Increasing Returns Versus National Product Differentiation as an Explanation for the Pattern of US-Canada Trade*

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Armington Vs. Krugman

A Test of Two Trade Models

Abstract

We evaluate two alternative models of international trade in differentiated products. An increasing returns models where varieties are linked to firms (Krugman model) predicts that increases in a country's share of demand translates to disproportionate increases in its share of output. In contrast, a constant returns model with varieties differentiated by nationality (Armington model) predicts a less than proportionate increase. We examine a panel of U.S. and Canadian manufacturing industries to test the models. While we find support for either model depending on whether we estimate based on within or between variation in the data, the preponderance of evidence supports the Armington specification.

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The monopolistic competition trade model introduced by Krugman (1980) predicts that strong demand at home raises domestic production for export. A large home market for the products of a manufacturing industry translates into a disproportionate share of output and a trade surplus. This "home market effect" derives from the choice of location by mobile firms producing symmetric varieties. A reduction of trade barriers in this model causes firms to relocate to the larger market and serve the small market through exports. In contrast, when varieties are tied to the nation of production—the Armington (1969) assumption—and there are constant returns to scale, the home market effect is reversed: The smaller country may be the net exporter of manufactures. Moreover, trade liberalization enables the small country's industry to increase its share of output because small-market firms gain improved access to the consumers in the larger foreign market.

The contrasting predictions of what we will refer to as the Krugman and Armington models are reflected in different relationships between a country's share of production and its share of demand. The Krugman model predicts that an increase in the demand share of one trading partner will elicit a more than one-for-one increase in that country's output share whereas the Armington model predicts a less than one-for-one relationship.

We use matched 3-digit industry data for Canadian and U.S. manufacturing for the period 1990–1995 to evaluate the models. Alternatively using between (cross-sectional) and within (time-series) variation in our panel, we provide estimates of the slope of the line relating a country's share of output in an industry to its share of demand in that industry. Our sample period includes tariff reductions mandated by the 1988 Canada-U.S. Free Trade Agreement (FTA). Information on tariffs enables us to conduct four useful exercises. First, we measure the elasticity of substitution between varieties, a key parameter in both the Armington and Krugman models. Second, we decompose the "border effect" impeding consumption of goods produced abroad into the portion attributable to tariffs and the portion resulting from all other trade barriers. Third, we assess the influence of tariffs on the slope of the output share–demand share relationship which we show to differ depending on the model. Finally, we examine how industries with relatively large demand shares differ from those with small demand shares in terms of the effect of trade liberalization on the share of output.

An empirical assessment of the Krugman and Armington models is important to policy and research. Under Krugman, trade liberalization reinforces the advantage associated with producing in the large country. Thus, a reduction in trade costs could result in the decrease or even elimination of small-country manufacturing. On the other hand, in the Armington model trade liberalization benefits small-country manufacturing in terms of greater trade surpluses. A test of the models against the data may also help guide the modeling choices of researchers. Features of both models are used extensively in international trade research and the findings will either support an increasing returns or constant returns depiction of the manufacturing economy.

The hypothesis that home demand plays in crucial role in explaining export performance was first proposed by Linder (1961).[1] He states, "It is a necessary, but not a sufficient, condition that a product be consumed (or invested) in the home country for this to be a potential export product (page 87)." Krugman (1980) develops a model showing how increasing returns, demand-size asymmetries, and trade costs combine to generate predictions about net exports. As we rely heavily on the formal structure developed in Krugman (1980), we refer to the monopolistic competition model with transport costs as the Krugman model, while recognizing its important antecedents in

[1] We thank a referee for alerting us to the relevance of Linder's work to the home market effect literature.

Linder's early analysis. Our derivation of the relationship between a country's share of firms and its share of demand parallels development of the Krugman model contained in Helpman and Krugman (1985).

We develop a Armington trade model as an alternative to the Krugman model. In this model, goods in each industry are distinguished by nationality, there is a constant elasticity of substitution between an industry's goods, and perfect competition prevails. We show these two trade models can be tested based on the relationship between a country's share of demand and its share of production. Namely, in contrast to the Krugman model, the Armington model predicts that the slope of the line relating production share and demand share will be less than one.

Feenstra, Markusen, and Rose (1998) present a free entry, imperfect competition, homogeneous good model that gives rise to a home market effect. They develop the "reciprocal dumping model" introduced by Brander (1981) where oligopolists sell output in segmented national markets. They find, however, that when the number of firms is fixed in this model a "reverse home market" effect occurs. Namely, an increase in a country's demand generates a less than one-for-one change in its output. In this paper, we show that a reverse home market effect also occurs in the Krugman model when the number of firms is held constant. This implies that the relationship between changes in a country's share of demand and changes in its share of output are similar for the short-run version of the Krugman model (where the number of firms are fixed) and the Armington model.

The key feature of our Armington model is that a reallocation of demand from one country to another does not influence where each variety is produced. Unlike the Krugman model where relative demand considerations and economies of scale in production can induce the complete exit of firms from the small country, the Armington model predicts that production will occur in both countries regardless of market size. It is not surprising that fixed-firm versions of imperfect competition models yield similar results to the Armington model. With firms producing in both countries, an increase in demand in one country will be met by additional output in both countries resulting in a less than one-for-one relationship between changes in demand shares and changes in output shares.

Moreover, models that predict that countries will specialize in different goods in an industry can generate reverse home market effects without assuming that varieties are differentiated by nationality. Davis (1995) shows that two countries may specialize in different goods produced with identical factor proportions due to Ricardian differences in production efficiency. If the goods are classified as being in the same industry, an increase in demand for goods in that industry will be met by increased production in both countries. Seen in this light, the Armington model we propose may be viewed as representative of a broader class of models where a larger market does not induce reallocation of the location of firms and product varieties.

Recent empirical papers test for home market effects using cross-sectional information or pooled cross-sectional and time-series information. Weder (1997) evaluates U.S.-U.K. trade for 26 products over the period 1970-1987. He finds that relative demand has a positive relationship with net exports which supports the Krugman model. Davis and Weinstein (1998, 1999) argue that, as a benchmark, a country allocates resources to produce goods in the same proportions as other countries. Production deviates from this benchmark due to differences in endowments and demand. Davis and Weinstein (1998) analyze 1985 production and trade data at the 4-digit level for OECD countries. They find that relative differences in spending patterns across countries translate into differences in relative production. Specifically, a nation that spends a higher proportion of its income on a good will tend to produce more of that good. While the magnitude of this effect varies across industries, the pooled results reveal a more than one-for-one relationship, thus indicating home market effects on average. The Davis and Weinstein (1999) examination of Japanese regional data identifies home market effects for eight of 19 industries in their sample.

Empirical research continues with Trionfetti (1998) who analyzes 1985 manufacturing data for 18 sectors in eight European countries. The critical element of his model are home-biased expenditures which he measures using input-output matrices. He distinguishes Krugman increasing-returns, monopolistic competition industries (IRS-MC) from constant-returns, perfect competition industries (CRS-PC) by the response of output shares to shares of home-biased expenditures. Based on estimates of this relationship for individual sectors (each with eight observations), he identifies six sectors as IRS-MC, nine sectors as CRS-PC, with with the remaining sectors undetermined. Feenstra, Markusen, and Rose (1998) examine bilateral exports for a large sample of countries for the years 1970, 1975, 1980, 1985, and 1990. Their cross-sectional results based on a gravity model specification show home market effects for goods classified as differentiated and reverse home market effects for homogeneous goods.

In the following section, we develop common aspects of the Krugman and Armington models and generate a method of utilizing market share information to calculate annual measures of the border effect between Canada and the United States. We present a decomposition of the border effect between tariff barriers and non-tariff barriers and provide estimates of the average elasticity of substitution between goods for 3-digit SIC industries. In section 3, we establish that both models imply a linear relationship between a country's share of production and its share of demand. The Krugman model predicts a slope greater than one whereas the Armington model generates a slope less than one. We also demonstrate that tariffs interact with the demand share in different ways: in the Krugman model, higher tariffs reduce the slope whereas the opposite interaction occurs in the Armington model. This section tests these competing predictions of the models for the relationship between output shares and demand shares and the sensitivity of this relationship to tariffs. With only six years of data for each industry, we do not attempt to categorize individually the 106 manufacturing industries studied in this paper. Rather, we examine whether the behaviour exhibited by manufacturing industries as a group adheres more closely to the Armington or the Krugman model. We summarize our findings in the final section.

1 Two Competing Models of Trade

In this section we develop the basic structure of the two alternate trade models. Both models are consistent with a salient feature of North American trade, namely that intra-industry trade exists between Canada and the United States in each 3-digit manufacturing industry.[2] Furthermore, both models are special cases of the same underlying preference structure. As a consequence, both models give rise to the same methodology for identifying the magnitude of trade barriers. The models differ dramatically, however, in their predictions for the effects of how a redistribution of demand would affect the allocation of production.

The first model adapts Dixit and Stiglitz's (1977) model of monopolistic competition to allow for trade subject to transport costs. Since the original statement of this model is by Krugman (1980) and it forms the basis for much of his subsequent work in trade and

[2]Net trade averaged 33% of total bilateral trade for our sample of industries in 1995, yielding a Grubel-Lloyd intra-industry trade index of 67%.

economic geography, we will refer to this model as the Krugman model.[3] A key feature of this model for our purposes is that it identifies product varieties with individual *firms*. The second model takes the alternative approach of identifying varieties with *nations*. Armington (1969) argued that a useful assumption for working with trade data is that "products are distinguished by place of production." He proposed a utility function in which each country makes different products which are viewed as imperfect substitutes by consumers. Armington's formulation has been used for estimation of the response of trade flows to price movements and has become a common feature of computable general equilibrium models.

We begin with a structure that is general enough to include both the Krugman and Armington models as special cases. The market consists of two countries, Canada and the United States. Variables associated with the U.S. have an asterisk superscript. Our focus is on the manufacturing sector that consists of I industries denoted with the subscript i. Within each industry there are n_i varieties manufactured in Canada and n_i^* varieties manufactured in the United States.

We assume that the marginal costs of production for firms in the manufacturing sector are exogenous. To generate this outcome, we assume a "numeraire" sector Z with constant returns to scale, perfect competition, and no trade costs.[4] This non-manufacturing sector establishes the prices, w and w^*, of the single factor, labour. Productivity differences between the United States and Canada in the numeraire sector could create a wedge between w and w^*. Trade deficits or surpluses in the manufacturing sector will be offset by the balance in the numeraire sector.

[3]The model has been further developed by Helpman and Krugman (1985) and Weder (1995) and we draw on their insights here.

[4]The zero trade cost assumption is not innocuous. Davis (1998) shows that the home market effect disappears when trade costs are higher for manufactures than the numeraire sector.

The representative consumer is assumed to have a two-tier utility function. The upper tier is a (logged) Cobb-Douglas function of the utility derived from consumption of the goods in each industry:

$$\mathcal{U} = \sum_{i=1}^{I} \alpha_i \ln u_i + (1 - \sum_{i=1}^{I} \alpha_i) \ln Z \text{ and } \mathcal{U}^* = \sum_{i=1}^{I} \alpha_i^* \ln u_i^* + (1 - \sum_{i=1}^{I} \alpha_i^*) \ln Z^*. \qquad (1)$$

where α_i and α_i^* are parameters in the Cobb-Douglas function, and Z and Z^* represent consumption levels of the numeraire good in each country.

Maximization of utility implies that expenditures in Canada and the U.S. in each manufacturing industry will be given by $E_i = \alpha_i wL$ and $E_i^* = \alpha_i^* w^* L^*$, where L and L^* represent the labour force in each country and therefor wL and w^*L^* are the national incomes. A crucial variable in the model, the Canadian demand share is given by

$$\text{shr}(E_i) \equiv E_i/(E_i + E_i^*) = 1/(1 + [(\alpha_i^*/\alpha_i)(w^*/w)(L^*/L)]).$$

Thus, Canada's demand share will vary across industries due to preference differences in the upper tier function. Demand shares will vary over time due to changes in preferences, relative wages, and labour supplies.

In turning to the lower tier choice between varieties in each manufacturing, we will omit the i subscript for now and examine expenditure allocation in a representative industry consisting of multiple product varieties. Canadian varieties are numbered from $j = 1$ to $j = n$. American varieties begin with $j = n+1$ and continue to $j = N = n+n^*$. Consumption of each variety is denoted with D_j in Canada and D_j^* in the United States.

The lower tier utility function is given by

$$u = \left(\sum_{j=1}^{n}(\gamma D_j)^{\frac{\sigma-1}{\sigma}} + \sum_{j=n+1}^{N}(\delta D_j)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

$$u^* = \left(\sum_{j=1}^{n}(\gamma^* D_j^*)^{\frac{\sigma-1}{\sigma}} + \sum_{j=n+1}^{N}(\delta^* D_j^*)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

The Dixit-Stiglitz utility function used by Krugman can be obtained by equating all the utility function parameters, i.e. by setting $\gamma = \delta = \gamma^* = \delta^* = 1$. In that case all varieties are symmetrically differentiated. The Armington formulation arises when $n = n^* = 1$. In the general formulation, the consumer's allocation of their total industry expenditures depends on preference parameters, the number of varieties produced in each country and the price of each variety faced by the consumer. Since consumers spend a constant share of expenditures on each industry's goods, consumption decisions in one industry are independent of the prices of varieties in other industries.

Trade barriers create wedges between the price paid for locally produced and imported products. Consumers in Canada pay p for Canadian goods and $p^*\tau$ for imports (where $\tau \geq 1$) from the United States. Similarly, consumers in the U.S. pay p^* for U.S.-made goods and $p\tau$ for goods they import from Canada. This implies that $\tau - 1$ is the tariff-equivalent of the trade barrier between the two countries.[5]

Maximizing lower tier utility yields expressions for the share of Canadian expenditures devoted to Canadian-made varieties and the share of U.S. expenditures on U.S.-produced varieties, which we label x and x^*.

$$x = \frac{n(p/\gamma)^{1-\sigma}}{n(p/\gamma)^{1-\sigma} + n^*(\tau p^*/\delta)^{1-\sigma}}, \tag{4}$$

[5] The assumption of symmetric barriers simplifies the model. It is also important at the estimation stage because it reduces the number of interactions to be estimated. Tariffs in the U.S. and Canada were highly correlated (0.66 in 1988) although Canadian tariffs were somewhat higher on average.

$$x^* = \frac{n^*(p^*/\delta^*)^{1-\sigma}}{n(\tau p/\gamma^*)^{1-\sigma} + n^*(p^*/\delta^*)^{1-\sigma}}. \quad (5)$$

The results are more intuitive if we reduce the dimensionality of preference parameters by assuming

$$\gamma/\delta = kh \quad \text{and} \quad \gamma^*/\delta^* = k/h.$$

In this formulation, k represents the "common" assessment of all consumers in the market over the relative quality of Canadian versus American varieties. Meanwhile h represents the "home bias" each consumer. The larger is h the more Canadians prefer goods made in Canada and Americans prefer goods made in the United States. In a symmetric home bias model, k would equal one.

In the analysis that follows, we assume industries are identical except for differences in exogenously given expenditure shares, $\text{shr}(E)$, and trade costs, τ. These differences give rise to variation in trade patterns across industries. In the empirical analysis we estimate model parameters common to all manufacturing industries based on variation in expenditure shares and trade costs. To simplify the presentation, we continue to omit industry subscripts in the derivations that follow.

2 Measuring and Decomposing Trade Barriers

Now we may define the parameter that quantifies the importance of trade barriers. Let $b \equiv (h\tau)^{\sigma-1}$ represent the border effect, i.e. the advantage domestically manufactured goods have relative to imports in either country. The higher the degree of home bias h and trade costs τ, the greater the border effect.

We use a second parameter a to measure the asymmetry between the two countries. It is defined such that increases in a raise the market shares of Canadian varieties in both countries: $a \equiv [k(p^*/p)]^{\sigma-1}$. We now re-express the share equations as

$$x = \frac{b}{b + n^*/(an)}, \tag{6}$$

$$x^* = \frac{b}{b + (an)/n^*}. \tag{7}$$

As $b \to \infty$, x and x^* will approach 1. Using equations 6 and 7 we may infer the value of b pertaining to each industry in each year. In doing so it is not necessary to make any assumptions on the number of varieties produced in each country. The border effect is calculated as the geometric mean of domestic firms' success relative to foreign firms' success in each home market:

$$b = \sqrt{\frac{x}{1-x}\frac{x^*}{1-x^*}}. \tag{8}$$

We use annual data on Canadian and U.S. shipments, bilateral exports, and world exports, to calculate annual measures x and x^*. To maintain consistency with our two country model, x represents Canadian producers' share of the Canadian market for North American (Canadian and U.S.) goods. Correspondingly, x^* is U.S. producers' share of the U.S. market for North American goods (see the data appendix for the sources and construction of these variables).

Figure 1 displays inferred annual values of b for different quartiles of our manufacturing industries over the period 1990 to 1995. Each of the three quartiles shown reveal a sharp drop in b over time. As a measure of the "odds" of purchasing from a domestic manufacturer, the range of b for the median industry of 20 in 1990 and 11 in 1995 indicates that a consumer was 20 and 11 times as likely to purchase from local producers as foreign producers in those years. Seven years after the signing of the FTA, the North American manufacturing sector is still quite far from frictionless integration which would

Figure 1: Quartiles for Industry Level Border Effects, 1990–95

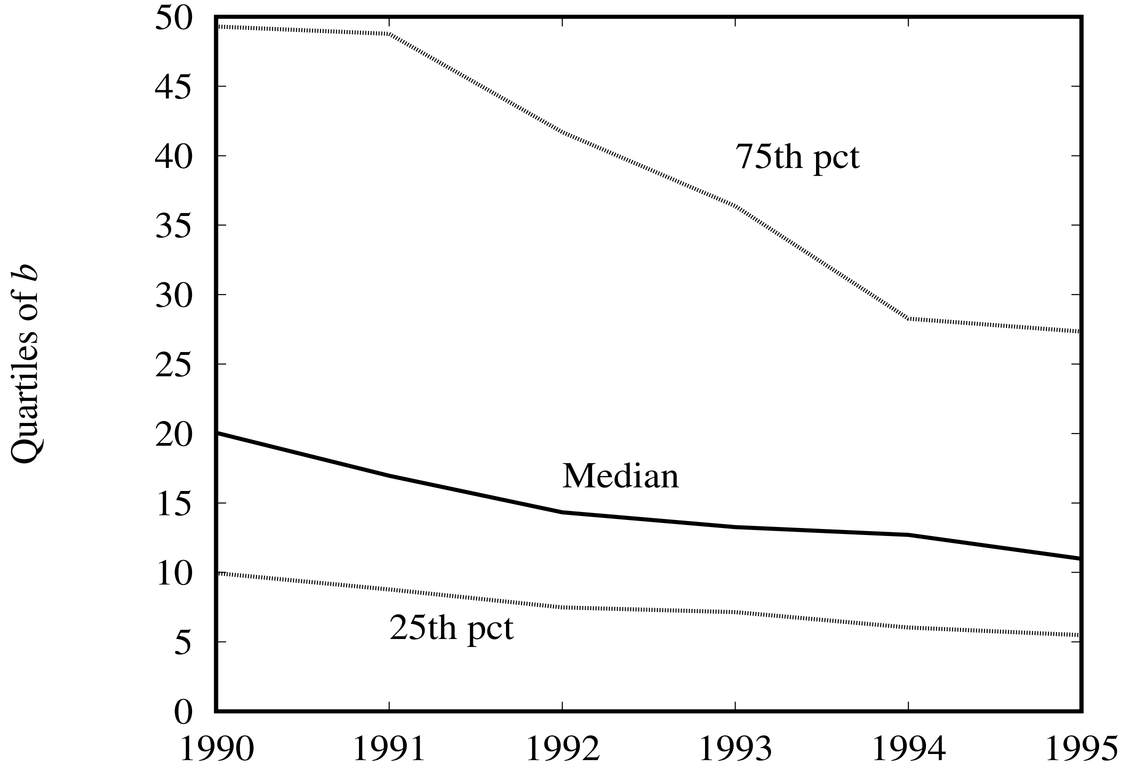
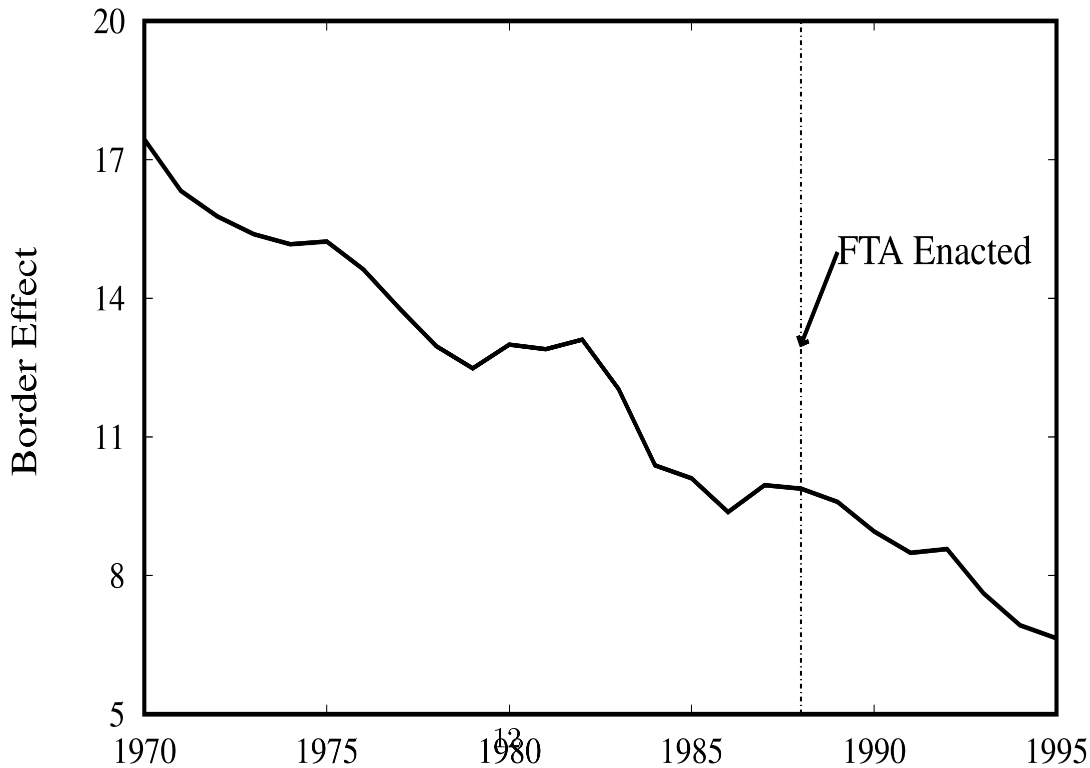


Figure 2: Border Effects for Canada's Manufacturing Sector, 1970–95



be the case when the value of b attains unity. Figure 2 displays the border effect over the period 1970-1995 calculated from aggregate manufacturing data. It reveals that the trend towards lower border costs has been under way for two decades.[6]

Can we attribute the decline in border effects to FTA tariff reductions? To investigate this question, we decompose the border effect as follows:

$$b \equiv (h\tau)^{\sigma-1} = ((1 + \mathrm{NTB})(1 + \mathrm{TAR}))^{\sigma-1}, \tag{9}$$

where TAR and NTB represent the *ad valorem* rates of tariffs and non-tariff barriers. We define NTB to comprise all barriers to export success other than tariffs, including transportation costs, home bias (h), and any government policies that favour domestically produced goods over imports. Other authors using different methodologies have estimated the overall border effect (McCallum (1995), Helliwell (1996), and Wei (1996)) but have not decomposed it into tariff and non-tariff barrier components. Denoting industries with i and years with t, note that we observe TAR_{it} (see data appendix) but must infer NTB_{it} as a residual. We assume that $(\sigma - 1)\ln(1 + \mathrm{NTB}_{it})$ can be approximated as $(\sigma - 1)\ln(1 + \overline{\mathrm{NTB}}_t) + \epsilon_{it}$. Substituting, we obtain a log-linear regression equation:

$$\ln(b_{it}) = (\sigma - 1)\ln(1 + \overline{\mathrm{NTB}}_t) + (\sigma - 1)\ln(1 + \mathrm{TAR}_{it}) + \epsilon_{it}. \tag{10}$$

We estimate the first term with year dummies. Note that almost any border effect can be obtained from tiny tariff barriers if the elasticity of substitution, σ, is high enough.

[6]The level of the border effect based on aggregate data for the period 1990-1995 is lower than than the border effect based on the average across industries. This is because aggregate manufacturing data disproportionately reflects large sectors like motor vehicles that have low barriers to trade.

Table 1: Decomposing Changes in Trade Costs into Tariff and Non-Tariff Effects

	Dependent Variable: Ln Border Effect: ln(b)			
Model :	(1:OLS)	(2:FE)	(3: OLS NTB_t)	(4:FE NTB_t)
Ln 1 + Tariff	10.409[a]	6.882[a]		
	(1.916)	(1.532)		
Intercept (1990)	2.742[a]	2.883[a]	30.1%	52.0%
	(0.139)	(0.070)		
1991	-0.074	-0.082[b]	29.2%	50.2%
	(0.159)	(0.040)		
1992	-0.123	-0.156[a]	28.6%	48.6%
	(0.161)	(0.044)		
1993	-0.166	-0.240[a]	28.1%	48.6%
	(0.164)	(0.050)		
1994	-0.212	-0.30[a]	27.5%	45.5%
	(0.167)	(0.056)		
1995	-0.242	-0.335[a]	27.1%	44.8%
	(0.169)	(0.061)		
N	615	615		
R^2	0.073	0.387		
RMSE	1.133	.275		

Note: Standard errors in parentheses with [a], [b] , and [c] denoting significance at the 1%, 5%, and 10% level. Column (1) reports OLS regressions and column (2) reports industry fixed-effect regressions. Columns (3) and (4) convert the year dummies from columns (1) and (2) into tariff equivalents

Column (1) of Table 1 presents results for OLS estimation whereas column (2) reflects results when we add industry fixed effects. The coefficient on the tariff variable implies that the elasticity of substitution between goods, σ, ranges between 7.9 (fixed effects) and 11.4 (pooled OLS). The reduction in estimated σ caused by controlling for industry-specific effects suggests that the OLS estimate is upwardly biased due to a positive correlation between tariff levels and fixed, unmeasured characteristics of industries that raise b_{it}. While even the fixed effects estimate of σ may appear high, it is consistent with results in several other recent studies. Feenstra (1994) estimates price elasticities for a demand and supply system using a panel of exporting countries over the years 1964–1987. He obtains 95 percent confidence intervals for six products with an average lower bound of 3.9 and average upper bound of 8.8.[7] Baier and Bergstrand (1999) fit a gravity equation to bilateral trade between 16 industrialized countries. They obtain a point estimate for the elasticity of substitution equal to 6.43 with a 90 percent confidence interval of [2.44, 10.4]. Hummels (1998) calculates σ equal to 7.6 using information on how freight costs affect trade. Using a methodology based on geographic variation in wages, Hanson (1998) obtains estimates of σ that range between 6 and 11. Eaton and Kortum (1998) estimate a model based on technology differences but obtain a value of 8.3 for a parameter that is observationally equivalent to our σ.

Our estimates tend to be higher than those obtained from directly estimating import price elasticities. For example, Blonigen and Wilson (1999) report an average elasticity across 146 3-digit sectors of just 0.81. They obtain their estimates by regressing the ratio of imports to domestic output on the import/domestic price ratio using quarterly U.S. data for the period 1980–1988. There are four potential explanations for the difference

[7]The six products and their 95 percent confidence intervals are men's leather athletic shoes [4.4, 10.6], men's and boy's cotton knit shirts [4.2, 11.0], stainless steel bars [2.8, 5.3], carbon steel sheets [3.0, 10.0], color TV receivers [6.4, 12.3], and portable typewriters [2.5, 3.6].

between their estimates and ours. First, we consider U.S. and Canadian goods which may be closer substitutes than U.S. goods and aggregate U.S. imports. Second, increases in import prices partially reflect increases in average import quality. These unobserved changes in the nature of the import mix would tend to attenuate the negative demand response to higher prices. Third, if the supply curve for imports is upward sloping, OLS estimates will suffer from simultaneity bias. Finally, since the Blonigen and Wilson estimates mainly reflect on *quarterly* variation in output and prices, they might be more appropriately seen as short-run price elasticities. Overall, there is significant variation in the elasticity estimates in the empirical literature. Our fixed-effect estimate is towards the high end of the range but in line with recent estimates using novel estimation techniques.

The year dummies indicate that non-tariff barriers have fallen steadily over the period. The coefficients for the year effects can be re-expressed in terms of average levels of non-tariff barriers in tariff equivalent terms. According to the fixed-effect regressions where these barriers are highest in 1990, column (3) shows non-tariff barriers to be 52% in 1990 and decreasing to 45% by 1995. The OLS estimates put these values at 30% and 27%.

The empirical results in this section show that consumption in North America is strongly distorted by trade barriers: in the median industry consumers were 10 times as likely to purchase domestically produced goods as foreign goods in 1995. While the fairly high elasticity of substitution we estimate suggests that tariff reductions translate to a large change in consumption patterns, remaining non-tariff barriers continue to impede consumption of foreign goods. In the next section, we derive a linear relationship between a country's share of output and its share of demand. Our estimate of the border effect will have implications for the slope that we may expect in the cases of the Krugman and

Armington models.

3 Relating Output Shares to Demand Shares

We now turn to the derivation of the linear relationship between a country's share of industry output and its share of industry demand. Equilibrium in the representative industry obtains when the values of total output from each country, V and V^*, equal consumer expenditures:

$$V = xE + (1 - x^*)E^*, \tag{11}$$

$$V^* = x^*E^* + (1 - x)E. \tag{12}$$

where x and x^* are expressed in equations 6 and 7. In each case, total output comprises production for the home market (the first term) and exports (the second term). Imports need not equal exports in manufacturing as trade balances are achieved via offseting balances in the numeraire sector.

We combine equations 11 and 12 to generate a relationship between production and demand shares:

$$\text{shr}(V) = [x - (1 - x^*)]\text{shr}(E) + (1 - x^*) \tag{13}$$

where $\text{shr}(V) = V/(V + V^*)$ and $\text{shr}(E) = E/(E + E^*)$. Using equations 6 and 7 to substitute for x and $1 - x^*$ yields:

$$\text{shr}(V) = \frac{(b^2 - 1)}{[b + an/n^*][b + n^*/(an)]}\text{shr}(E) + \frac{1}{1 + (bn^*)/(an)}. \tag{14}$$

Recall that $a \equiv (kp^*/p)^{\sigma-1}$. To derive a reduced form expression for $\text{shr}(V)$ we need to determine relative prices and the relative number of firms. Prices are a function of the exogenous marginal costs of production represented as $c = \beta w$ and $c^* = \beta * w*$ with β and β^* representing unit labour requirements.

The Armington Model (National Product Differentiation)

In the Armington model, $n = n^* = 1$. We also assume that prices are given by perfectly elastic supply curves, thus $p = c$ and $p^* = c^*$. The Armington share equation is given by

$$\text{shr}(V) = \frac{(b^2 - 1)}{[b + a][b + 1/a]}\text{shr}(E) + \frac{1}{1 + b/a}. \tag{15}$$

where a equals $(kc^*/c)^{\sigma-1}$. Observe that when $a = 1$ (marginal costs of production are equal and there are no common preference for either Canadian or U.S.-produced varieties) the expression for the slope simplifies to $(b - 1)/(b + 1)$.

The Armington framework yields a linear relationship between output shares and demand shares. There are a number of important features of this relationship. First, the slope of the equation is less than one and the intercept is positive. Second, reductions in trade barriers reduce the slope of the equation. As the market becomes more integrated, the location of demand has less predictive power for the location of production.

The Krugman Model (Increasing Returns)

In the Krugman model, the Dixit-Stiglitz assumption that firms price as if they faced a constant price elasticity of demand yields pricing rules of

$$p = \frac{\sigma c}{\sigma - 1} \text{ and } p^* = \frac{\sigma c^*}{\sigma - 1} \tag{16}$$

for domestic and foreign firms.[8] The above pricing equations imply that in Krugman,

[8]This derivation relies on the assumption that firms specialize in the production of a single good

as in Armington, $a = (kc^*/c)^{\sigma-1}$. The Krugman model treats the relative number of varieties produced in each country, n/n^*, as an endogenous variable. In a zero-profit equilibrium, the producer prices in each country are driven to average cost. This implies domestic and foreign firms will produce outputs of

$$q = \frac{(\sigma-1)F}{c}, \text{ and } q^* = \frac{(\sigma-1)F^*}{c^*}, \tag{17}$$

where F and F^* are fixed costs. Combining this result with the price equation, we find that $V = npq = n\sigma F$ and $V^* = n^*\sigma F^*$. We assume equal fixed costs in the two countries. This allows us to express the relative number of varieties manufactured in terms of the output share, $\text{shr}(V)$:

$$n/n^* = V/V^* = \text{shr}(V)/[1 - \text{shr}(V)]. \tag{18}$$

Substituting this equality into equation 14 and rearranging yields

$$\text{shr}(V) = \frac{(b^2-1)}{(b-a)(b-1/a)}\text{shr}(E) - \frac{1}{ab-1}. \tag{19}$$

Observe that when $a = 1$ (marginal costs of production are equal and there are no common preference for either Canadian or U.S.-produced varieties) the expression for the slope simplifies to $(b+1)/(b-1)$.

There are several important contrasts between this relationship and the one predicted by the Armington model. First, the slope of the function is greater than one. This means

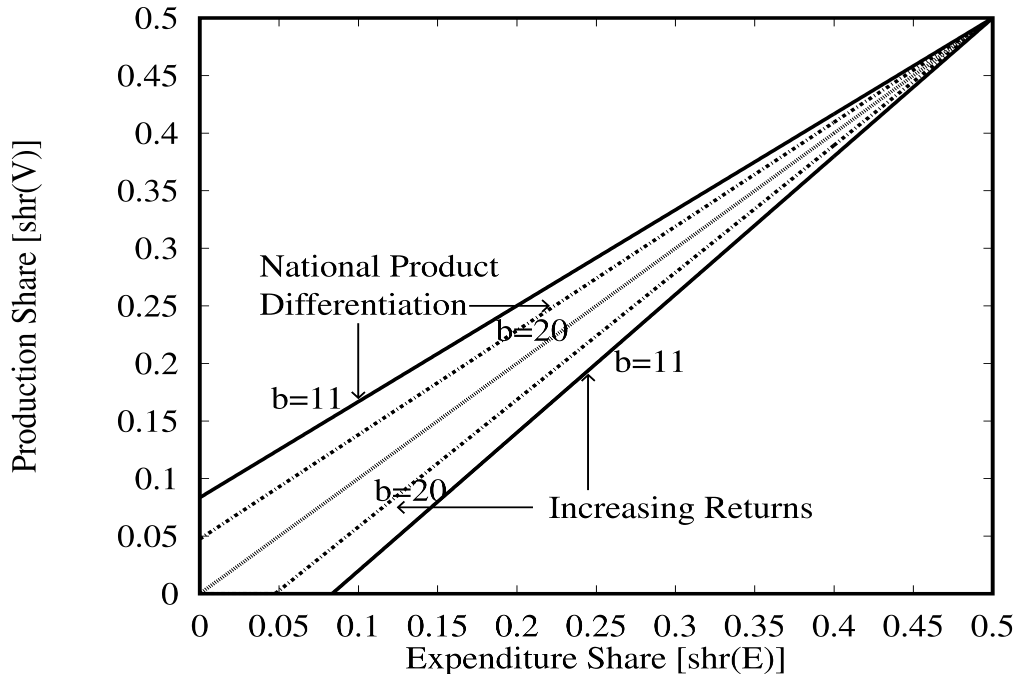
in a single location. This is a restrictive assumption since it appears to rule out both multi-product and multi-national enterprises. An alternative interpretation would be that each business unit produces a unique variety and maximizes its own profits without taking into account the effects of its pricing decisions on other units owned by the same parent company.

increases in demand shares cause output shares to rise on a more than one-for-one basis. Moreover, there will be a critical home expenditure share that causes the disappearance of the production in the home industry. Similarly, sufficiently large values of shr(E) will lead to shr(V) = 1. In the intermediate range, production shares are a linear function of demand shares. Finally, a reduction in trade barriers, will increase the slope of the equation, implying that home market size matters more when trade barriers are lower.

Figures 3 summarizes the contrasting predictions of the Armington and Krugman models. The figure plots the share equations for the case of $a = 1$. The slope of the lines depicting the linear relationship between the share of output and the share of demand for each model are drawn for two values of b. The solid lines correspond to $b = 20$ which is the median value of b_{it} in the first year of the sample while the dashed lines are for $b = 11$, the median value in the last year. The figure plots the range of shr(E) between 0 and .5, thereby representing small-country output and expenditures. The slope exceeds one for the Krugman model and is less than one for Armington trade. The Krugman model exhibits the home market effect—output shares fall below the 45 degree line implying small-country industries are net importers. The Armington model exhibits the opposite net export pattern (reverse home market effects). Under Krugman, high trade barriers dampen advantages associated with demand share (the slope falls with an increase in b). The opposite occurs in the Armington model. Correspondingly, the effect of trade barriers on the intercept is opposite in the two models. As trade barriers become very large both models predict that output shares will equal demand shares (i.e. both models have the 45 degree line as a limiting value).

The figure suggests that even industries with small expenditure shares will have positive output shares in the Krugman model. The lowest value of shr(E) where production

Figure 3: Border Effects in the Krugman and Armington Models



occurs in the small country is

$$\text{shr}(E) = \frac{(b-a)}{a(b^2-1)}.$$

Recall that

$$a = (kc^*/c)^{\sigma-1} = [k(\beta^* w^*)/(\beta w)]^{\sigma-1}$$

where k exceeding one indicates a preference by consumers for Canadian goods, β and β^* are unit labour requirements, and w and w^* are wage levels. Preferences for Canadian goods, lower relative wages in Canada, or higher productivity in Canada will cause a to exceed one. For $a = 1$, the case of symmetric costs and preferences, the critical value where $\text{shr}(V) = 0$ is .05 when $b = 20$ and .08 when $b = 11$. If $a > 1$ this critical value declines.

As all Canadian industries have a demand share below .5, the figure implies that

Canada would either be a net importer in all manufacturing industries (Krugman model) or a net exporter (Armington model). The prediction of net export patterns across industries changes when a deviates from one. If a exceeds one, the lines relating the share of output and the share of demand in Figures 3 will shift up. In the Krugman model, the line steepens as it shifts up whereas it flattens in the Armington model. Equations 15 and 19 define values of a that make the intersection of the 45 degree line and the share relationship occur at $\text{shr}(E)$ equal to .1 (roughly Canada's share of combined U.S. and Canadian GNP). Assuming that b is equal to the median value for industries in our sample of 14.7, these values of a are 2.21 and 0.30 for the Krugman and Armington models. In the Krugman model with these parameters, industries with $\text{shr}(E) > .1$ are net exporters and industries where $\text{shr}(E) < .1$ are net importers.[9] The opposite net export pattern would obtain for Armington. Deviations of a from one, however, will not affect the basic differences between the models in terms of the slope being greater or less than one, the intercept being positive or negative, or the sensitivity of the slope to differences in tariff levels.

The endogeneity of the location of each variety in the Krugman model is based on a zero-profit condition that may not be a good approximation of entry and exit behaviour over relatively short periods like the six-year time span we employ in this paper. For this reason we believe it is also worth considering the "short-run" version of the Krugman model. In that case n and n^* are determined by the initial long-run equilibrium described by equations 18 and 19. In the short-run, n and n^* are fixed and do not respond to changes in demand or tariffs. This short-run Krugman model shares two of the main

[9]The result that relatively large industries in a small country can be net export industries is established in Weder (1995). He extends Krugman's model to consider exogenous differences in country size (labour forces) as well as in preferences across two classes of differentiated goods. He shows that exchange rate adjustments will allow a each country to be a net exporter in one industry and a net importer in the other industry with overall trade balanced trade.

features of the Armington model: the slope of the line relating a change in demand share to a change in output share is less than one and this slope is an increasing function of the level of trade barriers. Unlike Armington, however, the intercept and slopes of the Krugman model in the short-run are functions of the initial value of n/n^*. This feature leads to systematic differences in the predicted responses of different industries to tariff changes.

Before we proceed with the formal regression analysis, we note that the values of b calculated in the previous section offer predictions for the slope of the regression line relating output shares and demand shares. In the Krugman model with $a = 1$ (symmetric costs and preferences), the slope equals $(b+1)/(b-1)$. For the median value of b in our sample, the Krugman model predicts the average slope across our industries should be 1.15. In the case of the Armington model with $a = 1$, the slope is just the reciprocal: $(b-1)/(b+1)$. Thus, in this model our estimates of b imply slopes of 0.87 for the average industry. These calculations indicate that due to the large values of border effects we have estimated for most Canadian manufacturing industries, we expect the estimated slope of the share equation to be fairly close to one in either model.

We test the predictions of the models with regression analysis using our six-year panel of 3-digit industries. We identify relationships based on two sources of variation in our data: across industries (between variation) and across time (within variation). Between estimation reduces the observations to one per industry by computing average values across time for each industry. We conduct within estimation by including industry fixed effects. In this specification, we also add year dummies to capture changes in the macroeconomic environment that have a common influence on industries. The existing empirical literature estimates are based on cross-sectional data (Feenstra, Markusen, and Rose (1998), Davis and Weinstein (1998, 1999), Trionfetti (1998)) or pooled time-

Table 2: Production Shares and Demand Shares

Method:	Between Estimates			Within Estimates		
Model :	(1)	(2)	(3)	(4)	(5)	(6)
Depvar:	shr(V)	shr(VA)	shr(emp)	shr(V)	shr(VA)	shr(emp)
Intercept	-0.011[c]	-0.008	0.003	0.015[a]	0.033[a]	0.079[a]
	(0.007)	(0.009)	(0.011)	(0.002)	(0.004)	(0.003)
shr(E)	1.128[a]	1.007[a]	1.133[a]	0.836[a]	0.590[a]	0.310[a]
	(0.069)	(0.089)	(0.111)	(0.019)	(0.038)	(0.033)
1995				0.000	-0.006[a]	-0.006[a]
				(0.001)	(0.001)	(0.001)
N	106	106	106	615	615	615
R^2	0.721	0.549	0.502	0.854	0.526	0.322
RMSE	.028	.036	.044	.005	.009	.008

Note: Standard errors in parentheses with [a], [b], and [c] denoting significance at the 1%, 5%, and 10% level.

series, cross-sectional data (Weder (1997)). The use of within estimates is unique to this study.[10]

We begin by reporting the basic bivariate regression results relating production shares (shr(V)) to demand shares (shr(E)). In addition to shipments as a measure of output, we also consider employment and value added in our first set of results. As discussed in the data appendix, we subtract exports to the rest of the world from shipments to derive a measure of shipments destined for the North American market. Unfortunately, since exports are not measured in employment or value added terms, we cannot do this adjustment for these two measures of output. Thus, we will focus on the shipment share variable and consider employment and value added only in the bivariate regressions as a robustness check.

Table 2 shows that the results for all three variables are extremely sensitive to the source of variation used for identifying the coefficients. The first three columns display

[10]We opt not to report ordinary least squares or random effects regressions, both of which generate estimates that are weighted averages of between and within estimates.

the between results and the second three columns the within results. The between estimates yield slopes of 1.128, 1.007, and 1.133 for the share of shipments, value added, and employment as the dependent variable. The intercept estimates in the between regression are negative in two of the three cases. Thus, the between results are generally consistent with the Krugman model which predicts a slope exceeding one and a negative intercept. In the shipment share regression, the slope estimate is significantly greater than one at the 10% level and the intercept is significantly less than zero at the 10% level. The slope and intercept estimates in the other two specifications are not significantly different from one or zero. Moreover, the slope estimates are close to the 1.15 we expected under Krugman based on the median value of b in our sample.

The within regression yields estimates which are precisely reversed from the between estimates and support the Armington model: the intercept is positive and the slope less than one in all cases. In the case of shipments as the dependent variable, the slope is estimated to equal 0.836 which is also very similar to what we expected based on our median b in the case of Armington trade. The slope estimate is much lower for value added and employment as the dependent variable. The significance levels of the fixed-effect regression estimates are higher than those of the between regressions, partly due to the greater number of observations in the former.

There are a number of reasons to interpret the estimated coefficients with caution. The matching of Canadian and U.S. industries and industries to trade data will generate concordance errors that can cause output shares to be correlated with expenditures shares. Since expenditure shares are calculated directly from shipments shares, to the extent concordance error "overstates" Canada's shipments, it will also overstate its expenditures. Thus, the between estimates could be positively biased. This source of bias is less important for the fixed effect estimation which is based on variation within each

Table 3: Tariffs and the Production-Demand Share Relationship

	Dependent Variable: Shipments Share					
Method:	Between Estimates			Within Estimates		
Model :	(1)	(2)	(3)	(4)	(5)	(6)
Tariffs:	High	Low		High	Low	
Intercept	-0.004	-0.014^c	-0.017^c	-0.001	0.031^a	0.018^a
	(0.004)	(0.008)	(0.009)	(0.002)	(0.004)	(0.002)
shr(E)	0.965^a	1.191^a	1.270^a	0.946^a	0.717^a	0.813^a
	(0.044)	(0.088)	(0.098)	(0.019)	(0.039)	(0.022)
TAR			0.174			-0.089^b
			(0.257)			(0.043)
shr(E) · TAR			-4.647^c			0.713^b
			(2.484)			(0.306)
1995				0.000	-0.001	-0.001
				(0.001)	(0.002)	(0.001)
N	83	83	106	309	306	615
R^2	0.856	0.695	0.744	0.945	0.712	0.856
RMSE	.015	.031	.027	.003	.006	.005

Note: Standard errors in parentheses with ^{a}, ^{b} , and ^{c} denoting significance at the 1%, 5%, and 10% level. High corresponds to industries with tariff levels exceeding two percent.

industry. However, there are two potential source of bias in the fixed-effect estimates. First, within estimation exacerbates measurement error leading to downward bias. On the other hand, an industry-specific positive shock to production will also give rise to a positive change in expenditure share due to the construction of the data. The bottom line is that we should be careful not to infer too much from the regressions in Table 2.

We can subject the models to more demanding tests by considering how tariff levels influence the slope of the equation. As shown in Figure 3, these have opposite effects in each model. To assess the influence of tariffs, we divide the sample into high and low tariff industries as well as interact tariff levels with demand. The first three columns of Table 3 present between results and the second three columns show within results. In columns (1) and (2) and columns (4) and (5), the sample is split at the median tariff level in the six-year panel data set. As before, the results reveal that the between results support the Krugman model and the within results support the Armington model. In the between regression, low tariff industries have a larger slope coefficient than high tariff industries (1.191 versus 0.965). On the other hand, the slope estimate based on within variation is higher for high tariff industries than low tariff industries (0.946 versus 0.717). Columns (3) and (6) show results when we add the tariff level and a tariff-demand share interaction variable. While the interaction assumes that tariffs have a linear affect on the slope whereas the model indicates a nonlinear effect, it allows us the test whether tariffs have a significant influence on the slope of demand share. The signs of the interaction variable have the signs we would expect based on the results when we split the sample. In the case of the between estimates, the tariff level enters positively while the interaction variable is negative. For the within estimates, tariffs have a negative sign and the interaction is positive. Thus, again the results of each estimation technique accord with one model or the other. The within estimates, however, yield more significant estimates of the effects of tariffs and tariffs interacted with demand share.

A concern about the specification is the possible endogeneity of the demand share variable. Our models assume the expenditure share is exogenous which would be the case when the upper tier utility function is Cobb-Douglas. However, there may be features of industries that cause both shipments and demand to be high or low. One case where this may occur is when factor prices vary across countries and factor intensities vary across industries. Low prices for factors used intensively in the production of an industry's goods may translate to high output and high demand. Whether or not expenditures on an industry's goods rise when prices are low depends on the price elasticity of demand—if the elasticity exceeds one, expenditures will rise with a fall in prices. In this case, there may be a positive relationship between output and expenditures that arises due to endogeneity. This concern is not worrisome in the within regressions which control for fixed industry effects. It may, however, cause a positive bias in the between estimates. In Table 4 we examine the robustness of our between results to differences in factor abundance.

We begin by postulating that the distribution of factor endowments in North America determines the distribution of output shares for 2-digit SIC industries. Given that distribution, deviations of 3-digit industry shares from the 2-digit shares are explained by deviations of demand shares from the 2-digit share as well as tariff levels.[11] The first two columns of Table 4 portray between results when we reconstruct the output share and demand share variables as deviations. The results displayed in these columns reveal that the slope is robust to this new calculation of output share and demand share. In the bivariate regression, the slope equals 1.129 which is almost identical to the 1.128 estimate shown in Table 2. Likewise, column (2) results mirror those in the corresponding regression (column (3) in Table 3): Higher demand shares raise shipment shares more than proportionately but tariffs moderate this effect. These results indicate that our previous results are not simply an artifact of correlation between demand shares and unobserved factor endowments at the 2-digit SIC level.

The last two columns of the table add a measure of Canadian cost advantage, natural resource intensity. This variable is the share of natural resource (forestry, fishing, agriculture, mining, and energy) inputs in production. We assume that Canada has a comparative advantage in industries that use natural resources intensively. Thus, this variable should have a positive effect on Canada's shipment share.[12] Column (3) indicates that this variable does have a positive effect in the between regression and it is

[11] We employ this specification in part because of its similarity to the approach taken in the papers cited above by Davis and Weinstein. In each of their papers, differences with respect to a more aggregated industry are analyzed.

[12] Weinstein and Davis (1998, 1999) add a vector of factors to control for factor abundance.

Table 4: Factor Abundance and the Production-Demand Share Relationship

Model :	(1)	(2)	(3)	(4)
Depvar:	shr(V)†	shr(V)†	shr(V)	shr(V)
Intercept	-0.005[c]	-0.004	-0.014[b]	-0.019[b]
	(0.003)	(0.004)	(0.007)	(0.009)
shr(E)	1.129[a]	1.253[a]	1.112[a]	1.242[a]
	(0.066)	(0.097)	(0.068)	(0.098)
shr(E) · TAR		-4.213[c]		-4.135[c]
		(2.494)		(2.476)
TAR		-0.016		0.168
		(0.109)		(0.255)
Resource Intensity			0.046[b]	0.034[c]
			(0.019)	(0.019)
N	106	106	106	106
R^2	0.739	0.748	0.735	0.752
RMSE	.025	.025	.027	.026

Note: Standard errors in parentheses with [a], [b] , and [c] denoting significance at the 1%, 5%, and 10% level. † Columns (1) and (2) express shr(V) and shr(E) as deviations from the 2-digit industry shares. All coefficients are between estimates.

significant at the 5% level. The intercept is estimated to be negative and significant at the 5% level in this specification. When we add tariffs and tariffs interacted with the expenditure share, column (4) reveals that the addition of natural resource intensity advantage has little effect on the coefficients estimated in the absence of this variable. Overall, the results contained in Table 4 indicate that incorporating comparative advantage considerations does not affect the signs and significance of the estimates obtained from the previous regressions.

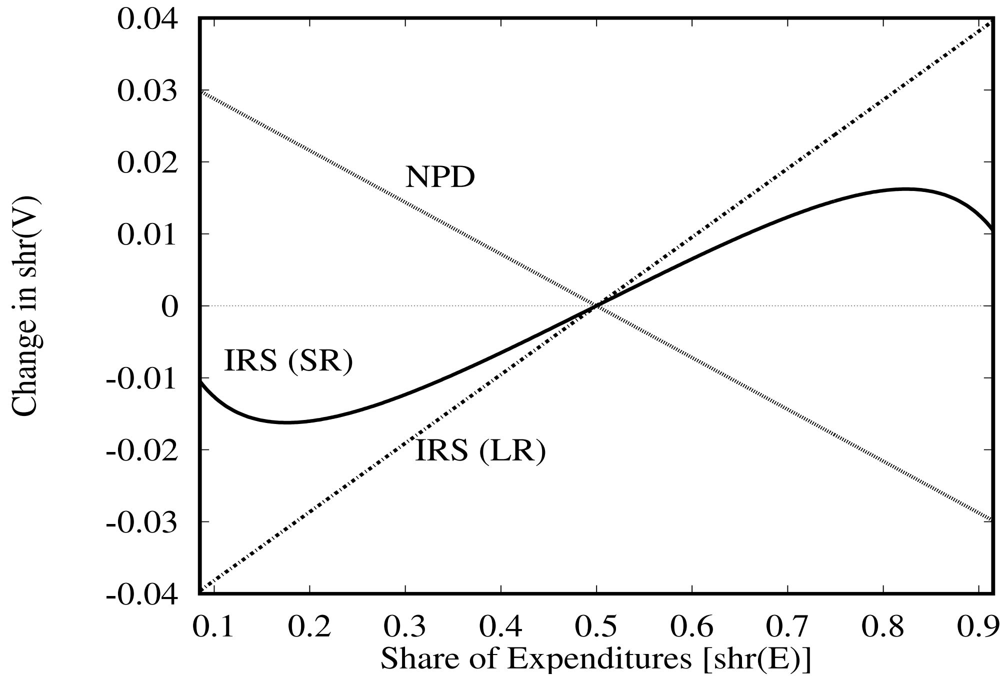
Thus far, we have seen that the between results are consistent with the Krugman model whereas the within results support our Armington model. Moreover, the between results are robust to our controls for differences in factor abundance. Recall that the Armington predictions for the slope are equivalent to those of the Krugman model when the number of firms is fixed. Thus, one way to reconcile these seemingly opposite results is the between estimates reflect a long-run equilibrium and the within results reflect what happens to the output share when demand changes in the short-run when the number of firms remains fixed. When interpreted this way, the results support the Krugman model while indicating that adjustment to the long-run equilibrium is not immediate. These considerations indicate we need to devise a test that distinguishes the Armington model for both the long-run and short-run versions of the Krugman model. One such test is to consider how output share responses to tariff changes differ across industries with high and low shares of demand.

In both models trade liberalization should reinforce existing net export patterns. Namely, a country with a disproportionate share of production relative to its share of demand in an industry (a net export industry) should have its share of output increase when trade barriers are lowered. In the Krugman model, these industries will be those with high demand shares (the home market effect) and they should be low demand share industries under Armington. In the case of the short-run Krugman model where firm entry and exit does not occur in response to tariff changes or changes in demand shares, trade liberalization will also magnify existing net export patterns. As long as prior to the round of trade liberalization high demand share industries are net exporters (the central prediction of the Krugman model), a reduction in trade barriers will raise the output share of these industries in the short-run Krugman model.

Figure 4 demonstrates the differential effects of a decrease in trade barriers on industries with different levels of demand share ($\text{shr}(E)$) for each of the models—the long-run and short-run Krugman models and the Armington model. The figure plots the change in output share against levels of $\text{shr}(E)$ when the border effect, b, falls from 20 to 11.[13] We confine the range of $\text{shr}(E)$ to values that are consistent with positive production

[13] These are the border effects for the median industry in the first and last years of our sample.

Figure 4: Consequences of a Trade Liberalization in 3 models



in both countries in the Krugman model. We consider the case of $a = 1$ (symmetric costs and preferences). For the the short-run Krugman model, we start with the relative number of firms implied by a free entry equilibrium when the border effect is 20. We then lower the border effect holding the number of firms constant. Under Armington, lower tariffs increase the output share of small demand share industries but decrease the output share of high demand industries. Both the long-run and short-run versions of the Krugman models display the opposite pattern. The effects are smaller in the short-run due to the inability of the relative number of firms to adjust. The level of shr(E) where the change in output share equals zero corresponds to an industry with balanced trade. In this exercise, this occurs at shr$(E) = .5$ due to symmetry. As noted previously, deviations of a from one due to differences across the two countries in wages, productivity, or the quality of goods, will shift the critical level of shr(E) that leads to balanced trade.

The above analysis indicates that we can discriminate between the models by examining how output responds to tariff changes for industries with high and low shares of demand. We implement this test by estimating regressions where the change in an industry's share of output is a function of the change in its demand share, the change in the level of trade barriers, and the change in trade barriers interacted with the industry's share of demand. The coefficients on the last two variables will indicate differential effects of trade barriers across industries with different demand shares. In the case of Armington, we expect a negative coefficient on the change in the level of trade barriers variable (higher trade barriers harm industries with small demand shares) and a positive coefficient on the interaction variable (the harmful effect of higher trade barriers dissipates as the demand share increases). The opposite pattern would emerge from the long-run Krugman model. In the short-run version of this model, the coefficient on the variable measuring the (non-interacted) change in tariffs should be positive. The non-monotonic relationship between demand share and the change in the output share that is apparent in the figure suggests we cannot be certain of the sign of the interaction term in the short-run Krugman model.

We consider two basic measures of trade liberalization. First, changes in tariff levels for which we have industry-specific data. Second, changes in non-tariff barriers (NTBs) which we compute based on estimates of b (equation 8) and its decomposition into NTBs and tariff components (equation 9). We consider both industry-level estimates of NTBs as well as the average across manufacturing reported in column (4) of Table 1.

We calculate the changes in the variables as deviations from the industry mean. This specification resembles the industry fixed effect method with one crucial difference—the change in a trade barrier (such as tariffs) is interacted with the level of shr(E). Thus, the interaction identifies systematic differences *between* industries in how changes in trade

Table 5: Production Shares and Trade Liberalization

	Dependent Variable: Shipments Share			
Model :	(1)	(2)	(3)	(4)
Intercept	0.001^b	0.001	0.000	0.000
	(0.001)	(0.000)	(0.000)	(0.000)
shr(E) [demeaned]	0.833^a	0.828^a	0.839^a	0.843^a
	(0.018)	(0.018)	(0.017)	(0.017)
Barrier†	-0.074^c	0.004	-0.041^b	-0.027^b
	(0.039)	(0.006)	(0.018)	(0.012)
Barrier · shr(E)	0.684^b	0.092	0.575^a	0.356^a
	(0.323)	(0.083)	(0.182)	(0.121)
1995	-0.001	0.000		
	(0.001)	(0.001)		
N	615	615	615	615
R^2	0.855	0.858	0.853	0.852
RMSE	.004	.004	.004	.004

Note: Standard errors in parentheses with ^{a}, ^{b} , and ^{c} denoting significance at the 1%, 5%, and 10% level. † Each column employs a different measure of barrier reflecting changes in trade barriers: industry-level tariffs in column (1); industry-specific NTBs in column (2), average (across all industry) NTBs in column (3), and the sum of tariffs and average NTBs in column (4).

barriers affect changes in output shares *within* industries.

Column (1) of Table 5 reports results when we use the first measure of trade barriers—the change in the tariff level. The coefficient on tariff changes enters negatively whereas the coefficient on tariff changes interacted with demand share is positive. They are significant at the 10% and 5% levels, respectively. The coefficients on these variables indicate that the critical demand share where an industry's output share is unaffected by tariff changes is 0.108 (.074/.684). These results support the Armington model: tariff reductions increase (decrease) the output share of industry's with small (large) demand shares. In columns (2) and (3) we specify barriers to be the changes in NTBs. Column (2) reports regressions which use our industry-specific measure of NTBs and the results for these variables are insignificant. However, when we use the average level of NTBs across manufacturing, the estimates in column (3) provide further support for the Armington model. Again, the negative coefficient estimate for changes in trade barriers and the positive coefficient for its interaction with demand share indicate that tariff reductions benefited low demand share industries relative to high demand share industries. Moreover, the coefficient estimates are similar to those displayed in column (1). The last column of the tables shows results when we consider barriers to be the sum of tariffs and (average) non-tariff barriers. The results are consistent with those in columns (1) and (3).[14] Overall, it is clear that the trade liberalization that occurred over the period favoured Canadian industries with small demand shares over industries with large demand shares. These findings are consistent with the Armington model.

4 Conclusion

We have proposed Krugman and Armington models as alternative models of trade in manufactures between Canada and the United States. In both models there is intra-industry trade because, within each industry, the countries specialize in different products. We showed that the two models are special cases of the same underlying preference structure. As a consequence, they give rise to the same methodology for identifying the magnitude of trade barriers and the elasticity of substitution between products. Data on output, domestic absorption, and tariffs for 106 3-digit U.S. and Canadian industries enabled us to estimate the border impediment biasing consumption towards goods produced at home and decompose it into tariff and non-tariff terms. We estimate that the tariff equivalent of non-tariff barriers between Canada and the United States to have declined over time but it still exceeded 27% in 1995. The elasticity of substitution implied

[14] We tried adding both changes in average NTBs and industry tariffs along with their interactions with demand shares in the same regression. In this specification only one liberalization variable is significant—changes in NTBs interacted with demand share. Apparently, the high level of multicollinearity between NTB changes and tariff changes (correlation of 0.81) make it impossible to discern separate effects of reductions in tariffs and reductions in non-tariff barriers.

by tariff effects on trade is large but in line with recent estimates of other researchers.

Both the Krugman and Armington models predict a linear relationship between a country's share of total production in an industry and its share of expenditures. The two models differ in one key assumption and that generates a number of predictions that we are able to test. In the Krugman model, a reallocation of demand from one country to another influences where each variety is produced. In contrast, our Armington model takes the location where each product variety is produced as exogenous. As a result the models differ in terms of the relationship between output shares and expenditure shares and the sensitivity of this relationship to tariffs.

We find that estimates of the slope of the line relating a country's share of output to its share of demand depend on the estimation technique. Those based on variation between industries support the Krugman model. This result is consistent with the findings of Davis and Weinstein (1998, 1999) and Weder (1997) as well as those of Feenstra, Markusen,and Rose (1998) for the case of differentiated goods. In contrast, our estimates based on within variation support the Armington model. One potential reconciliation of the contrasting between and within estimates is that the within results reflect the short-run case of the Krugman model when the number of firms does not adjust. We find, however, that reductions in tariff and non-tariff barriers that occurred over the period 1990–1995 harmed large-demand industries relative to those with small demand shares. This evidence supports the Armington model and conflicts with both the long-run and short-run versions of the Krugman model. Thus, the preponderance of evidence indicates that reverse home market effects characterize manufacturing industries in Canada and the United States.

Data Appendix

Industry Canada provided U.S. and Canadian shipment, employment, value added, and trade data classified according to Canadian SICs. These data are graphically depicted on their strategis.ic.gc.ca website. We aggregate their 4-digit industry data to the 3-digit level. To maintain consistency with our two-country model, we confine analysis to goods that are produced in North America (Canada and the U.S.) and purchased by North American consumers. Canadian expenditures on North American goods consist of purchases of Canadian goods (Canadian shipments minus Canadian world exports) plus imports from the United States. Likewise, U.S. expenditures on North American goods are purchases of U.S. goods (U.S. shipments minus U.S. world exports) plus imports from Canada. We measure Canadian shipments to North America as Canadian total shipments minus Canadian exports to non-U.S. destinations. Correspondingly, U.S. shipments are U.S. total shipments minus U.S. exports to non-Canadian destinations. These data form the basis for our construction of $\text{shr}(V)$ and $\text{shr}(E)$. Canadian producers' share of the Canadian market for North American goods, x, is the Canadian good share (Canadian total shipments minus Canadian world exports) of Canadian expenditures on North American goods. We define x^* analogously. In cases where we use value added share and employment share as measures of output share (Table 2), we construct $\text{shr}(V)$ as the Canadian level divided by the sum of the Canadian and U.S. level.

It should be noted that variation in production shares may arise from errors in the concordance between the original U.S. and Canadian industries. The Industry Canada data aggregates 5-digit U.S. industries into the corresponding 4-digit Canadian industry. In some cases, the match appears to be rough. Aggregating to 3-digit industries removes the most serious cases of concordance mismatch. In addition, three types of errors may emerge matching industry data to trade data. First, the manufacturing census attributes all of an establishment's sales to a single SIC (according to its main product) whereas customs records the product category for each good that is traded. Second, there may be a difference between the year of production and the year of export. Third, valuation methods in the census and in customs may differ. We omit 20 observations where the data show Canada exporting more than it produces to obtain a panel of 106 manufacturing industries with a total of 615 valid observations.

Tariffs (TAR) are measured as follows. Lester and Morehen (1987) provide 1987 industry-level tariffs for Canada and the United States. We created a single tariff to reflect the average protectionist tendency of each industry. It weights the tariffs of the U.S. and Canada by the respective shares of their exports in bilateral trade in the industry. Thus, if most trade flows from Canada to the U.S., then the American tariff receives greater weight in the average. The trade-weighted average tariff (TAR) is highly correlated (0.88) with both country's tariffs. To obtain tariff levels for years subsequent to 1987, we used information from the Canada-U.S Free Trade Agreement. For each Canadian industry we assigned a tariff staging category. We did this by using a concordance between Canadian SICs and the Harmonized System commodity classifications which formed the basis of the tariff reduction agreement. Usually each industry corresponds to one of three staging categories (A, B, or C) representing whether tariffs were to be phased out immediately, over a five-year period, or over a ten-year period. In cases where an industry comprised commodities with different staging categories, we took the simple average.

The share of natural resource (forestry, fishing, agriculture, mining, and energy) inputs in production is derived from Input-Output Matrix information available at the

2-digit SIC level in Statistics Canada Cat. No. 15-201.

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