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COMPLEMENTARITY AND INCREASING RETURNS IN INTERMEDIATE INPUTS:

A THEORETICAL AND APPLIED GENERAL-EQUILIBRIUM ANALYSIS

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ABSTRACT

Conventional analysis in the trade-industrial-organization literature suggests that, when a country has some market power over an imported good, some small level of protection must be welfare improving. This is essentially a terms-of-trade argument that is reinforced if the imported goods are substitutes for domestic goods produced with increasing returns to scale, goods that are initially underproduced in free-trade equilibrium. This paper notes that this result may not hold when (1) the imports are intermediates used in a domestic increasing-returns industry, and/or (2) the intermediates are complements for domestic inputs produced with increasing returns. We then demonstrate such an outcome with respect to Mexican protection against imported auto parts using an applied general-equilibrium model of the North American auto industry.

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1. Introduction

A number of papers in the trade-industrial-organization literature, particularly those exploiting monopolistic- competition models, derive results that support protectionist arguments in import-competing sectors. These policy prescriptions rely on two reinforcing welfare effects. First, since products are differentiated, countries have some measure of monopoly power in trade no matter how small they are. Thus there is the usual terms-of-trade argument for protection. Second, the imported products are (usually implicitly) assumed to be substitutes for domestic products produced with increasing returns. The latter goods are undersupplied in free trade equilibrium insofar as prices exceed marginal costs. Import protection thus switches expenditure from the foreign goods to the domestic goods which creates a secondary benefit due to the existing distortion. Much of the analysis is found in Flam and Helpman (1987), Venables (1987) and discussed at length in Helpman (1990). To the best of our knowledge, the only papers that present an alternative conclusion within the same class of models are Markusen (1989, 1990). Markusen uses Ethier (1982) as a point of departure, assuming that the differentiated goods produced with increasing returns are intermediate goods, used as inputs into final production. Within this framework, it is reasonable to suggest that imported and domestic differentiated intermediates may be complementary. In many developing countries, for example, imported machinery, high-tech and/or capital-intensive components, and the services of engineering consultants may be complements for domestic inputs.

When the relationship between domestic and imported intermediates is complementary, a tariff or other barrier against the foreign goods/services may be welfare reducing. The terms-of-trade argument remains valid, but a tariff may now switch expenditure away from the domestic intermediates. Higher prices for the imported intermediates reduce the output of the final good(s) and, because the domestic intermediates are complementary, the effect of the reduced output on domestic intermediate demand dominates any expenditure switching from the foreign to the domestic intermediates. This generates a negative welfare effect due to the difference between price and marginal cost noted above. If this "derationalization" effect dominates the terms-of-trade effect, then even a small level of import protection is welfare reducing (Markusen 1990).

The possibility of welfare-reducing protection in spite of a favorable terms-of-trade effect is more likely if the intermediates are in turn an input into a final good produced with increasing returns. Again, due to an excess of price over marginal cost, such an industry is under-producing for the domestic market. It may also be under-exporting (if indeed it is an export industry), although this is much less obvious.

The purpose of this paper is to develop these ideas and apply them to a particular case study. Section 2 below develops a simple model to exposit the theoretical possibility of welfare-reducing protection. Section 3 outlines the details of the applied general-equilibrium model, which further develops the North American auto model of Hunter, Markusen, and Rutherford (1992) by adding an auto parts sector.[1] Section 4 presents results of several counter-factual experiments, and shows that Mexico achieves a welfare gain by unilaterally removing its protection on auto parts. Mexican auto production and exports significantly expand following the removal of parts protection, and Mexican auto parts production also experiences an increased output. This last result is an illustration of the "derationalization" effect: protection on parts generates a scale effect that dominates the expenditure switching effect.

[1]The purposes of the Hunter, Markusen, and Rutherford paper are very different from the objectives of the present paper. The former paper is concerned with the effects of multinational price and output coordination on trade liberalization scenarios, and with the ability of producers to segment markets (free trade for producers versus free trade for consumers).

Finally, zero protection on parts is shown to be the optimal (non-negative) protection level for Mexico.

2. The Theoretical Argument

In this section, we will outline the principal theoretical argument of the paper. We will attempt to keep the analysis simple and stylized, since some of the points have previously appeared in print. A fully analysis of the technology and markup formulae etc. in the auto sector (sector X below) is given in Hunter, Markusen, and Rutherford.

Suppose that an economy has two final goods X and Y, and an intermediate good Z (parts). Foreign Z is differentiated from domestic Z and so the former is denoted Z^*. Throughout the paper, foreign variables are superscripted with a *. We will think of Mexico as the domestic (home) economy and the US as the foreign country throughout. Domestic consumption of X and Y are denoted C_x and C_y, and domestic welfare is given by

(1) $$U = U(C_x, C_y)$$

Good X (autos) is produced using domestic labor, L and domestic and imported Z.

(2) $$X = F(L_x, Z, Z^*)$$

Good Y is produced with constant returns to scale by a competitive industry using labor and a sector-specific factor R.

(3) $$Y = G(L_y, R)$$

Z is produced from labor alone.

(4) $$Z = H(L_z)$$

Let Y be numeraire and let p_x (p_x^*) denote the home and export price of X in terms of Y respectively (p_x^* is the foreign price net of foreign protection). Assume for simplicity that Z is not exported (and therefore non-traded). p_z (p_z^*) will denote the home price of Z and the foreign (import) price of Z^* respectively. The balance-of-payments constraint for the economy is given by

(5) $$p_x^* E_x + E_y - p_z^* Z^* = 0, \qquad E_x \equiv X - C_x \quad E_y \equiv Y - C_y$$

where E_x and E_y are domestic excess supplies of X and Y respectively. We assume no tariffs or export taxes initially, so p_z^* gives the domestic price of Z^* as well as the import price. X is an export good by assumption and exporters of X may be able to price discriminate between markets, so p_x and p_x^* need not be equal. In our applied model developed in the following section, auto firms are foreign owned, but free entry drives profits to zero so that there is no repatriation term in (5).

We assume that a unit of exports of X requires a shipping cost of s units of labor, so total labor devoted to exporting is $L_s = sE_x$. The overall labor constraint (L) on the domestic economy is given by

(6) $$L_x + L_y + L_z + L_s = L_x + L_y + L_z + sE_x = L$$

Through a process of differentiation and substitution, equations (1) through (6) can be transformed into a welfare differential useful for policy analysis. Differentiating (1), we obtain an expression for the change in welfare measured in terms of good Y.

(7) $$dW = \frac{dU}{U_y} = \frac{U_x}{U_y} dC_x + dC_y = p_x dC_x + dC_y$$

Now differentiate the production function X in (2), and replace dX with dC_x + dE_x.

(8) $$dX = dC_x + dE_x = F_l dL_x + F_z dZ + F_{z^*} dZ^*$$

X and Z are assumed to be produced with increasing returns by imperfectly competitive industries. Let m_x and m_x^* be the markups (wedge between price and marginal cost) applied to domestic and foreign sales of X respectively, and let w denote the home (Mexican) wage rate in terms of Y. If the US market is served by plants in both the US and Mexico, optimal pricing implies that the MNE equates delivered marginal cost from Mexico to the US marginal cost. Specifically, US marginal cost (mc_x^*) is equated to delivered marginal cost from Mexico inclusive of the US tariff (t^*) levied on Mexican marginal cost (mc_x) plus shipping cost (ws): $mc_x^* = (1 + t^*)(mc_x + ws)$. The firm's pricing equations for thee foreign (US) and domestic (Mexico) economies are given by

(9) $$p_x^u(1 - m_x^*) = mc_x^* = (1 + t^*)(mc_x + ws), \qquad p_x(1 - m_x) = mc_x$$

where p_x^u is the foreign (US) domestic price of autos: $p_x^u = p_x^*(1 + t^*)$. Noting this last relationship, divide the first equation of (9) through by $(1 + t^*)$ and replace $p_x^u(1 + t^*)^{-1}$ with p_x^*. The two equations of (9) together then imply

(10) $$p_x^*(1 - m_x^*) - ws = p_x(1 - m_x) = mc_x$$

Factors of production used in the X industry are paid their marginal revenue products (marginal revenue times physical marginal products), so we can multiply (8) through by marginal revenue

$p_x(1 - m_x) = p_x^*(1 - m_x^*) - ws$ given in (10) to get

(11)

$$p_x(1 - m_x)dC_x + p_x^*(1 - m_x^*)dE_x - wsdE_x = wdL_x + p_z dZ + p_z^* dZ^*$$

The second equality of (11) follows from the fact that marginal revenue products of factors equal factor prices; e.g., $p_x(1 - m_x)F_l = w$. Differentiate (4) and multiply through by marginal revenue

$p_z(1 - m_z)$ where m_z is the domestic markup on parts.

(12) $$dZ = H'dL_z; \quad p_z(1 - m_z)dZ = wdL_z$$

The second equality follows from the fact that the marginal-revenue product of labor, $p_z(1 - m_z)H'$, equals the wage, w. Differentiate (3) recalling that Y is numeraire (implying $w = G'$).

(13) $$dY = G'dL_y = wdL_y$$

Rearrange (11) with only $wdL_x + wsdE_x$ on the right-hand side. Sum (11), (12), and (13) noting that the sum of the right-hand sides equals zero: $w(dL_x + dL_y + dL_z + sdE_x) = 0$.

(14)

$$p_x(1 - m_x)dC_x + p_x^*(1 - m_x^*)dE_x - p_z dZ - p_z^* dZ^* + p_z(1 - m_z)dZ + dY$$

Subtract (14) from the welfare differential (7).

(15) $$dW = p_x m_x dC_x - p_x^*(1 - m_x^*)dE_x + p_z m_z dZ + p_z^* dZ^* - dE_y$$

Differentiate equation (5).

(16) $$p_x^* dE_x + E_x dp^* + dE_y - p_z^* dZ^* - Z^* dp_z^* = 0$$

Add (16) to (15)

(17) $$dW = p_x m_x dC_x + \left[p_x^* m_x^* dE_x + E_x dp_x^*\right] + \left[p_z m_z dZ - Z^* dp_z^*\right]$$

Now assume that the domestic economy institutes a small import tariff on Z^*. Assume also without further analysis that this tariff has the "expected" effects of (A) reducing imports of Z^* and driving down the import price of Z^*, $dp_z^* < 0$; (B) reducing the domestic consumption and exports of the final good X and thereby driving up the world price of X, $[dC_x, dE_x] < 0$, $dp_x^* > 0$.

The first term in (17) results from the distortion between price and marginal cost on domestic sales of X. This first term in (17) has a negative sign: the tariff on Z^* reduces domestic consumption of X, which is priced above marginal cost, thus there is a loss of the consumption change times the difference between price and marginal cost, $(p_x - mc_x) = p_x m_x$.[2]

Trade economists will recognize the first term in square brackets in (17) as a volume-of-trade effect and a terms-of-trade effect on exports of X. The optimal export tax is simply the value of m_x^* that sets this expression to zero. In the present case, the auto firms pick m_x^*, and the markup may therefore be greater than or less than its optimal value. With $dE_x < 0$ and dp_x^*

[2]Although the auto firms are foreign owned, the difference between price and marginal cost (mc) is captured by the Mexican economy in our model. Free entry drives profits to zero, and $(p_x - mc_x)$ accrues to the Mexican economy as lower average cost (ac) (higher productivity). Denote total cost as c, so $c_x = ac_x * X$. We then have $mc_x = dc_x/dX = X(dac_x/dX) + ac_x$. $(p_x - mc_x)$ then equals $(p_x - ac_x) - X(dac_x/dX)$. The first term accrues to the multinational but is zero in our model due to free entry. The second term including the minus sign is positive (decreasing average cost) and accrues to the Mexican economy as higher real wages.

> 0 due to the tariff on Z^*, this expression in the first set of square brackets in (17) contributes negatively to welfare if

$$(18) \qquad m_x^* > -\frac{E_x}{p_x^*}\frac{dp_x^*}{dE_x} > 0.$$

Most readers will recognize the right-hand side of (18) as the (inverse) price elasticity of foreign import demand for X. This inequality will hold if the actual markup applied by the exporters of X (m_x^*) is greater than the "optimal" export tax given by the right-hand side of (18). In other words, (18) holds if the country is "under exporting" X initially. This question has been much discussed in the trade industrial-organization literature, with Brander and Spencer (1985) showing that a single domestic Cournot firm under exports (the markup is too high), and Eaton and Grossman (1985) showing that a single Bertrand firm (or several Cournot firms) over export (the markup is too low).[3]

The optimal export tax formula takes into account a production response in the foreign country, implying that a given increase in domestic exports is larger than the resulting increase in the foreign consumption level since some foreign production is displaced: $dC_x^*/dE_x < 1$. This in turn implies that $-[dp_x^*/dC_x] > -[dp_x^*/dE_x]$. We can rewrite this last expression as

$$(19) \qquad \frac{E_x}{C_x^*}\left[-\frac{C_x^*}{p_x^*}\frac{dp_x^*}{dC_x^*}\right] = \frac{s_{mu}}{\sigma} > -\frac{E_x}{p_x^*}\frac{dp_x^*}{dE_x} \qquad s_{mu} \equiv \frac{E_x}{C_x^*}$$

The term in brackets on the left-hand side of (19) is the (inverse) Marshallian

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[3]See also Brown (1989) and Hertel (1992) for more general discussions concerning alternative pricing rules.

price elasticity of demand, denoted σ. The left-hand side of (19) is thus, in the context of the model to follow, the share of Mexican exports of autos in US auto consumption, denoted s_{mu}, divided by the Marshallian price elasticity of demand in the US.

In our model to follow, US multinational firms coordinate their exports from Mexico (and Canada) to the US with their US production and sales. These firms complete with one another according to a Cournot markup rule time a calibrated parameter that is very close to 1.0, so let's ignore the later. The markup m_x^* applied to Mexican exports is then given by the share of one US multinational in the US market, denoted s_{uu}, divided by the Marshallian price elasticity of demand: $m_x^* = s_{uu}/\sigma$. From (18) and (19), a *sufficient* condition for (18) to hold is thus that $s_{uu} > s_{mu}$: the share of one US multinational car producer in the US market must be larger than the share of all Mexican auto exports in the US market. In our data, s_{uu} is just over 10% (averaged over large and small firms) while s_{mu} is just over 1%. Thus in our data and theoretical model formulation, the inequality in (18) holds. Mexico is under exporting autos initially to the US (i.e., the initial markup is too high), and this in turn implies that the reduction in exports caused by the import tariff on Z^* contributes negatively to Mexican welfare according to the first bracketed term in (17).

The seconed term in square brackets in (17) consists of a term resulting from the distortion between price and marginal cost on domestic parts sales, and a terms-of-trade effect on imported parts. The sum of these two terms (the entire expression in the second set of square brackets) is analyzed by Markusen (1990). $(-Z^*dp_z^*) > 0$ due to the fact that the import tariff on Z^* drives down the import price of Z^*. This is the usual favorable terms-of-trade effect discussed earlier. In the conventional analysis of differentiated final goods (Flam and Helpman (1987), Venables (1987)), the first term $p_z m_z dZ$ is also positive, since the import tariff switches expenditure from the foreign goods to the domestic goods. Markusen (1990) shows that this effect can be reverse when the Z's are complementary intermediate inputs such that $p_z m_z dZ < 0$, and indeed the strength of this effect can outweigh the favorable terms-of-trade effect. Markusen shows that this "perverse" outcome is more likely as (A) the elasticity of substitution between Z and Z^* is low, and (B) the price elasticity of demand for X is high (in the present case, the domestic price elasticity). The latter effect strengthens the expenditure switching away from X when the price of Z^* increases, making it more likely that the negative scale effect on demand for Z outweighs the substitution effect in favor of Z.

This analysis establishes the theoretical plausibility that all three terms in (17) might be negative, or at least the plausibility that the entire expression is negative. Considering certain aspects of the Mexican auto (X) and auto parts industry (Z) that we have referred to and will expand upon below, there is then a prima facia case that Mexico's optimal (non-negative) protection level in that industry might be zero.

3. The Applied General-Equilibrium Model

The model consists of four regions: Canada (CAN), the United States (USA), Mexico (MEX), and the rest of the world (ROW). There are two final goods in the model and two primary factors, immobile between countries. Good Y is a homogeneous product produced by a competitive industry with constant returns to scale. Y is produced with a composite factor which we will refer to as "labor" (although it bears no relationship to empirical labor) and a sector-specific factor R. Y is numeraire, and the existence of R implies that labor must be drawn into the auto sector at increasing cost in terms of Y.

X is finished autos, which we have modelled as a homogeneous good.

There is clearly product differentiation by firm, but not by country per se (US consumers generally do not know if their US car is made in the US, Canada, or Mexico), so we have simply modelled cars as homogeneous. Cars are produced with "labor" and parts (Z) which are assumed to be differentiated by firm. Empirically, the types of parts produced and exported by firms in Mexico are quite different from the parts that are imported.

There are two types of auto firms in the model, North American (NA) and rest-of-world (R). Each NA firm is assumed to have plants in each of CAN, USA, and ROW initially, and to coordinate production, pricing, and shipments among the three markets to maximize firm profits. NA firms are assumed to be able to segment markets (consumer price arbitrage constraints do not bind) which is consistent with our evidence on prices in the three countries. R firms export to North American, but do not produce within North American.

Production cost for a type j firm (j = NA,R) in market i (C_i^j) is given by a constant marginal cost (for a given price of labor) (mc_i^j) times output plus a fixed cost (also a function of the price of labor) (fc_i^j).

$$(20) \qquad C_i^j = mc_i^j * X_i^j + fc_i^j, \qquad ac_i^j = C_i^j / X_i^j = mc_i^j + fc_i^j / X_i^j$$

where ac_i^j is average cost and X_i^j is output of a j-type firm in market i. The elasticity of scale (ϵ), which we get from engineering data combined with output data, is defined as the ratio of average to marginal cost.

$$(21) \qquad \epsilon_i^j \equiv \frac{ac_i^j}{mc_i^j} = 1 + \frac{fc_i^j}{mc_i^j * X_i^j}$$

Note that the elasticity of scale is a variable, and falls with firm output.

Firm type j sets a markup m_i^j in market i, and if it is a NA firm that also ships to market i from market k, joint maximization across plants requires that the marginal cost in i is equated to the delivered marginal cost from market k. Let τ_{ki} denote the shipping cost from market k to market i, and t_{ki} the ad valorem tariff rate from k to i. We assume that the tariff rate is applied to marginal cost plus transport cost. The pricing equations are thus

$$(22) \quad p_{xi}(1 - m_i^j) = mc_i^j = (1 + t_{ki})(mc_k^j + \tau_{ki})$$

We assume free entry and exit of firms such that profits equal zero. We make this operational by assuming zero profits at the plant level for NA firms. That is, no copy of an additional plant (same output, shipments, prices, and markups as existing plants) can make positive profits. For a NA plant located in market k and shipping to some or all of the three NA countries, this condition is given by

$$(23) \qquad \sum_i p_i^j m_i^j X_{ki}^j = fc_k^j \qquad i = (CAN,USA,MEX), \qquad j = NA$$

For the multi-plant firms (j = NA), equations (21), (22) (first equality), and (23) give us nine equations in nine unknown (i = CAN,USA,MEX). Variables p_{xi}, e_i^j, X_i^j, X_{ki}^j, are known, and our preliminary calibration program then solves this system for the nine unknowns m_i^j, mc_i^j, and fc_i^j. The estimates of the elasticity of scale and the free entry assumption are thus allowed to determine the initial markups.

These markups are then used to calculate a "conjecture parameter" Ω which reconciles the calibrated markup with a Cournot pricing rule.

$$(24) \qquad m_i^j = \Omega_i^j \left[\frac{s_i^j}{\sigma_i} \right]$$

where s_i^j is the share of a j-type firm in the sales of cars in market i, and σ_i is the Marshallian price elasticity of demand in market i. The term in brackets is the Cournot pricing rule for a homogeneous product, market share divided by the Marshallian price elasticity of demand. Markups are thus Cournot if $\Omega = 1$. Our calibration indicates that the US is somewhat more competitive than Cournot ($\Omega_{US}^{NA} = 0.88$), while Canada and Mexico are much more collusive than Cournot ($\Omega_C^{NA} = 2.45$, $\Omega_M^{NA} = 2.49$). The Ω's are held constant in subsequent analysis while the market shares are allowed to vary. Finally, the transport cost parameters τ are calibrated using (22).

The parts sector Z is assumed to be monopolistically competitive, with product differentiation by firm. While the multinational car producers certainly have significant parts production, there are a great many small producers as well (about 500 in Mexico, 2300 in the US). We thus make the modelling choice that parts producers are treated as small, independent, national firms. We will exposit just a two-region example to show how the parts sector works. In the notation of the previous section of this paper, domestic and foreign composite parts Z and Z^* are composed of the individual underlying parts from each country, and these are in turn aggregated into a single composite Z_c in a Cobb-Douglas nest.

(25)

$$Z_c = \left[\sum_i^{n_z} Z_i^\beta\right]^{\frac{\alpha}{\beta}} \left[\sum_j^{n_z^*} Z_j^{*\beta}\right]^{\frac{1-\alpha}{\beta}} = Z^\alpha Z^{*(1-\alpha)} \qquad Z \equiv \left[\sum_i^{n_z} Z_i^\beta\right]^{\frac{1}{\beta}}, \quad Z^* \equiv \left[\sum_j^{n_z^*}\right.$$

Let p_z denote the domestic price of the domestic parts composite Z. Any part produced will be produced in the same amount and priced the same, so we can deal with a representative part. It is assumed that the small parts producers cannot segment markets, so arbitrage constraints hold and we need only consider the domestic price received on both domestic and export sales. The price received by an individual domestic parts firms, p_{zi}, is the marginal product of Z_i in producing Z. The revenue of the producer is then $p_{zi}Z_i$. These are given by

$$(26) \qquad p_{z_i} = p_z(1/\beta)Z^{1-\beta}\beta Z_i^{\beta-1} \qquad R_{z_i} = p_{z_i}Z_i = \left[p_z Z^{1-\beta}\right]Z_i^{\beta}$$

We make the usual monopolistic-competition assumption that each parts producer views itself as small in the market, so that Z and p_z are viewed as constant. Hence the bracketed term in the second equation of (26) is viewed as constant. Marginal revenue for an individual parts producer is thus given by

$$(27) \qquad MR_{z_i} = dR_{z_i}/dZ_i = \left[p_z Z^{1-\beta}\right]\beta Z_i^{\beta-1} = p_{z_i}\beta$$

Price is a constant markup over marginal cost. We assume the same type of cost function that we did for auto producers: a fixed cost plus a constant marginal cost. Free entry produces zero profits: price equals average cost. Together these give us

$$(28) \qquad \left[p_{z_i}\beta = mc_z, \;\; p_{z_i} = ac_z\right] \;\; \Rightarrow \;\; \epsilon_z \equiv ac_z/mc_z = 1/\beta$$

where ϵ_z is the elasticity of scale in parts production. Our data estimates of these elasticities give us estimates for the substitution parameter β for each country's parts composite (i.e., these vary across countries).

Note that (28) implies that Z_i and Z_i^* are constants; since parts are produced using only the composite factor "labor", ac/mc is independent of factor prices and depends only on Z_i. If ac/mc is constant, so is Z_i. The parts industry expands through the addition of new firms (Helpman and Krugman (1985) provide extensive discussions of this type of model). The production functions for the parts composites can be written as

$$(29) \qquad Z = n_z^{1/\beta} Z_i, \qquad Z^* = n_z^{*(1/\beta)} Z_i^*$$

where Z_i and Z_i^* are constants. We thus have convenient "industry" production functions for the parts composite of each country in (29), with that production function homogeneous of degree $1/\beta_i > 1$ in country i. We use this simplification in computing the solution to the model.

4. Data, Results, Interpretations

Tables 1 through 5 present some of the data used in the model and several key calibrated parameters. Table 1 gives GNP, the elasticities of scale in autos and parts production, the number of firms operating in the country, relative prices of cars and parts in terms of the composite commodity, and the share of North American firms in total auto sales in each country. Note that the number of firms producing in the US is not the same as the number of those in Canada and Mexico, so we made a modelling simplification in this regard when we assumed that all NA firms operate in all three countries.[4]

Table 2 gives protection levels and includes conversion of non-tariff barriers to tariff equivalents. We regard this as appropriate for present purposes, which is assess the effects of protection when we have intermediate goods of this type, rather than to predict the effect of a free trade area per se. In a later paper, we will attempt to model the various non-tariff barriers on content protection, balance of payments, ownership, etc.

Table 3 gives flows of finished autos in billions of US dollars. Since autos are treated as a homogeneous good, we list net trade flows (exports minus imports) in this table. Table 3 also gives parts flows, where two-way flows are listed since parts are assumed differentiated by firm. Parts include engines, but parts used in the production of parts are netted out (our figure for this intermediate use is 20%). Note that Mexico is a net exporter of cars to the US and a net importer of parts from the US.

Table 5 gives some calibrated parameters and "guesstimates". PS is the share of purchased parts in car production, while PC is the share of parts sold directly to final consumption (spares). We don't have good figures for

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[4]The five firms in Canada are not the same five as those in Mexico. Six of the eight US firms produce in either Canada or Mexico. See Hunter, Markusen, and Rutherford (1992) for more details and a discussion of our modelling assumption.

PS, but PC is between 20 and 30%, so by setting PC in this range we infer values for PS. The lower value in the US than Canada and Mexico suggests more integrated plants in the US. The figures for ROW seem inaccurate; the ROW parts industry should be much larger, but this likely has a trivial effect on our results for NA liberalization. m^{NA} and Ω^{NA} are the calibrated values of the markup and "conjecture" parameters respectively. The latter are much higher for Canada and Mexico relative to the US (more collusive pricing in the smaller economies) and, while they take on similar values in Canada and Mexico, Canada has a much smaller markup due to the fact that firms in Canada have individually smaller market sizes. η is the elasticity of the "wage rate" (marginal cost of production) with respect to auto sector production. 0.20 indicates that a doubling of auto production would increase marginal cost by 20%, a simple guess on our part. This elasticity is used to calibrate the share of the specific factor in the composite sector (see Hunter, Markusen, and Rutherford). σ is the elasticity of substitution in consumption between the composite commodity and autos. This elasticity plays little role given the way we have constructed the model; increasing it would just be compensated for by an increase in the conjecture parameters.

TABLE 1: DATA PARAMETERS

	GNP	ϵ_x	ϵ_x	N	p_x	p_x	s^{NA}(%)
CAN	543.63	1.15	1.2	5	1.15	1.05	49.53
USA	5166.09	1.1	1.1	8	1.0	1.00	83.79
MEX	211.97	1.7	1.5	5	1.4	1.20	100.00
ROW	17495.40	1.1	1.1	12	1.0	1.05	

TABLE 2: PROTECTION LEVELS

	CAN.CARS	USA.CARS	MEX.CARS	ROW.CARS
CAN			.335	.125
USA			.335	.125
MEX	0.095	0.038		.125
ROW	0.095	0.038	.335	

	CAN.PARTS	USA.PARTS	MEX.PARTS	ROW.PARTS
CAN			0.17	0.065
USA			0.17	0.065
MEX	0.092	0.040		0.065
ROW	0.092	0.034	0.16	

TABLE 3: TRADE FLOWS: CARS (NET) AND PARTS (GROSS)

	CAN.CARS	USA.CARS	MEX.CARS	ROW.CARS
CAN	3.347	11.970		
USA		140.345		
MEX		1.989	4.430	0.243
ROW	3.496	32.027		400.199

	CAN.PARTS	USA.PARTS	MEX.PARTS	ROW.PARTS
CAN	2.680	6.392	0.072	0.152
USA	9.669	71.267	2.664	3.532
MEX	0.285	0.870	3.505	0.587
ROW	1.929	11.564	0.427	149.167

TABLE 4: CALIBRATED AND SELECTED PARAMETERS

	PS	η	σ	PC	m^{NA}	Ω^{NA}
CAN	0.70	0.20	1.0	0.27	.240	2.45
USA	0.50	0.20	1.0	0.22	.091	0.88
MEX	0.70	0.20	1.0	0.23	.499	2.49
ROW	O.35	0.20	1.0	0.01		1.00

Table 5 gives the effects of a North American free trade area (NAFTA) in autos and parts, removing all protection on autos and parts within North America. All variables are in percentage changes except the last two. Mexico is a major gainer from this liberalization, gaining 0.9%. This is impressive since the sector is less than 3% of GNP and since US protection is initially very low. The US and Canada suffer trivial losses. Mexico has a large gain in auto output (147%) along with a strong rationalization effect on output per firm (114%). Parts output increases by 24% despite the fact that it is a net import industry (exports decrease, imports increase). The US experiences essentially a zero change in parts production, as increased exports to Mexico are balanced by the loss of domestic sales. The Mexican price of autos falls significantly (11%) generating a further consumer surplus gain to complement the industrial organization gains.

Table 6 analyzes a unilateral Mexican policy of removing protection against US and Canadian auto parts. The resulting Mexican welfare gain is highly significant given the size of the sector, and given that it has some monopoly power over the inputs as noted above. Here we see some of the effects identified in the theoretical section of the paper. Output per firm in autos

TABLE 5: NAFTA, ALL PROTECTION REMOVED WITHIN NORTH AMERICA

(% change in)	CAN	USA	MEX	ROW
WELFARE	-0.01	-0.01	0.90	
NUMBER OF AUTO FIRMS	0.54	-1.76	15.24	
AUTO OUTPUT	-2.97	-4.91	146.54	-0.32
AUTOS PER FIRM	-3.48	-3.21	113.93	-0.33
PARTS OUTPUT	-2.12	-0.15	23.73	-0.36
AUTO EXPORTS	-4.18		408.51	-5.18
AUTO IMPORTS	-1.12	15.35		-100.00
PARTS EXPORTS	-2.72	14.27	-2.02	-1.52
PARTS IMPORTS	-1.59	-3.76	86.87	-0.35
PRICE OF AUTOS	-0.20	-0.13	-11.15	-0.05
NA FIRM MARKUPS (level)	0.24	0.09	0.43	
ROW FIRM MARKUPS (level)	0.10	0.01		0.08

TABLE 6: MEXICAN PROTECTION AGAINST US AND CANADIAN PARTS REMOVED

(% change in)	CAN	USA	MEX	ROW
WELFARE			0.40	
NUMBER OF AUTO FIRMS	-0.75	-0.99	6.95	-0.31
AUTO OUTPUT	-2.38	-2.20	81.91	-0.30
AUTOS PER FIRM	-1.63	-1.22	70.08	
PARTS OUTPUT	-0.98	0.24	12.43	-0.30
AUTO EXPORTS	-2.96		226.01	-0.47
AUTO IMPORTS	0.14	6.88		558.32
PARTS EXPORTS	-1.01	8.26	-2.61	-0.64
PARTS IMPORTS	-1.51	-1.74	51.56	-0.35
PRICE OF AUTOS		-0.05	-8.02	-0.05
NA FIRM MARKUPS (level)	0.24	0.09	0.47	
ROW FIRM MARKUPS (level)	0.10	0.01		0.08

TABLE 7: MEXICAN PROTECTION ON US AND CANADIAN PARTS LOWERED TO 1%

(% change in)	CAN	USA	MEX	ROW
WELFARE			0.39	
NUMBER OF AUTO FIRMS	-0.70	-0.93	6.54	-0.30
AUTO OUTPUT	-2.23	-2.07	77.38	-0.29
AUTOS PER FIRM	-1.54	-1.15	66.49	
PARTS OUTPUT	-0.92	0.22	11.88	-0.28

expands significantly (70%) (footnote 2, section 2) so the Mexican economy captures the benefits of decreasing average cost (increasing productivity). Auto exports from Mexico expand significantly (226%), and we argued earlier that they are under exported initially. Parts production expands in Mexico (12%) as do parts imports (52%) which help fuel the auto sector expansion. As discussed in section 2, domestic Mexican auto parts are under supplied initially, so this expansion in the Mexican parts sector confers a welfare benefit to Mexico.

The welfare increase in Table 6 from Mexico's unilateral elimination of its 17% protection against US and Canadian parts does not imply that there might not be some optimal protection level between zero and 17% which increases welfare above either extreme. Simulations in between these values convinces us that welfare is monotonically decreasing with protection on parts, and we report partial results for lowering protection to 1% in Table 7. Welfare for Mexico increases by 0.39%, less than the 0.40% increase under full removal of protection. Relative to free trade in parts, the 1% protection on parts reduces domestic production, consumption and export of autos and reduces the domestic production of auto parts. Domestic and foreign parts are indeed general-equilibrium complements in our model. The theory in section two above thus helps explain the result that this small level of protection is welfare reducing despite the existence of some monopoly power in trade for Mexico.

5. Summary and Conclusions

Existing analyses of increasing-returns, differentiated products have generally focused on final consumer goods, and have made the natural assumption in this context that domestic and foreign varieties are better substitutes for one another than for other classes of commodities. Since the domestic goods are undersupplied in initial free-trade equilibrium (price exceeds marginal cost), protection has the beneficial effect of shifting expenditure to the domestic goods, thereby creating a welfare benefit to the domestic economy in addition to the normal terms-of-trade effect.

Markusen (1989, 1990) focuses on differentiated intermediate inputs following Ethier (1982), and raises the possibility of complementarity between domestic and foreign inputs. This then reverses the above argument about protection. The present paper reviews this point and then adds a further consideration. If the intermediates are in turn used as inputs into a good(s) produced with increasing returns, and therefore also undersupplied initially, we have a further argument against protection.

After developing the theoretical argument, the paper extends the earlier auto model of Hunter, Markusen, and Rutherford by adding a parts sector. The earlier paper focussed on the effects of multinational price and output coordination, and on the consequence of market segmentation. In this paper, the extended model is used to evaluate trade policy for the differentiated intermediates. We find that the welfare-maximizing unilateral, non-negative protection policy for Mexico is zero protection on parts. Protection reduces the output and exports of the increasing- returns auto sector, and also reduces the output of the increasing-returns domestic Mexican parts sector. These generate negative welfare effects that dominate whatever small terms-of-trade benefit such protection might generate for Mexico. Given the large share of producer intermediate goods in total imports of many developing countries, these results may have some general applicability.

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(Data sources are listed in Hunter, Markusen, and Rutherford)