Tariff Effects on MNC Decisions to Engage in Intra-Firm and Arms-Length Trade

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Abstract: Using confidential firm level data from the Bureau of Economic Analysis (BEA) on activities of U.S. multinational corporations (MNCs) and their Canadian affiliates, we study the dramatic growth of intra-firm and arms-length U.S.-Canada trade over the 1984-1995 period. We find that the increase in trade occurred almost entirely on the *intensive* rather than the *extensive* margin. That is, MNC parents and affiliates that already engaged in intra-firm and arms-length trade in 1983 expanded trade dramatically, while very few firms commenced trade. We also find that decisions to engage in intra-firm and arms-length trade are essentially unrelated to tariff and transport cost reductions over this sample period. This is consistent with case study evidence in Keane and Feinberg (2005), where MNC executives consistently indicate that the modest tariff reductions of the '84-'95 period were not sufficient to justify fixed costs of overhauling international supply chains. Our results have important implications for recent influential models of international trade that rely on sensitivity of intra-firm trade to tariffs at the *extensive* margin to explain how small tariff declines could have led to the explosion of intra-firm trade since the 80s. Our results here and in Keane and Feinberg (2005) suggest that the real reason for the growth of intra-firm trade is not tariff reductions but rather the adoption of just-in-time logistics, which has substantially reduced the inventory carrying cost of intra-firm trade.

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1. Introduction

This paper examines the degree to which trade liberalization leads to increased trade – both intra-firm and arms-length (i.e., with unaffiliated buyers) – at the *extensive* margin. The context of our study is trade between U.S.-based multinational corporations (MNCs) and their affiliates in Canada from 1983-1996. This context is particularly significant, since U.S.-Canada trade is the world's largest bilateral trade relationship. And this time window is important, because it includes the US-Canada Free Trade Agreement (FTA) of 1989, as well as a broad US export "boom" (Bernard and Jensen, 2004a) that occurred during this time.

Figure 1 shows the declines in average U.S. and Canadian tariff rates over this period. Note that U.S. tariffs fell about 3 points on average, while Canadian tariffs fell about 4 points.[1] Strikingly, over the same period, intra-firm trade between U.S. MNCs and their Canadian affiliates grew by nearly 100% (see Feinberg and Keane (2005)). In Figure 2, we show the large increases in intra-firm trade as a percent of total parent and affiliate sales that occurred during our sample window. These figures seem puzzling. Rather implausible demand elasticities for intra-firm intermediates on the order of -25 to -30 would appear to be necessary to explain the dramatic growth of intra-firm trade based on such modest tariff declines. Furthermore, as Feinberg and Keane (2005) describe, the puzzle is more severe at the industry level, since the growth of intra-firm trade tended to be just as great in industries where tariffs declined very little.

Nor do transport costs or non-tariff barriers seem to provide an answer. There is no evidence of significant transport cost declines over this period (see Feinberg and Keane (2005), Hummels (1999)). Furthermore, Trefler (2004) has called the FTA a "relatively clean policy experiment" in the sense that it did not involve other major changes in policy besides tariff reductions (such as reductions in non-tariff barriers or capital constraints).

The surprisingly rapid growth of intra-firm trade in the U.S.-Canada context can be viewed as part of a broader puzzle: The magnitude of the increase in world trade over the past few decades is generally considered a "mystery" because (1) the growth of trade was so large relative to the modest declines in tariffs and transport costs, and (2) the growth of trade actually accelerated in the mid-1980s, despite the fact that tariff reductions in 80s and 90s were much smaller than those in the 60s and 70s (a situation that applies to U.S.-Canada in particular).

[1] Note in Figure 1 that both sets of tariff reductions were gradual over the 1983-1996 time window and were not concentrated in the years following the implementation of the FTA. We describe the construction of the tariff data in Section 3.2.

A recent literature attempts to resolve this puzzle by emphasizing the important role of the extensive margin (see Yi (2003), Eaton and Kortum (2002)). In this literature, the proposed explanation for the recent upsurge in trade is that, while tariff reductions during the 80's and 90's were small by historical standards, they were "more potent" than earlier rounds of liberalization. The reason is *vertical specialization* – a new kind of trade in which countries specialize in stages of production. With vertical specialization and multi-stage fragmented production processes, intermediate inputs must cross national boundaries, and be subject to tariffs, during the production process. Hence, this mode of organization is infeasible unless tariffs are quite low.

In Yi's (2003) model, vertical specialization becomes feasible, and expands rapidly, once tariffs fall below some critical (low) level. This generates nonlinearity in the response of trade to tariffs, as firms initiate much more trade in intermediates once tariffs fall below the critical point. A similar mechanism, whereby the number of varieties of intermediates that are traded increases rapidly as tariffs fall, is operative in Eaton and Kortum (2002). These theories predict that recent trade liberalization should have led to expansion of intra-firm trade at the extensive margin - i.e., it should have led firms to initiate trade in intermediates. Empirically, the rapid recent growth of intra-*industry* trade in intermediates has been taken as evidence supporting this story.

It is important to note, however, that this industry level evidence is indirect, and prior empirical work has not looked directly at how tariffs affect trade in intermediates at the individual firm level.[2] Prior work using firm or plant level data is limited to studies of arms-length exports (e.g., Bernard and Jensen (2004a, 2004b), Das, Roberts and Tybout (2001)). These studies find that the preponderance of increased exports occurred at the *intensive* margin. However, this does not necessarily contradict theories of the growth of trade that emphasize increased vertical specialization and increased trade in intermediates on the extensive margin, since intra-firm trade may behave quite differently from arms-length exports.

The present study fills this gap in the literature by using firm level data to examine the effect of trade liberalization on both intra-firm trade in intermediates and arms-length trade in final goods. Using confidential firm-level panel data from the Bureau of Economic Analysis (BEA), on more than 500 US MNCs and their Canadian affiliates from 1983-1996, we estimate discrete choice models of firms' decisions to trade intra-firm and arms-length.

[2] For instance, Kehoe and Ruhl (2003) document that the composition of goods are traded has changed substantially in recent decades, but, since they look at industry level data, they cannot show that individual firms have actually commenced trade in particular goods.

It seems likely that some key lessons learned from the literature on export decisions may carry over to the study of intra-firm trade in intermediates as well. The work by Bernard and Jensen (2004a, 2004b) and Das, Roberts and Tybout (2001) emphasizes that firms must bear large fixed costs of initiating export activity. Hence, marginal tariff reductions are unlikely to cause firms to initiate exports, rationalizing the finding that most of increase export activity has been on the intensive margin. Similarly, we would expect that a shift toward vertical specialization (i.e., geographic fragmentation) of the production process would involve significant restructuring of firms, and hence large fixed costs. In that case, modest tariff reductions might be expected to lead primarily to increased trade in intermediates by those firms already organized to trade intra-firm, with little change on the extensive margin.

The work by Bernard and Jensen (2004a, 2004b) and Das, Roberts and Tybout (2001) also emphasizes the importance of firm heterogeneity. The latter paper assumes that firms (plants) are heterogeneous with respect to costs, and that, in response to a change in prices, firms' export supply responses will depend upon their previous exporting status. Firms that already export can increase trade at marginal production plus transport costs, while firms that do not must incur significant sunk costs before commencing export operations. This suggests that careful controls for firm heterogeneity and state dependence[3] are necessary in order to draw reliable inferences about the effects of tariffs on trade at the extensive margin.

As is well known, the presence of both heterogeneity and state dependence leads to an "initial conditions" problem that must be resolved in order to consistently estimate effects of changing covariates (like tariffs) in a dynamic discrete choice model (see Heckman (1991)). Specifically, one must model how the firm's "type" is related to the initial status of the choice variable. One contribution of the paper is that we estimate our models using a flexible and computationally attractive new procedure suggested by Wooldridge (2001) to deal with the initial conditions problem.

In our own prior work (see Feinberg and Keane (2001, 2005)), we found substantial heterogeneity in how U.S. MNCs and their Canadian affiliates are organized. Specifically, even within three-digit manufacturing industries, we observed considerable variation in MNCs' organization of production prior to liberalization. Some MNCs were organized to trade

[3] Fixed costs of commencing export activity generate state dependence – meaning a dependence of the current choice on the lagged choice.

bilaterally both intra-firm and arms-length; some MNCs traded intra-firm but not arms-length and vice versa. Some MNCs trade in only one direction, or not at all. This heterogeneity had not been previously noted, simply because few researchers had been granted access to the BEA's confidential firm level data.[4] Thus, it is likely that initial conditions and firm heterogeneity play a very important role in explaining how firms responded to trade liberalization.

Examining the intra-firm and arms-length trade of MNCs should cast considerable new light on the ability of theories that emphasize the importance of the extensive margin to explain the growth of world trade. We expect that if vertical specialization *induced by tariff declines* is a key mechanism driving increased trade, then intra-firm trade should appear to be very sensitive to tariffs at the extensive margin. That is, MNCs that geographically fragment production in response to tariff declines should be observed to initiate intra-firm trade in intermediates.

To preview our results, we find, first, that contemporaneous tariffs and transportation costs are uncorrelated with MNCs' decisions to trade – both intra-firm and arms-length. Thus, at the firm level, decisions to engage in intra-firm and arms-length trade appear to be insensitive to modest tariff reductions. Second, initial (i.e., 1983) tariff levels are also uncorrelated with decisions to trade. Third, and perhaps most surprising, initial tariffs are uncorrelated with the firm effects in our models, further indicating that the decision to have trade flows is unrelated to tariff levels. Thus, we show that increased trade in the U.S.-Canada context occurred almost entirely at the *intensive* margin.

This result is consistent with simple visual inspection of the data. That is, firms that did not engage in intra-firm or arms-length trade in 1983 rarely commenced trade activities during our sample period. But, in general, intra-firm and arms-length trade increased substantially for firms that already engaged in these activities in 1983.

The remainder of this paper is organized as follows. In the next section, we discuss our estimation techniques and in section 3 we describe the BEA data. In section 4, we present our results, and section 5 concludes. In the conclusion, we discuss whether the failure to find effects of tariffs on intra-firm trade in intermediates at the extensive margin can be reconciled with those models where tariff reductions have led to increased vertical fragmentation of production. And we ask, "if tariff reductions have not driven increased vertical fragmentation, then what has?"

[4] Only recently have theories of the MNC begun trying to incorporate the great heterogeneity in MNC organization noted in Feinberg and Keane (2005). See Grossman and Helpman (2005), Yeaple (2003), Helpman, Melitz and Yeaple (2004), Grossman, Helpman and Szeidl (2005) and Helpman (2005) for such attempts.

2. Estimation Method

Our empirical work is motivated by a two-country model in which an MNC has a single foreign affiliate (see Feinberg and Keane (2005) for more details). The MNC solves a dynamic optimization problem in order to decide, in each period (i.e., year), whether to engage in intra-firm and arms-length trade activities. As in Roberts and Tybout (1997) and Das, Roberts and Tybout (2001), dynamics arise due the fixed costs of commencing trade flows. We model four different potential trade flows – bilateral intra-firm trade between U.S. parents and Canadian affiliates and arms-length trade between parents (affiliates) and unaffiliated buyers in Canada (the U.S.). *Conditional* on its annual decisions about whether or not to engage in each of these four trade activities, the MNC makes marginal decisions about the quantities of domestic and foreign capital, labor and raw materials inputs to use in each location, as well as the volume of intra-firm flows, exports and imports.

Fully structural estimation of this complete model would be extremely computationally demanding. Furthermore, full solution of firms' dynamic optimization problem would require strong assumptions about the processes governing the evolution of all the state variables (e.g., tariffs, exchange rates, transport costs, demand conditions, materials costs, wages) that influence the firms' decisions. To avoid these problems, we instead estimate reduced form approximate decision rules[5] for the trade flows, jointly with a structural model of the marginal production decisions, using a quasi-structural approach described in more detail in Feinberg and Keane (2005). That paper reports our estimates of the structural model of marginal production decisions. In this study we report our estimates of the reduced form approximate decision rules for the four trade flows.

Specifically, let "N" denote goods traded intra-firm (with "d" and "f" indicating domestic and foreign), let "E" denote arms-length exports from the U.S. to unaffiliated buyers in Canada, and let "I" denote arms-length imports from the Canadian affiliate to unaffiliated buyers in the U.S.. Then, for instance, V_{it}^{Nd} denotes the value function for firm *i* at time *t* associated with the decision to set $N^d > 0$ (i.e., the decision to engage in intra-firm shipments of intermediates from the affiliate to the parent). We approximate this value function as a linear function of the relevant state variables that would influence the firm's decision, as follows:

[5] See, e.g., Keane and Wolpin (1997) for a discussion of approximate decision rules for dynamic models.

$$V_{it}^{Nd} = \psi_0 + \psi_1 \alpha_{it}^{Kd} + \psi_2 \alpha_{it}^{Kf} + \psi_3 [\tau_{dit} + c_{dit}] + \psi_4 g_{1it} + \psi_5 w_{dit} + \psi_6 w_{fit} + \psi_7 t + \psi_8 I[N_{it-1}^{d} > 0]$$
$$+ \psi_9 I[N_{i1}^{d} > 0] + \psi_{10} [\tau_{di1} + c_{di1}] + \mu_i^{Nd} + \nu_{it}^{Nd}$$

Here, we let V_{it}^{Nd} depend on α_{it}^{Kd} and α_{it}^{Kf}, the capital shares of the U.S. parent and Canadian affiliate, respectively, and a measure of the U.S. parent's market power, g_{1it}.[6] We also include domestic and foreign wage rates, w_{dit} and w_{fit}, a time trend, *t*, and domestic tariffs plus transportation costs, both at time *t*, denoted $[\tau_{dit} + c_{dit}]$, and at time *t*=1 (that is, 1983), denoted $[\tau_{di1} + c_{di1}]$. To accommodate state dependence, we also include indicators for the MNC's lagged choice $I[N_{i,t-1}^{d} > 0]$, and choice at time *t*=1 (that is, 1983), $I[N_{i,1}^{d} > 0]$, where $I[\cdot]$ is an indicator function for the event in brackets.

Finally, we also include a firm specific effect, μ_i^{Nd}, which captures heterogeneity across firms in the propensity to engage in intra-firm trade (perhaps arising from differences in firms' technology), and a stochastic term, ν_{it}^{Nd}, that captures transitory firm-specific shocks to the value of engaging in intra-firm trade (perhaps due to demand shocks).

The firm's decision rule is to set $N_{i,t}^{d} > 0$ (i.e., to engage in intra-trade in intermediates from the affiliate to the parent) if $V_{it}^{Nd} > 0$, where we have normalized the value of the $N_{i,t}^{d} = 0$ alternative to 0 without loss of generality (since V_{it}^{Nd} can simply be interpreted as the value of engaging in intra-firm trade *relative* to the alternative of not doing so). We assume that the firm effect μ_i^{Nd} is distributed normally across firms, and that the time *t* specific stochastic term has an extreme value distribution, which gives rise to what is known as the heterogeneous logit model.

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[6] α_{it}^{Kd} and α_{it}^{Kf} and g_{1it} are unobserved production function and demand parameters estimated as part of the structural estimation in Feinberg and Keane (2005). Recall that the structural model of that paper and the reduced form decision rules in this paper are estimated jointly, and these parameters link the two estimations. However, as a practical matter, the jointness of the estimation has little influence on the results obtained here. This is because the estimated share parameters are very close to the actual capital shares we could construct from the data, and the market power parameter g_{1it}, which is the inverse price elasticity of demand, is very close to the markup of revenue over costs.

We have included the lagged choice in each value function to accommodate state dependence that would arise due to fixed costs of commencing trade activity (see Das, Roberts and Tybout (2001)). But including lagged choices in a model that also contains unobserved firm effects introduces an initial conditions problem (see Heckman (1991)). That is, simply conditioning on the initial value of the choice variable $I[N_{i,1}^d > 0]$ (i.e., treating it as exogenous) when forming the likelihood function will lead to inconsistent estimates, since $I[N_{i,1}^d > 0]$ is correlated (by construction) with the firm effect μ_i^{Nd}. In practice, the effect of ignoring this problem is typically to exaggerate the role of state dependence.

We deal with the initial conditions problem using a recent suggestion by Wooldridge (2001, p. 495). The idea is to specify the distribution of the random effects conditional on the initial condition. For example, we assume $\mu_i^{Nd} \sim N(Z_{i1}^{Nd}\Gamma_{Nd}, \sigma_{Nd}^2)$. Here, Z_{i1}^{Nd} contains covariates that characterize the initial condition – including both $I[N_{i1}^d > 0]$ (the indicator for whether the MNC traded intra-firm in 1983), as well as other relevant covariates dated at t =1. In our case, we felt it was also important to include the t =1 tariff and transport cost variable in Z_{i1}^{Nd}. The reasoning is as follows: Obviously, the distribution of the firm effect depends on $I[N_{i1}^d > 0]$, since the latter is a function of the firm effect by construction. But it is also often argued, based on political economy considerations, that tariffs placed on a particular industry may be affected by the importance of trade flows in that industry. For example, if μ_i^{Nd} is large, then firm i, and other firms in the same industry, may lobby for low tariffs, leading to a negative covariance between μ_i^{Nd} and τ_{di1}. Including the initial tariff level in Z_{i1}^{Nd} controls for this effect.

The intuition behind the Wooldridge approach to the initial conditions problem is as follows: Suppose we do not control for the initial choice, and treat the lagged choice as exogenous. Then, even if there is no true state dependence, the lagged choice, $I[N_{i,t-1}^d > 0]$, may still appear to be a significant determinant of the current choice just because the initial choice, $I[N_{i1}^d > 0]$, is correlated with the random effect, μ_i^{Nd}, and because the lagged choice proxies for the initial choice. But, if the lagged choice is significant even after controlling for the initial choice, then there is clear evidence of dynamics.

The approximate decision rules for the other three trade flows are specified in a similar way. For instance, the value function V_{it}^{Nf}, which denotes the value to firm *i* at time *t* associated with the decision to set $N_{i,t}^{f}>0$ (i.e., the decision to engage in positive intra-firm shipments of intermediates from the parent to the affiliate) is written symmetrically, except that the affiliate's market power parameter, g_{2it}, replaces that of the parent, the Canadian tariff rate plus transport cost variables replace the U.S. values,[7] and the lagged choices of the affiliate appear rather than those of the parent.

The value function for the decision to export from the U.S. to third parties in Canada is specified as follows:

$$V_{it}^{E} = \psi_0 + \psi_1 \alpha_{it}^{Kd} + \psi_2 [\tau_{fit} + c_{fit}] + \psi_3 g_{1it} + \psi_4 w_{dit} + \psi_5 w_{fit} + \psi_6 t + \psi_7 I[E_{i,t-1} > 0] + \psi_8 I[E_{i1} > 0] + \psi_9 [\tau_{fi1} + c_{fi1}] + \mu_i^{E} + \nu_{it}^{E}$$

The only difference between this and the N^d and N^f equations is that the affiliate capital share parameter α_{it}^{Kf} is not included.[8] The equation for V_{it}^{I} is symmetric to that for V_{it}^{E}.

Finally, we note that the logit equations for the four trade flows were estimated jointly, allowing for correlations among the firm specific effects in the four equations. Specifically, we assume that the firm effects have a joint normal distribution $(\mu_i^{Nd}, \mu_i^{Nf}, \mu_i^{E}, \mu_i^{I})' \sim N(0, \Sigma_{\mu}^{V})$ while assuming that $\left(\nu_{it}^{ND} \ \ldots \ \nu_{it}^{E}\right)' \sim$ iid extreme value. This gives us a heterogeneous multivariate logit model, which we estimate using simulated maximum likelihood – SML (see, e.g., Geweke and Keane (2001) for a discussion of SML).[9]

[7] The U.S. values for these variables were insignificant in the N^f equation, so we did not include them. The reverse was true in the N^d equation.

[8] A priori, we did not expect that the capital intensity of the affiliate's production process would affect whether the parent sells the final goods it produces to third parties in Canada, and, in fact, α_{it}^{Kf} was not significant in the V_{it}^{E} equation.

[9] We used 200 draws from the distribution of the random effects to simulate the likelihood function. Results were not sensitive to increasing the number of draws.

3. The BEA Data

3.1 Construction of the Data Set

Our data are from the Benchmark and Annual Surveys of U.S. Direct Investment Abroad administered by the Bureau of Economic Analysis (BEA). These confidential surveys contain the most comprehensive information available on the activities of the population of U.S.-based MNCs and their foreign affiliates. We describe the data and the construction of our panel in detail in Feinberg and Keane (2005). For this study, we use the BEA data on U.S. MNCs with one or more Canadian affiliates. For the 1983-1996 period, this data set contains 24,313 affiliate-year observations. It is worth emphasizing that this is a population, not a "sample."

As discussed in Feinberg and Keane (2005), we made several alterations to the original BEA data to construct our panel data set. First, we use only data on manufacturing affiliates, since many non-manufacturing industries produce non-tradeables. Limiting the population to manufacturing affiliates reduced the number of observations from 24,313 to 12,241. Second, since we assign each affiliate to an industry in order to match it with the appropriate tariff and transport cost data, we dropped 1677 affiliate-year observations in which affiliates had less than 80% of their sales in a single industry. Third, we eliminated 4247 affiliate-year observations in which the affiliate data was estimated, rather than reported (the BEA often estimates data for small affiliates that do not have to report). This left 6358 affiliate-year observations.

Next, data on same industry manufacturing affiliates of the same parent were merged into one "composite" manufacturing affiliate, leaving 5583 affiliate-year observations. After this step, we removed some observations due to missing data, or because they were not part of a string of three consecutive observations, since we need at least three observations per firm to implement the estimation procedure (see Feinberg and Keane (2005) for more details). This left 5175 firm-year observations on 551 parents and 716 affiliates.

Next, we wished to avoid having multiple affiliates for the same U.S. parent in a given year. Thus, if a parent had "composite" affiliates in multiple industries, we used only the largest "composite" affiliate, based on total sales, reducing the number of affiliates to N=551. Of course, this step could cause us to miss cases where a parent commenced trade with a smaller affiliate in a different industry. To be sure that this step did not have any effect on our results, we estimated our models using both the "complete" data set, including all possible parent-affiliate pairs, and the "smaller" data set, with only one "composite" affiliate per parent. Results in each case were

essentially identical, so below we report only the results for the smaller data set with one affiliate per parent. After removing non-consecutive observations and removing 1983 and 1996 (since these years are used only to construct leads and lags (see Feinberg and Keane (2005) for details), our final data set contained 2335 affiliate-year observations on 446 unique parent-affiliate pairs.

Table 1 gives descriptive statistics for the firms in our data. The first panel gives means and standard deviations for parent and affiliate total sales. The next four panels describe each of the four trade flows in three lines. The first line reports the unconditional mean, the second line reports the mean conditional on the trade flow being *positive*, and the third line gives the percent of MNC-year observations for which the flow is positive. Note that 75% of affiliates have intra-firm sales to parents, while 86% of parents have intra-firm sales to the Canadian affiliate. On average, affiliate intra-firm sales to U.S. parents represent 37.6% of affiliate total sales, while parent sales to affiliates average 33.6% of affiliate total sales. These figures imply a high degree of integration of the production processes of parents and affiliates. Using the Benchmark survey data from 1989 and 1994, we verified that 93% of the goods shipped intra-firm from U.S. parents to Canadian manufacturing affiliates were intermediates destined for further processing.[10]

Table 1 only reports means for the whole 1984-95 period. But it is notable that the percentage of firms with positive values for each of the four trade flows is quite stable over time, despite tariff reductions. This simple fact is consistent with our main empirical result (see below) that tariff reductions did not cause MNCs to initiate intra-firm or arms-length trade activity. In contrast, as noted in Feinberg and Keane (2005), conditional on being positive, the mean of intra-firm trade nearly double over this period, and arms-length trade also grew substantially.

3.2 Construction of Variables

The BEA data contain three of the four trade flows we examine here – the value of goods shipped intra-firm (in both directions), and affiliates' arms-length sales to the U.S.. To construct U.S. parents' arms-length sales to Canada, we used data from Compustat on total parent sales to Canada, and netted out the value of intra-firm shipments.

Key variables of interest in our model are tariffs and transport costs. We measure U.S. and Canadian tariffs on an ad valorem basis for each of our 50 manufacturing industries. That is,

[10]Note that the 93% figure on shipments of intermediates for further processing from U.S. MNC parents only reflects trade with (single-industry) Canadian manufacturing affiliates. It is quite likely that U.S. MNC parents ship a greater proportion of finished goods for local resale to affiliates classified in sales or distribution industry codes. However, we do not include these in our dataset.

the tariff on imported goods in industry *j* in year *t* is measured as the ratio of duties paid to the value of the imports. While these tariff measures are more aggregate than the level at which tariffs are actually imposed, they are more disaggregated than measures often used in empirical work (see Grubert and Mutti, 1991). Our measure of transportation costs was constructed by dividing the industry-level cost of insurance and freight by the total value of imports in each industry *j* at time *t*. Such ad valorem freight rate measures are commonly used in empirical work (see, e.g., Head and Reis (2003), Hanson, Mataloni and Slaughter (2002)).

Since the affiliates in our data are predominantly single-industry, it was straightforward to assign them the appropriate U.S. tariff and transport cost data. For diversified U.S. parents, we constructed sales-weighted average Canadian tariff and transport cost measures across the (up to) eight industries in which U.S. parents report sales.

Figure 1 shows how U.S. and Canadian tariffs fell to very low levels over the 1983-1996 period. Canadian tariffs fell from an average of about 6% to 1.75%, and U.S. tariffs fell from 4% to less than 1%. There is also considerable cross-industry variation in tariffs. U.S. tariffs are highest in tobacco (average 13%) and lowest in motor vehicles and pulp and paper (average less than 0.2%). Canadian tariffs are highest in tobacco and apparel (both averaging over 17%), and lowest in agricultural chemicals, autos and farm machinery (all averaging approximately 1%).[11]

In addition to contemporaneous tariff and transport cost variables, we also include domestic and foreign wages at time *t*, constructed from the BEA data on parents' and affiliates' wage bills and employment. Other observed state variables that we include in our model are the lagged choices with regard to each trade flow, an indicator for the choice at time t=1 (which is 1983), the tariff level at time t=1, and a time trend. As discussed above, we also use several unobservables in our model derived from the structural model in Feinberg and Keane (2005). We use estimates of parent and affiliate capital share to pick up domestic and foreign technology, which we expect should be significantly correlated with firms' export decisions. And we include domestic and foreign market power parameters (i.e., inverse price elasticities of demand), which should relate to firms' ability to appropriate the benefits of lower tariff costs. These variables are closely related to the markup, as measured by sales to cost ratios.

[11] Our use of weighted average tariffs for diversified U.S. parents explains the approximately 1% average Canadian tariff for firms in the auto industry. Tariffs on autos and auto parts were eliminated under the Auto Pact of 1965, but since many U.S. parents whose primary industry code is SIC 371 (autos) are diversified, the average tariff for these firms is greater than zero.

4. Empirical Results

Next we turn to our estimates of the decision rules for whether the MNC will have positive values of each of the four trade flows. Table 2 shows the heterogeneous multivariate logit results for the four trade flows: N^d – Canadian affiliate intra-firm sales to U.S. parents; N^f – US parent intra-firm sales to Canadian affiliates; E – US parent arms-length sales to Canada; and I – Canadian affiliate arms-length sales to the US.

Several remarkable features of the results are evident. First, (contemporaneous) tariffs and transportation costs are uncorrelated with MNC decisions to ship intermediates intra-firm from the affiliate to the parent. Second, initial tariff levels (time t=1) are also irrelevant. The only significant predictors of the decision to ship goods intra-firm from the Canadian affiliate to the US parent (N^d) are the lagged choice, the choice at t=1, and the affiliate's capital share (which is negatively related to the decision to export intermediates from affiliate to parent).

The contemporaneous tariff coefficient in the N^d equation is not only insignificant, but also quantitatively small. The magnitude of -3.55 is a bit difficult to interpret in a heterogeneous logit, so consider the following: We see from the estimated variance matrix at the end of Table 2, that the N^d equation has a random effect with a variance of 1.884. As is well known, a logistic error has a variance of $B^2/3 = 3.290$. Thus, the overall variance of the composite error is 5.174, and its standard error is 1.254 times greater than that of a standard logit model. Thus, to a good approximation, the latent index in the heterogeneous logit has to be scaled up by about 25.4% to generate the same outcome probability as the conventional logit. While a value of $ln3$ generates an outcome probability of .75 in a conventional logit, here would need roughly 1.254 θ $ln3$. Now consider a 4.4 point increase in the U.S. tariff, which is two standard deviations (see Table 1). This reduces the latent index by – 3.55 θ (0.044) = – .156. This gives a probability of $N^d>0$ of approximately exp(v)/(1+exp(v)) where v= $ln3$ - .156/1.254 = ln 3 - .124 = .975, which is .726. Thus, a two standard deviation increase in the U.S. tariff reduces the probability that the affiliate ships intermediates intra-firm to the U.S. parent by only 2.4%.

We obtain very similar results for U.S. parents' decision to ship goods intra-firm to the foreign affiliate (N^f), reported in the second panel of Table 2. Canadian tariffs and transport costs (both contemporaneous and initial) are again insignificant. But lagged and initial export choices are significantly correlated with the U.S. parent's decision to export goods intra-firm to the affiliate at time t, again indicating the presence of substantial state dependence.

A difference between the N^d and N^f results is how capital shares are related to intra-firm trade decisions. The affiliate capital share is significantly negatively associated with the decision to ship intermediates intra-firm from parent to affiliate. This seems reasonable, as more capital-intensive affiliates are more likely to produce their own intermediates. The parent capital share is positively related to the decision to ship intermediates to the affiliate, but only significant at the 10% level. While capital shares are related to intra-firm trade decisions for both parents and affiliates, the firm's domestic and foreign wages are not.

Finally, the affiliate's market power parameter is positively associated with the parent's decision to ship intermediates intra-firm to the affiliate. It seems reasonable that U.S. parents, wanting to assure global quality control with regard to particular brands or products, might opt to produce some important components centrally and ship them to foreign affiliates for further processing. Such considerations are more important if final goods produced by the affiliate are more highly differentiated. This is also consistent with Helpman's (1985) suggestion that intra-firm shipments of intermediates from parent to affiliate are more likely when the intermediates require "general know-how" that is typically more abundant in the "entrepreneurial unit."

To summarize, our model essentially says that changes in tariffs and transport costs (and other exogenous factors) do not alter whether an MNC has intra-firm flows. There are MNCs that have intra-firm flows, and MNCs that do not, and firms don't change type over time in response to tariffs. The observed increases in intra-firm trade shown in Figure 2 are accounted for almost entirely by increased trade among MNCs that had positive intra-firm trade to begin with. *These results seem inconsistent with what we would expect if tariff induced increases in vertical specialization were the driving mechanism behind increased intra-firm trade*. Under such a scenario, we would have expected significant increases in intra-firm flows at the extensive margin as low tariffs induced firms to adopt vertical specialization.

Next we turn to the decision rules for whether to engage in arms length trade (see the second page of Table 2). The results are similar to the results for intra-firm trade in that the lagged and initial export (import) choices are important predictors of current export (import) decisions. Again, similar to the intra-firm trade results, current and initial tariffs and transport costs are not significant determinants of whether a firm currently exports/imports. These results complement Bernard and Jensen's (2004a) finding that the 1990's U.S. export boom was driven primarily by firms that already traded.

However, a few interesting differences are evident in the arms-length trade models:

First, neither the parent nor the affiliate capital share is significantly associated with the parent's (or affiliate's) decision to export goods arms-length to Canada (the U.S.). Since, intermediates shipped intra-firm are inputs into the recipient's production technology, while goods shipped arms-length go to entirely different end users, it is not surprising that decisions to engage in intra-firm trade (i.e. to vertically integrate) are related to capital intensities of parent vs. affiliate, while decisions to engage in arms-length trade are not.

Second, parent wages are positively and significantly associated with the parent's decision to export goods arms-length to Canada. Evidently, high-wage U.S. MNC parents are more likely to export goods arms-length to Canada.

Third, in the model for Canadian affiliate arms-length exports to the U.S., we find, interestingly, that affiliate market power is significant and negatively associated with the decision to ship goods arms-length to the U.S. This may seem counterintuitive. However, as we discuss Feinberg and Keane (2001), there are important differences in the composition of the intra-firm versus arms-length trade flows. In particular, there is a greater concentration of manufactured goods traded intra-firm vs. a higher concentration of resource-based goods (such as primary metals, pulp and timber, crude oil) being sold arms-length. It seems likely that the manufactured goods shipped intra-firm are more easily differentiated (e.g., confer more market power) than the commodity products shipped at arms-length.

Taken together, our results show no significant correlations between tariff and transport cost levels – either contemporaneous or at time t=1 (i.e., 1983) – and MNCs' decisions to trade intra-firm or at arms-length. Our finding that decisions to engage in intra-firm and arms-length trade are essentially unrelated to tariff and transport cost reductions over the '83-'95 sample period is consistent with case study evidence in Keane and Feinberg (2005). There, MNC executives consistently indicated that modest tariff reductions of the type that occurred in the U.S.-Canada context during the 1984-1995 period were not sufficient to justify fixed costs of overhauling international supply chains. Of course, some caution is needed in interpreting this result - it certainly does not mean that tariff reductions from much higher levels would not cause firms to initiate trade.

5. Conclusion

We have used confidential BEA data on the activities of U.S. MNCs and their Canadian affiliates to study the effect of trade liberalization on trade at the extensive margin. Specifically, we examined the effect of tariffs on MNC decisions whether to engage in each of four trade flows – intra-firm trade in intermediates from parents to affiliates and vice-versa, exports from the U.S. parent to unaffiliated third parties in Canada, and imports from the Canadian affiliate to unaffiliated third parties in the U.S.. Prior related work by Roberts and Tybout (1997), Das, Roberts and Tybout (2001) and by Bernard and Jensen (2004a, 2004b) has looked at firm decisions to engage in export activity. The main contribution of our work is that we are the first to examine MNC decisions to engage in intra-firm trade in *intermediates*.

The study of how tariffs affect intra-firm trade on the extensive margin is of particular theoretical interest at the present time – recently, some important and influential papers have argued that this is a key mechanism leading to the rapid growth in world trade over the past few decades (see Yi (2003), Eaton and Kortum (2002), Kehoe and Ruhl (2003)). This rapid growth of trade is generally viewed as an important "mystery," because it seems difficult to explain based on the rather modest tariff reductions that have occurred since the early 1980s. However, based on industry level or aggregate data indicating that intra-firm trade in intermediates has increased rapidly in recent decades, these authors have inferred that the cause of the increase is vertical specialization induced by trade liberalization. That is, once tariffs fell below some critical level, it became optimal for firms to engage in extensive fragmentation of production processes across countries, leading them to initiate substantial intra-firm trade in intermediates.

However, we find that tariffs are uncorrelated with firms' decisions to initiate intra-firm trade in intermediates. Rather, these decisions are most strongly driven by lagged choices and firm heterogeneity (i.e., differences in technology across firms within industries). We also find that tariffs are unrelated to firms' decisions to initiate arms-length imports and exports. This latter finding is consistent with earlier work by Roberts and Tybout (1997), Das, Roberts and Tybout (2001), and Bernard and Jensen (2004a, 2004b), that finds large fixed costs of initiating exports, so that it is unlikely that small tariff reductions[12] would lead to initiation of trade.

Thus, our findings appear to be inconsistent with the literature that emphasizes the importance of tariff-induced increases in vertical specialization for the growth of world trade**.** Is

[12] In the U.S.-Canada context, tariffs were mostly down to the 4-6% range in 1983, but varied widely by industry.

it possible to reconcile our results with models of that type? In fact, there is a way, which goes as follows: Suppose the typical MNC already engaged in some intra-firm trade in intermediates at the start of our sample period, but that tariff reductions caused it to substantially increase the extent of vertical integration, and hence the number of *varieties* of intermediates traded intra-firm. In our data, this would appear as an increase in the volume of intra-firm trade.[13] That is, it would show up as a change on the intensive margin.

But, in that case, MNCs' *volume* of intra-firm trade (as we measure it) should appear to be very responsive to tariffs. Yet, in Feinberg and Keane (2005), we find that changes in intra-firm trade at the intensive margin are also uncorrelated with tariff reductions at the industry/firm level. That is, in the U.S.-Canada context in the '83-'96 period, intra-firm trade in intermediates tended to increase just as much in industries where tariffs fell little or not at all as in industries where tariffs fell more substantially.

Taken together, the findings that tariff reductions are uncorrelated with increased intra-firm trade at both the intensive and extensive margins would seem quite inconsistent with models where *tariff-induced* increases in vertical specialization are a key factor driving increased trade. At the same time, our results clearly suggest that increased vertical specialization *is* a key factor driving increased intra-firm trade. Indeed, intra-firm trade in the U.S.-Canada context did roughly double as a share of firm output in the 1983-1996 period (see Figure 2). If tariff reductions did not drive this dramatic increase in vertical specialization, then what did?

In our companion paper Keane and Feinberg (2005) we have examined this question and concluded that advances in logistics management is the most plausible explanation for the rapid increase in intra-firm trade in the U.S.-Canada context over the 1983-1996 period. This conclusion is based on two types of evidence. First, when we regress measures of intra-firm trade on a wide range of firm characteristics and potential driving factors, we find that a single variable "explains" much of the growth of intra-firm trade: the inventory-to-sales (I/S) ratio at the industry or firm level. Second, in case studies of a large number of U.S. MNCs and their Canadian affiliates, we find that the 80s and early 90s was precisely when many of these firms

[13] In the BEA data, we only see the total volume of intra-firm trade flows. We do not know whether the number of varieties of intermediates traded intra-firm increased. The literature on vertical specialization (e.g., Yi, 2003; Eaton and Kortum, 2002) suggests that tariff reductions lead to trade of more varieties of intermediates. Now, suppose lower tariffs did not cause firms to initiate intra-firm trade, but did cause firms that already traded intra-firm to increase the variety of intermediates they trade intra-firm. This could be consistent with what we find here, because, in the BEA data, increased variety will look like an increase on the intensive margin.

began in earnest to adopt important advances in logistics or supply chain management, such as the Just-in-Time (JIT) production system pioneered at Toyota in the 50s and 60s.

Thus, it appears that a declining I/S ratio is an indicator of a firm's success in adopting advanced logistics management practices. The operations research and industrial engineering literatures suggest that these advances reduced the costs of intra-firm trade, by making it easier for firms to organize flows of intermediates across diverse geographic locations (see, e.g., Strader et al (1999), McGrath and Hoole (1992)). Specifically, these advances reduced the inventory carrying cost of intra-firm trade by: (1) reducing the time that intermediates shipped intra-firm sit in stock before being used in the next stage of production, and (2) reducing the buffer stocks of intra-firm intermediates that must be held to protect against delayed or faulty shipments. As Strader et al (1999) note "… information, which provides the basis for enhanced coordination and reduced uncertainty, can substitute for inventory."

Indeed, the two industrial engineering studies of the issue by HP (see Lee, Billington and Carter (1993)) and DEC (see Arntzen et al (1993)) concluded that inventory-carrying costs were a substantial part of the cost of intra-firm trade – much more important than tariffs. This realization led both HP and DEC to adopt JIT logistics and reorganize their international supply chains in ways that led to increased intra-firm trade in intermediates and reduced trade costs. In the relatively low tariff environment that already existed between the U.S. and Canada in 1984, it is plausible that inventory-carrying costs were a more important component of trade costs than were tariffs in many other industries as well.

Our case studies in Keane and Feinberg (2005) shed considerable light on the cause of increased affiliate shipments of intermediates to parents in the 80s and 90s, and the decline in affiliate production of final goods (i.e., sales of intermediates back to parents increased from 38% of affiliate total sales in 1984 to 63% in 1995). In the early 80s, Canadian manufacturing affiliates of large U.S. MNCs mostly produced of final goods. Indeed, tariffs were already low enough by 1983 that most affiliates had been assigned "mandates" to produce a few final goods for sale to the whole North American market. Yet, in the early 80s, many U.S. MNCs suffered severe global excess manufacturing capacity, and many affiliates faced the prospect of being shut down. According to our case studies, those affiliates that were successful in the 80s and 90s were generally ones that adopted JIT and other advanced manufacturing techniques, and used these to become efficient suppliers of high-value added intermediates for the MNC parent.

For example, in 1983, IBM Canada specialized in production of terminals for North America. In danger of being shut down (as terminal production was a "non-core," low value added activity which could be outsourced or performed more cheaply elsewhere), the affiliate took the initiative to adopt JIT techniques and become the low cost worldwide supplier of advanced memory cards for all of IBM. This led to a dramatic increase in intra-firm trade from the affiliate to the U.S. parent.[14] Tariff reductions played no significant role in the reorganization of IBM Canada, or of any other Canadian affiliate we studied.

In an important sense, our argument that technical change (in the form of improved logistics management), rather than tariffs, was the main factor driving increased intra-firm trade is not at all inconsistent with the quantitative results in Yi (2003). His work has been widely interpreted as suggesting that tariff-induced vertical specialization can explain the very rapid growth in world trade in the last 30 years, but a careful reading of his results suggests that this interpretation is not correct. As Yi (2003) notes, when historical tariff reductions are fed into his model, it explains only half of the growth of U.S. exports in the post-1962 period, and "falls short of capturing the nonlinear export surge beginning in the late 1980s" (p. 85). As Yi further notes, in the 1989-99 period, U.S. exports grew 80% in the data while his model generates only a 27% increase (p. 88). In his conclusion, Yi speculates that one reason for the remaining growth of trade may be "technology induced increases in the … possibilities for vertical specialization." We have argued improved that logistics management is a key source of such technical change.

Finally, we note the following caveat: it remains to be seen whether our results generalize beyond the U.S.-Canada context. That is, while tariff reductions may not have caused much increase in intra-firm trade between the U.S. and Canada during the '83-'96 period, it is certainly possible that they have induced large increases in intra-firm trade between other countries during the past 25 years – particularly in cases where tariffs were higher to begin with.

[14] Under such a scenario, one would observe significant changes in the volumes of trade flows at the 4-digit industry level, as in Kehoe and Ruhl (2003), but these would not have been induced by trade liberalization.

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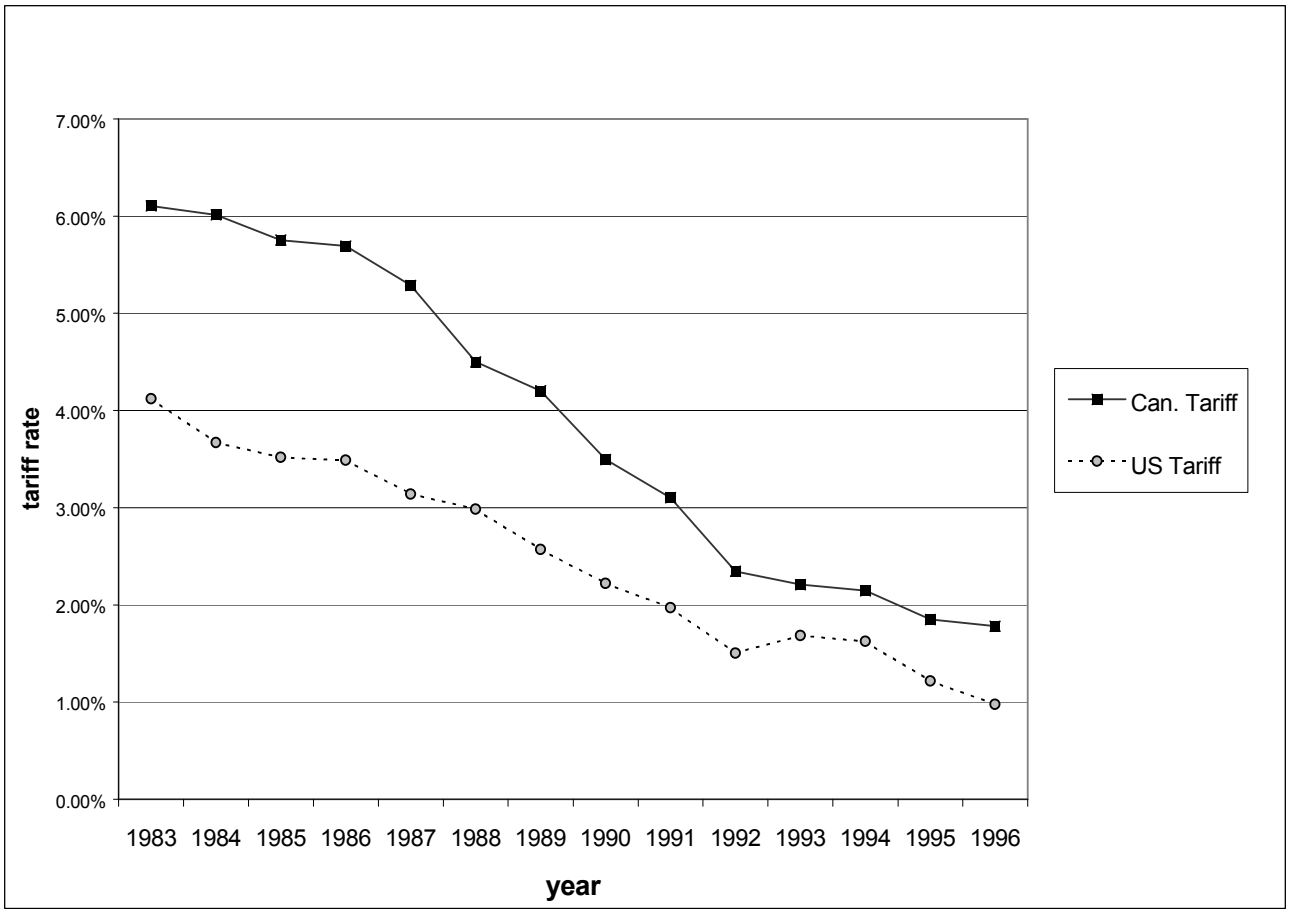
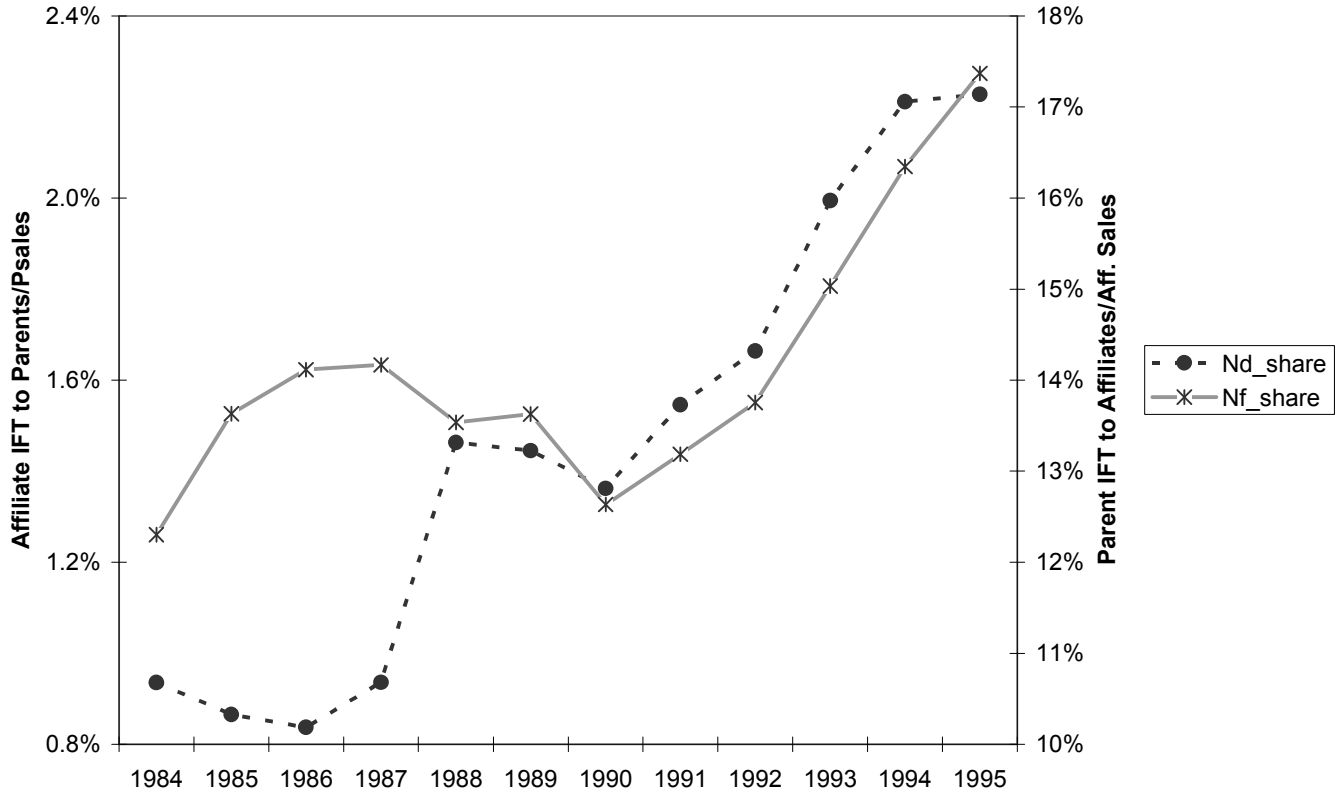
Figure 1: Average U.S. and Canadian Tariffs in Manufacturing: 1983-1996



Note: Average U.S. and Canadian tariffs are calculated for firms in the BEA sample in this study. Both tariffs are defined as duties paid in industry *j* divided by total sales in industry *j*. U.S. data were obtained from the Census Bureau, and Canadian data from Statistics Canada.

Figure 2: Changes in Intra-firm Intermediate Shares, 1984-1995



Note: Average intra-firm trade (IFT) shares were constructed using parent and affiliate level data (N=2335), including observations with no trade flows. Shares were defined as Affiliate IFT to parents/Parent total sales and Parent IFT to affiliates/Affiliate total sales.

Table 1: Descriptive Statistics

	Mean	Std. Dev.
Affiliate Total Sales	288,030	(1272911)
US Parent Total Sales	2,894,530	(7711666)
Affiliate intra-firm sales to US Parents	108,167	(740065)
Conditional on > 0	143,833	(850445)
% > 0	75.20%	
US Parent intra-firm sales to affiliates	96,772	(673554)
Conditional on > 0	117,444	(740411)
% > 0	82.40%	
Affiliate arms-length sales to US	12,393	(41440)
Conditional on > 0	29,588	(59944)
% > 0	41.90%	
Parent arms-length sales to Canada	29,316	(136145)
Conditional on > 0	34,056	(146193)
% > 0	86.10%	
Parent real wage	27.64	(9.41)
Affiliate real wage	26.38	(8.00)
Parent Capital share	29.78%	(7.09)
Affiliate Capital Share	19.73%	(8.74)
US tariffs (time t)	2.43%	(2.21)
Canadian tariffs (time t)	3.92%	(3.63)
US tariffs in 1984 (t=1)	3.68%	(2.70)
Canadian tariffs in 1984 (t=1)	6.32%	(4.25)

Notes: Output, wage and trade flow variables are in ($000's) 1984 US dollars. Wages are total parent (affiliate) employee compensation divided by parent (affiliate) employment, expressed in ($000's).

Table 2: Heterogeneous Logit Model of Trade Flows

Canadian Affiliate sales of Intermediates to U.S. parents (N^d)

Parameter Name	Symbol	Estimate	Std. Error
Exogenous covariates			
Intercept	ψ_0	-1.8682	(1.3094)
U.S. Parent capital share	$\psi_1 \alpha_{it}^{Kd}$	2.6540	(3.5285)
Canadian Affiliate capital share	$\psi_2 \alpha_{it}^{Kf}$	-3.9909	(1.3219) ***
U.S. Tariff plus transport cost at time *t*	$\psi_3(\tau_{dit} + c_{dit})$	-3.5521	(9.4507)
U.S. Parent market power	$\psi_4 g_{1it}$	14.8839	(24.2639)
U.S. Parent wage rate	$\psi_5 w_{dit}$	0.0025	(0.0155)
Canadian Affiliate wage rate	$\psi_6 w_{fit}$	-0.0040	(0.0175)
Time trend	$\psi_7 \cdot t$	-0.0640	(0.0404)
State Dependence			
Indicator for positive flows at *t*-1	$\psi_8 I[N_{i,t-1}^d > 0]$	2.7082	(0.2613) ***
Initial conditions			
Indicator for positive flows at *t*=1	$\psi_9 I[N_{i1}^d > 0]$	2.0432	(0.3885) ***
U.S. Tariff plus transport cost at time *t*=1	$\psi_{10}(\tau_{di1} + c_{di1})$	0.6535	(8.1493)

U.S. Parent Sales of Intermediates to Canadian Affiliates (N^f)

Parameter Name	Symbol	Estimate	Std. Error
Exogenous covariates			
Intercept	ψ_0	-1.2835	(1.6649)
Canadian Affiliate capital share	$\psi_1 \alpha_{it}^{Kf}$	-17.6723	(3.9726) ***
U.S. Parent capital share	$\psi_2 \alpha_{it}^{Kd}$	5.3974	(2.9113) *
Canadian Tariff plus transport cost at time *t*	$\psi_3(\tau_{fit} + c_{fit})$	-3.8424	(9.6310)
Canadian Affiliate market power	$\psi_4 g_{2it}$	62.1002	(19.1856) ***
U.S. Parent wage rate	$\psi_5 w_{dit}$	0.0057	(0.0227)
Canadian Affiliate wage rate	$\psi_6 w_{fit}$	-0.0276	(0.0264)
Time trend	$\psi_7 \cdot t$	-0.0923	(0.0732)
State Dependence			
Indicator for positive flows at *t*-1	$\psi_8 I[N_{i,t-1}^f > 0]]$	2.6841	(0.3699) ***
Initial conditions			
Indicator for positive flows at *t*=1	$\psi_9 I[N_{i1}^f > 0]$	3.1723	(0.6660) ***
Canadian Tariff plus transport cost at time *t*=1	$\psi_{10}(\tau_{fi1} + c_{fi1})$	-0.3242	(7.7293)

Notes: *** = significant at 1% level; **=significant at 5% level; *=significant at 10% level.

U.S. Parent Arms-Length Sales to Canada (E)

Parameter Name	Symbol	Estimate	Std. Error
Exogenous covariates			
Intercept	ψ_0	-2.3931	(1.5575)
U.S. Parent capital share	$\psi_1 \alpha_{it}^{Kd}$	4.0199	(5.2116)
Canadian Tariff plus transport cost at time *t*	$\psi_2(\tau_{fit} + c_{fit})$	6.7880	(9.7591)
U.S. Parent market power	$\psi_3 g_{1it}$	-33.2785	(25.1416)
U.S. Parent wage rate	$\psi_4 w_{dit}$	0.0763	(0.0269) ***
Canadian Affiliate wage rate	$\psi_5 w_{fit}$	-0.0295	(0.0323)
Time trend	$\psi_6 \cdot t$	0.0022	(0.0633)
State Dependence			
Indicator for positive flows at t-1	$\psi_7 I[E_{i,t-1} > 0]$	2.9516	(0.4054) ***
Initial conditions			
Indicator for positive flows at t=1	$\psi_8 I[E_{i1} > 0]$	3.3328	(0.7916) ***
Canadian Tariff plus transport cost at time *t=1*	$\psi_9(\tau_{fi1} + c_{fi1})$	-7.6606	(7.8508)

Canadian Affiliate Arms-Length Sales to the U.S. (I)

Parameter Name	Symbol	Estimate	Std. Error
Exogenous covariates			
Intercept	ψ_0	-0.3746	(0.7916)
Canadian Affiliate capital share	$\psi_1 \alpha_{it}^{Kf}$	2.6306	(1.9747)
U.S. Tariff plus transport cost at time *t*	$\psi_2(\tau_{dit} + c_{dit})$	-0.0552	(9.9939)
Canadian Affiliate market power	$\psi_3 g_{2it}$	-30.3235	(10.8977) ***
U.S. Parent wage rate	$\psi_4 w_{dit}$	-0.0165	(0.0162)
Canadian Affiliate wage rate	$\psi_5 w_{fit}$	-0.0018	(0.0156)
Time trend	$\psi_6 \cdot t$	-0.0430	(0.0364)
State Dependence			
Indicator for positive flows at t-1	$\psi_7 I[I_{i,t-1} > 0]$	2.5033	(0.2408) ***
Initial conditions			
Indicator for positive flows at t=1	$\psi_8 I[I_{i1} > 0]$	2.0843	(0.3913) ***
U.S. Tariff plus transport cost at time *t=1*	$\psi_9(\tau_{di1} + c_{di1})$	-12.0584	(8.9857)

Covariance Matrix of the Heterogeneous Logit Model Random Effects

	μ^{ND}	μ^{NF}	μ^{E}	μ^{I}
μ^{ND}	1.8843***			
μ^{NF}	1.9975***	2.9511**		
μ^{E}	1.0310**	1.0927**	3.1797**	
μ^{I}	1.4941***	1.0196**	0.9690*	2.2521***

Notes: *** = significant at 1% level; **=significant at 5% level; *=significant at 10% level.