(5) \quad q = q(\omega, \eta).$$

Totally differentiating (5) with respect to the tariff  $\tau$  yields

$$(6) \quad \frac{dq}{d\tau} = \frac{\delta q}{\delta \omega} \frac{d\omega}{d\tau} + \frac{\delta q}{\delta \eta} \frac{d\eta}{d\tau}.$$

Note from (6) that, if the demand elasticity is unaltered, a change in the level of protection will affect the equilibrium level of output for the representative firm in the sector only through its effect on the wage-rental ratio  $\omega$ . It is this production side link between trade liberalization and rationalization that is in my view the primary methodological contribution of the paper.

To focus on this link between changes in protection and output per firm in the monopolistically competitive sector, I will assume throughout that demand elasticity is held constant. To see how output per firm varies with relative factor prices when the elasticity of demand is held constant, totally differentiate (4) to get

$$(7) \quad \frac{\delta q}{\delta \omega} = \frac{-\delta\theta/\delta\omega}{\delta\theta/\delta q}.$$



Therefore, with the elasticity of demand held constant, the general equilibrium effect of a change in the level of protection on output per firm in the monopolistically competitive sector is given by

$$(8) \quad \frac{dq}{d\tau} = \frac{\delta q}{\delta \omega} \frac{d\omega}{d\tau} = \frac{-\delta\theta/\delta\omega}{\delta\theta/\delta q} \frac{d\omega}{d\tau}.$$

Direct calculation and substitution of equilibrium condition (4) allows (8) to be rewritten as

$$(9) \quad \frac{dq}{d\tau} = - [q\eta(\varphi - \psi)] \frac{d\omega}{d\tau}$$

where  $\varphi$  and  $\psi$  are the elasticities of marginal and total cost, respectively, with respect to the wage-rental rate.

With the assumption of constant marginal cost, total cost can be written as

$$(10) \quad C(\omega, q) = F(\omega) + qC_q(\omega, q),$$

where  $F(\omega)$  is fixed cost for a representative firm. Using (10), an expression for  $(\varphi - \psi)$  can be derived as

$$(11) \quad \varphi - \psi = (1 - \theta) \left( \varphi - \frac{\delta F}{\delta \omega} \frac{\omega}{F} \right).$$

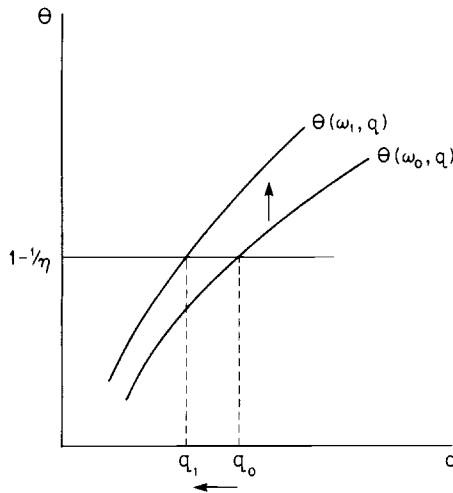
Hence,  $\varphi - \psi$  will be positive if and only if fixed costs are more capital intensive than variable costs. Expression (9) then implies that, provided this factor intensity condition is met,

$$(12) \quad \text{sign} \left( \frac{dq}{d\tau} \right) = - \text{sign} \left( \frac{d\omega}{d\tau} \right).$$

In words, abstracting from demand side effects, the monopolistically competitive sector will undergo “rationalization” when trade is liberalized if and only if liberalization reduces the wage-rental ratio in the country.

Figure 7C.1 illustrates this relation. The variable  $\theta$  is measured on the vertical axis, while output is measured on the horizontal axis. The positively sloped solid curve measures  $\theta$  as a function of output holding factor prices fixed at  $\omega_0$ . This curve will have a positive slope provided we maintain the assumption of constant marginal cost. A solid horizontal line has been plotted through  $1 - 1/\eta$ , and its intersection with the  $\theta$  curve determines the equilibrium output level given factor prices  $\omega_0$ . Firm profits would be negative if output were below  $q_0$ , leading to exit and a rise in output per remaining firm. Output above  $q_0$  would result in positive firm profits and a fall in output per firm as entry of new firms occurs.

An increase in the wage-rental ratio will shift the  $\theta$  curve vertically upward provided that fixed costs are more capital intensive than variable costs. At the original level of output, firms now make positive profits owing to the



**Fig. 7C.1 Rationalization and the wage-rental ratio**

diminished magnitude of fixed relative to variable costs. This induces entry and lowers output per firm.

The production side relation between liberalization and rationalization is surprising both in its simplicity and in its apparent generality. Aside from the free-entry equilibrium conditions for monopolistic competition, the relation requires only that marginal costs be constant and that fixed costs be more capital intensive than variable costs. Of course, as the authors point out, demand side consideration also enter, and changes in demand elasticities associated with liberalization will factor into the rationalization process. But I think the authors have isolated an interesting and potentially important link between trade liberalization and rationalization.

**Implementation**

The power of the theoretical predictions outlined above can be readily appreciated once we turn to implementation. To quantify the bracketed term in the relation in (9), surprisingly little information need be gathered. In particular, under the assumption that capital is the only fixed factor, the authors require only measures of labor's primary input cost share, the primary input share of total cost, firm output, and the elasticity of demand faced by firms in the monopolistically competitive sector. Data on the first three variables are readily available. However, data on demand elasticities are difficult to come by and are absolutely crucial: demand elasticities play a central role in the production side relation emphasized by the authors, not to mention the direct effect that changes in demand elasticities will have on rationalization in response to trade liberalization.

For this reason, the quality of the results of the CGE experiments that the authors undertake in an attempt to quantify these relations will depend heavily on the quality of their estimates of demand elasticities for the monopolistically competitive sectors. Unfortunately, the authors come very close to simply assuming a value for the demand elasticities of the model with little in the way of discussion to support their chosen values. In the light of the central importance of the demand elasticities in determining the degree of rationalization in their model, this comes close to assuming the quantitative effects that are the focus of the paper. As such, I would have more confidence in drawing general lessons from the CGE modeling results of this paper if better estimates of the crucial demand elasticities could be found.

## References

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## Comment      John Whalley

I very much enjoyed this paper by Brown and Stern, which struck me as both well written and interesting. What the paper does is to use three different numerical general equilibrium models to look at tariff cuts between Canada and the United States using 1976 data. These are a perfectly competitive model, a monopolistically competitive model, and a market segmentation model.

The conclusion is that the model matters for the evaluation of tariff cuts. The early material in the paper gives clear intuition as to how various model features interact. For instance, with an assumption of product differentiation at the national level plus product differentiation by firm, it is clear that there are small rationalization effects resulting from tariff cuts. In turn, rationalization effects depend most on factor intensity differences across industries.

I have two points to make about the paper. One concerns the applicability of the paper to the recent Canada-U.S. free trade agreement and the other the results and implications of the analysis.

John Whalley is director for the Centre for the Study of International Economic Relations and professor of economics at the University of Western Ontario. He also currently holds the William G. Davis chair for international economics and is a research associate of the National Bureau of Economic Research.

First, however, I will present some comments about Canada-U.S. trade and the applicability of this analysis to the current free trade agreement. The Canada-U.S. free trade agreement is, of course, much more than the tariff cuts that are considered in this paper and, in turn, apply to 1988 rather than 1976 tariffs. The agreement has twenty-one chapters and is longer than the whole of the General Agreement on Tariffs and Trade (GATT). It has complex chapters on dispute settlement, energy, investment, agriculture, procurement, services, financial services, and standards. As a result, it is important to keep in mind that the paper is only tangentially related to the issues that are at the heart of the Canada-U.S. free trade agreement.

Indeed, from the point of view of the Canadians, who were the demanders for this agreement, the main objective was security of access rather than improvements in access per se. From the Canadian side, tariffs were not that big an issue. In the aggregate, approximately 80 percent of Canadian exports are already duty free, although there are remaining spikes in the U.S. tariff wall, particularly in the textiles area. Indeed, the tariff reductions are by no means complete since in the textile area these are restricted by a tariff quota.

As a result, when evaluating the agreement, it is important to keep in mind that such issues as the security value to Canada from hoped-for improvements on dispute settlement applying to countervailing and antidumping duties are in no way attacked through this modeling effort. Equally, from a U.S. point of view, the security value of access to Canadian energy supplies is not quantified, nor is the removal of investment restrictions.

In addition, it is important to keep in mind the nature of Canada-U.S. trade and how that also qualifies the analysis in this paper. A large fraction—my impression is as large as 60–70 percent of Canada-U.S. trade in manufacturers—is trade that is internal to integrated firms across the border. Thus, much of the analysis in the paper hinging on national product differentiation no longer applies. In turn, around 50 percent of Canadian exports to the United States are in the form of nonmanufactured exports. Also, 30 percent of trade takes place in autos and parts under the coverage of the auto pact, again covering vertically integrated firms on both sides of the border. Thus, to apply this modeling framework in an overly mechanical way to Canada-U.S. trade might be somewhat misleading.

Also, in analyzing rationalization effects, it seems to me that this paper has to confront the Canada-U.S. productivity differences that were at the heart of the earlier Harris analysis. This showed large effects from Canada-U.S. free trade, resulting from the collusive behavior in his work. The old view in Canada, from the 1950s, was that average costs in manufacturing were about 30 percent higher in Canada than in the United States and that production runs were shorter. As a result, there were more product lines per plant. These differentials tended to fall in the 1960s and 1970s as tariffs fell. These were the stylized facts that Harris was attempting to deal with in his work on Canada-U.S. trade but that in the framework in which Brown and Stern present are perhaps less transparent.

With these comments about the applicability of the modeling to both current Canada-U.S. trade and the agreement, it is perhaps worth moving on to some comments about the results and their implications. First comes the issue of the size and the sign of the welfare effects and how these change as model selection changes. In the constant returns-to-scale case, the authors find that, owing to an adverse terms-of-trade effect, Canada loses as a result of bilateral tariff elimination. This, in turn, reflects the differential level of initial tariffs. Although Canada is the smaller country and therefore might be expected to gain, because they have the higher level of initial protection they therefore lose.

In the monopolistically competitive model, they find, in contrast, that Canada gains by about 1.2 percent of GNP. And, in the market structure case, although the welfare effects are not emphasized, there is a loss of around 0.6 percent of GNP.

Rather than emphasize only the sign difference, it is important to compare these results to those of other studies, such as Harris. Harris's earlier models produced welfare effects for Canada as large as 10 percent of GNP because of large rationalization effects. Harris's treatment of collusion and implicit limit pricing under his treatment of the Eastman-Stykolt hypothesis has been discussed at some length in the literature. But the point to keep in mind is that the variation in results among the model approaches used by Brown and Stern is small compared to the larger differences relative to Harris.

Second, there is an issue of whether the authors' results are more parameter dependent than structure dependent. For instance, perceived elasticities in the monopolistically competitive model are not endogenous, nor are the markup rates. There are sensitivity analyses in the paper, and these indicate limited sensitivity of findings, but the question as to parameter or structural dependence remains as central in evaluating their results.

Third are some issues as to the plausibility of some of the detailed industry results in their analysis. For instance, in their table 7.5, there is an 85 percent increase in the output of transport equipment in Canada as a result of joint elimination of tariffs. This occurs even though there is free trade between Canada and the United States under the auto pact and is, therefore, somewhat doubtful. Also, there is a 32 percent reduction in output of textiles in Canada. It has long been held to be the case in Canada that the textile industry would be one of the main beneficiaries of a comprehensive Canada-U.S. trade agreement because of the improved access to the large U.S. market behind the quota wall against all developing countries through the multifiber arrangement provisions. Thus, a 32 percent reduction in output of textiles in Canada when the U.S. industry has fought so hard to maintain tariff protection against Canadian textiles in the actual negotiations seems somewhat implausible.

Fourth, there are some features of the model that are perhaps a little misleading. The entry assumptions are perhaps inadequately defended. The

implication seems to be that all firms in the monopolistically competitive case are of equal size. This is too strong since a typical structure is to have a small number of large firms and a larger number of small firms.

There are also issues concerning the modeling of Canada-U.S. barriers themselves and how they are to be interpreted vis-à-vis price dispersion data. My understanding, for instance, is that there are data in Europe that show that as part of the current integration exercise in Europe there is more dispersion among prices in national domestic markets in products where it is known that there are no significant country barriers than in those products where major barriers exist. This suggests that it may well be differences in market structure across the two borders that are more important than price differentials induced by restrictions.

In the final analysis, the question that I ask myself is whether this analysis has convinced me of major propositions that are important for the analysis of Canada-U.S. trade. The major contribution clearly lies in the insights the paper has generated rather than the precise results. Market structure makes a difference for the welfare analysis of trade policy. We can build many different models with different results. Unfortunately, however, there are other potential market structures that have not been taken into account in this analysis. Also, it is not obvious that one necessarily wants the same market structure for all industries, and the results are always parameter dependent—markups, the treatment of scale economies, and perceived elasticities all matter. Brown and Stern have given us an excellent paper, one that takes us well on our way, but more analysis is clearly needed.

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