Regional Integration and Dynamic Adjustments: Evidence from Gross National Product Functions for Canada and the United States[1]

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Abstract: We estimate a translog Gross National Product (GNP) function along with output and factor shares and test for endogenously determined structural change allowing for anticipated and lagged responses to regional trade agreements (RTAs). We found that Canada embarked on a long transition path prior to the implementation of the Canada-US Trade Agreement, a result reminiscent of Magee's (2008) results about RTAs' trade creation effects. In contrast, the United States experienced an abrupt structural change a year after the North American Free Trade Agreement took effect. This reflects that smaller economies benefitting from greater changes in terms of trade have much more adjusting to do than larger ones. We also found that Stolper-Samuelson and Rybcynski elasticities experienced sign reversals and a magnification effect, implying that the categorization of goods in terms of friends or enemies of labour and capital changed during the transition. The fact that exports have become a friend of labour should soften the opposition of labour unions toward RTAs.

Keywords: GNP function, regional integration, structural change, smooth transition regression, dynamic adjustments.

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1. Introduction

The Canada-United States Trade Agreement (CUSTA) took effect on January 1 of 1989. The two economies were each other's most important trading partner before the creation of the free trade zone and were already highly integrated. Both countries had agreed to phase out their tariffs on each other's exports over a 10-year period and the pace of liberalization was even accelerated for some goods. Plans to enlarge the free trade zone to include Mexico were finalized in December of 1992, resulting in the North American Free Trade Agreement (NAFTA) which took effect in January of 1994. Since then, Canada and the United States of America (U.S. henceforth) have been active in seeking other regional agreements, mirroring the actions of the international community.

RTA negotiations and the phasing-out of tariffs take time to implement and recent analyses about RTA effects on trade flows have attempted to characterize dynamic adjustments (e.g., Carrère (2006), Freund and McLaren (1999), Konno and Fukushige (2003)). Magee (2008) showed that the effects of regional agreements on bilateral trade flows are gradual and that traders had anticipated the implementation of CUSTA. Konno and Fukushige (2002) used the gradual switching approach to analyze the impact of CUSTA on U.S. and Canadian bilateral import functions. The impacts of RTAs go beyond trade flows and may vary from one country to another. The smaller size of Canada compared to the U.S. and the relatively greater importance of international trade in the Canadian economy suggests that Canada went through more adjustments than the U.S.

Back in the mid-1980s, the economic debate in Canada regarding the size of potential gains arising from CUSTA revolved around the exploitation of economies of scale and pro-competitive effects. Under this premise, computable general equilibrium models predicted large gains for Canada (Harris, 1984; Cox and Harris, 1985). Head and Ries (1999) investigated the effect of CUSTA on plant scale and found small net effects arising from the offsetting effects of U.S. and Canadian tariff reductions. Trefler (2004) relied on disaggregated data to show that average pre-CUSTA tariffs were higher than commonly believed and that the tariff cuts were large enough to "matter".[3] In fact, he found that CUSTA had strong negative effects on employment in the most impacted import-competing industries and strong positive effects on labour productivity in the most impacted export-oriented industries. Interestingly, he also found substantial increases in labour productivity in industries that were duty-free prior to CUSTA. CUSTA encouraged entry and exit of firms (in industries with low sunk costs) and allowed some plants in export-oriented industries to expand and reach the so-called minimum efficient scale. It has been shown by Tybout et al. (1991) that trade reforms also encourage firms to become more technically efficient. Efficiency within firms is also likely to rise when competition stiffens. The empirical evidence about so-called X-efficiency gains[4] suggests that trade liberalization causes various firm-level and industry-level effects (Tybout, 2003).

RTAs impact output and factor prices as well. The Stolper-Samuelson theorem tells us that factors have friends and enemies. A good is a friend of a factor if the price of the latter increases in response to an increase in the price of the former.[5] From survey data about the 1988 Canadian election, Beaulieu (2002) found that respondents' views about CUSTA could be explained by factors of production, namely labour skills.[6] Scheve and Slaughter (2001) found a similar result for the USA. A related question is whether CUSTA/NAFTA

[3] At the 4-digit level of product aggregation, tariffs in excess of 10 percent sheltered one in four Canadian industries in 1988, but almost no industries had tariffs in excess of 10 percent when industries are defined by 3-digit level data (Trefler, 2004; p. 872).

[4] Corden (1974) provides an intuitive discussion while Sjostrom and Weitzman (1996) and Campbell and Vousden (2000) provide formal analyses.

[5] The idea goes back to Jones and Schienkman (1977). A good is called a friend to a factor if an increase in the output price (factor's endowment) causes an increase in the factor's price (in output of the good). In the case of the reverse relationship, the good is called an enemy of the factor.

[6] In related work, Beaulieu and Magee (2004) use data from Political Action Committee (PAC) divided in labour and capital groups with respect to the industries represented by each group to examine trade policy preferences. They find that the factor represented by a group is more influential than characteristics of the industry.

produced the anticipated Stolper-Samuelson rewards and punishments or whether structural change caused by CUSTA/NAFTA changed winners into losers and vice versa.

In this paper, we posit that firm-level, industry and macro impacts induced by CUSTA and NAFTA have had a significant effect on the technological characterization of the Canadian and U.S. economies[7]; changing in the process the way factor prices and outputs adjust to changes in terms of trade and in factor endowments. Accordingly, we test for structural change in Gross National Product (GNP) functions for Canada and the United States and compare "before and after" Stolper-Samuelson, Rybczynski, output and factor demand elasticities and the manner with which Canada and the U.S. have adjusted.

GNP functions have been estimated for many countries to analyze a wide variety of issues.[8] Because CUSTA and NAFTA were not implemented along with other major economic reforms as it is often the case with trade liberalization analyses involving less developed countries, an analysis of CUSTA/NAFTA constitutes as "natural" an experiment as it can be hoped (Tybout, 2003). Because these agreements were implemented 5 years apart, it makes it easier to identify which if any induced structural change. Implementing tests that let the data determine the beginning of a new regime allows for anticipated responses. Freund and McLaren (1999) contend that joining a free trade zone induces dynamic adjustments that begin with "preaccessing adjustments" characterized by accelerating and decelerating phases and a jump in the accession year"[9]. As such, there could be a continuum of states as economic agents gather and process information about their

[7] We did not estimate a GNP function for Mexico for two main reasons. First, it is difficult to put together a dataset for Mexico that is comparable to the U.S. and Canadian datasets. It is also complicated to isolate the effects of trade agreements because Mexico went through significant monetary problems that led to a peso crisis.

[8] Kolhi (1978) and Lawrence (1989) focused on the Canadian economy and Kolhi's (1990, 1994) analyses pertained to the U.S. Kolhi (1982) fitted a GDP function for Switzerland and Kohli and Werner (1998) fitted one for South Korea. Harrigan (1997) studied a group of ten OCDE countries. Kee et al (2008) derive import demand elasticities to analyze trade distortions in 88 countries.

[9] See Freund and McLaren (1999, p. 16) for other theoretical and anecdotal arguments regarding anticipatory responses.

economic environment. In such cases, gradual switching or smooth transition regression models are most appealing because they let the data determine the beginning and length of the transition period. Otherwise, tests looking for one or more abrupt changes at endogenously-determined dates would be warranted. If either a gradual or an abrupt structural change is identified, it is then pertinent to assess whether Stolper-Samuelson and Rybcynski elasticities experience sign reversals and/or significant changes in magnitude. The former would imply that the categorization of goods in terms of friends or enemies of factors changed following liberalization.

Even though empirical GNP functions have a long and rich tradition, our analysis innovates by being the first to test for endogenous structural change in this context[10]. We specify a multivariate smooth transition GNP function model to test for gradual change. We rely on the flexible translog functional form to approximate the Canadian (U.S.) GNP function and use aggregated data covering the period 1970-2005 (1970-2007). An alternative approach proposed by Qu and Perron (2007) posits that structural change is abrupt and can occur more than once at unspecified dates. Interestingly, we find that the nature and timing of the structural changes experienced by the U.S. and Canada are quite different. For Canada, we found gradual structural change starting prior to the implementation of CUSTA and ending several years later. This contrasts with the evidence uncovered for the U.S. which identified an abrupt structural change occurring in 1995, a year *after* NAFTA came into force. Canada being a much smaller country, CUSTA impacted more on Canada's terms of trade than on the U.S. and hence induced greater changes in investment, production, trade and consumption decisions. Thus, it is quite intuitive that Canada embarked sooner on a longer lasting transformation process than its neighbour. The empirical analysis also shows

[10] Leamer (2001) considered structural change in the estimation of Stolper-Samuelson equations related to U.S. skilled and unskilled labour.

that several SS and R elasticities experienced sign reversals and a magnification effect over the different sub-periods.

The remainder of the paper is structured as follows. The next section presents the GNP function, its theoretical properties and the empirical specification adopted for estimation purposes. The third section focuses on the data, the estimation and testing for structural change. The implications of structural change for Stolper-Samuelson, Rybcynski, output and factor demand elasticities are analyzed in section four. The last section summarizes our results and their policy implications.

2. The Gross National Product Function: Theory and Empirics

The GNP function of an economy $G(P,V)$ is conditioned by I output prices and J factor endowments. It is defined as the maximum that can be produced by an economy through optimal resource allocation given its technology, factor endowments $V=(V_1,...,V_J)$, and output prices $P=(P_1,...,P_I)$:

$$G(P,V) \equiv \max_{v_i \geq 0} \sum_{i=1}^{I} P_i f_i(v_i) \qquad s.t. \qquad \sum_{i=1}^{I} v_{ik} \leq V_k, \forall k=1,...,J \qquad ; (1)$$

where $v_i = (v_{i1},...,v_{iJ})$, $Y_i = f_i(v_i)$ denotes the production function of good i. The GNP function results from equilibrium conditions pertaining to full employment the market for production factors, perfect competition and restrictions on the technology such that a production function is positive, increasing, concave and homogenous of degree one (Feenstra, 2004; p. 65). Thus, changes in output prices induce changes in input allocation that maintain production on the production possibility frontier. Accordingly, the GNP function is increasing and homogenous of degree one in prices, increasing and homogenous of degree one in endowments, twice differentiable and convex in prices and twice differentiable and concave in endowments (Wong, 1995). Using the envelope theorem, equilibrium output levels can be obtained through:

$$\partial G / \partial P_i = f_i\left(v_i\right) = Y_i, i = 1,..., I \qquad (2)$$

Young's theorem implies $\partial Y_i / \partial P_j = \partial^2 G / \partial P_i \partial P_j = \partial^2 G / \partial P_j \partial P_i = \partial Y_j / \partial P_i$. The convexity (in prices) property insures that the matrix of second derivatives is positive semi-definite which implies that diagonal elements are non-negative: $\partial Y_i / \partial P_i \geq 0$. Under the aforementioned assumptions, GNP can be expressed in terms of the value of endowments or of outputs since $\sum_{j=1}^{J} w_j V_j = \sum_{i=1}^{I} P_i Y_i$, with w_j denoting the price of factor *j*). Appealing to the envelope theorem, the relationship between factor prices and factor endowments can be obtained:

$$\partial G / \partial V_j = P_i \partial f_i / \partial v_{ij} = w_j \qquad i = 1,..., I;\ j = 1,..., J \qquad (3)$$

Combining the previous results yields:

$$\partial w_j / \partial P_i = \partial^2 G / \partial V_j \partial P_i = \partial^2 G / \partial P_i \partial V_j = \partial Y_i / \partial V_j \qquad (4)$$

The first derivative on the left hand-side of (4) is the Stolper-Samuelson (*SS*) relation and it is identical to the Rybczinsky (*R*) relation. The sign of a *SS* effect identifies the "friends" and "enemies" of each factor as an increase in the price of a given output generally hurts some factors and helps others. The magnitude of the *SS* effects is of great interest because the gains and losses of factors can be assessed by looking at how much their prices decrease or increase. The fact that they are reported as elasticities makes for easy comparisons across factors. The *R* effects tell us about how an increase in the endowment of a factor changes the level of output of a product under the assumption that output prices and others factors are constant.

The translog function is by far the most popular functional form used in the literature to estimate a GNP function and has the following structure in our context:

$$\ln G = \alpha_0 + \sum_{i=1}^{I} \alpha_i \ln P_i + \sum_{j=1}^{J} \beta_j \ln V_j + \frac{1}{2}\sum_{i=1}^{I}\sum_{k=1}^{I} \gamma_{ik} \ln P_i \ln P_k + \frac{1}{2}\sum_{j=1}^{J}\sum_{h=1}^{J} \phi_{jh} \ln V_j \ln V_h + \sum_{i=1}^{I}\sum_{j=1}^{J} \delta_{ij} \ln P_i \ln V_j \qquad (5)$$

Where the restrictions $\sum_{i=1}^{I}\alpha_i = \sum_{j=1}^{J}\beta_j = 1, \sum_{i=1}^{I}\gamma_{ik} = \sum_{i=1}^{I}\delta_{ij} = \sum_{j=1}^{J}\delta_{ij} = \sum_{j=1}^{J}\phi_{jk} = 0, \gamma_{ik} = \gamma_{ki}, \phi_{jh} = \phi_{hj}$ must hold for adding-up, homogeneity and symmetry properties to be verified. These parametric restrictions greatly reduce the number of parameters to be estimated at the empirical stage.[11]

Differentiating the GNP function in (5) with respect to $\ln P_i$ yields the output share of good *i*:

$$s_i = \partial \ln G / \partial \ln P_i = \alpha_i + \sum_{j=1}^{I} \gamma_{ij} \ln P_j + \sum_{j=1}^{J} \delta_{ij} \ln V_j \qquad (6)$$

Similarly, differentiating the of GNP function in (5) with respect to $\ln V_j$ yields the input share of production factor *j*:

$$s_j = \partial \ln G / \partial \ln V_j = \beta_j + \sum_{h=1}^{J} \phi_{jh} \ln V_h + \sum_{i=1}^{J} \delta_{ji} \ln P_i \qquad (7)$$

Elasticities are expressed as a function of the parameters in the system. Using a logarithmic transformation of $s_k = \frac{w_k V_k}{G}$ and $s_i = \frac{P_i Y_i}{G}$, we get $\ln w_k = \ln s_k + \ln G - \ln V_k$ and $\ln Y_i = \ln s_i + \ln G - \ln P_i$, respectively. The *SS* and *R* elasticities are:

$$\partial \ln w_k / \partial \ln P_i = \frac{\delta_{ki}}{s_k} + s_i; \qquad (8)$$

$$\partial \ln Y_i / \partial \ln V_k = \frac{\delta_{ik}}{s_i} + s_k; \qquad (9)$$

Factor price flexibilities and output elasticities are computed as:

[11] The convexity in prices and concavity in endowments properties cannot be imposed through simple parametric restrictions. If the properties do not hold at points of interest (i.e., at the mean or for a particular year), then it is possible to impose the properties locally as shown in Diewert and Wales (1997) and Ryan and Wales (1998).

$$\partial \ln w_j / \partial \ln V_h = \begin{cases} \dfrac{\phi_{jj}}{s_j} + s_j - 1, \text{if } j = h \\ \dfrac{\phi_{jh}}{s_j} + s_h, \text{if } j \neq h \end{cases} \quad (10)$$

$$\partial \ln Y_i / \partial \ln P_k = \begin{cases} \dfrac{\gamma_{ii}}{s_i} + s_i - 1, \text{if } k = i \\ \dfrac{\gamma_{ik}}{s_i} + s_k, \text{if } k \neq i \end{cases} \quad (11)$$

For practical consideration, rewrite the system of equations in (6) and (7) as:

$$Y_t = \theta X_t + e_t \quad (12)$$

where Y_t is the vector of dependent variables of dimension *H* x 1, θ a vector of parameters to be estimated of dimension *H* x *P*, X_t a vector of independent of dimension *P* x *1* variables and e_t a vector of error terms.

The introduction of gradual structural change is implemented by a multivariate smooth transition regression model developed by Bacon and Watts (1971), Tsurumi (1980), Ohtani and Takayama (1985) and Tsurumi et al (1986).[12] It identifies the beginning of the transition and measures its speed. Under the assumption of gradual structural change, the system in (12) can be rewritten as:

$$Y_t = \theta_1 X_t + \theta_2 X_t \times F\left(TV_t, \gamma, \mu\right) + \varepsilon_t \quad ; \quad (13)$$

where TV_t denotes a transition variable, $\theta_{1,h}$ and $\theta_{2,h}$ are ($P \times 1$) vectors of parameters, ε_h denotes a sequence of independent identically distributed errors. The function $F(TV_t, \gamma, \mu)$ is

[12] Camacho (2004) provides an excellent review of multivariate or vector smooth transition regressions. Smooth transition regressions have been also used in system of demand estimation among other by Moschini and Meilke (1989), Goodwin et al. (2003) and Holt and Balagtas (2009) .

called the transition function. It is assumed continuous, bounded between 0 and 1 and it varies with the transition variable s_t according to parameters γ and μ.[13]

In most applications, $F(TV_t, \gamma, \mu)$ is specified to be a logistic function or an exponential function. As noted by Van Dijk et al. (2002), the choice between these two functions generally depends on the nature of the dynamics to be investigated. For example, the logistic function is more appropriate to study business cycles, but the exponential function is more appropriate for regime switching between two different and distinct regimes. Accordingly, we chose the exponential function which is defined as:

$$F(TV_t, \gamma, \mu) = 1 - \exp\left\{-\gamma\left(TV_t - \mu\right)^2\right\},\ \gamma > 0.$$

This function is non-monotonic and symmetric around μ. The parameter μ is the threshold representing the date at which transition begins (i.e., $F\left(TV_t, \gamma, \mu\right) = 0$) and γ is the speed of adjustment between the two regimes. The transition variable in our model is a linear trend ($TV_t = t$). As a result, our model can be construed as a time-varying multivariate smooth transition model.

In what follows, we also investigate abrupt structural change using the procedure developed by Qu and Perron (2007). In essence, the case in which coefficients take one set of values throughout the period covered by the sample is pitted against models with coefficients taking two or more values over the sample[14]. The main advantage of the procedure is that the number of structural breaks and the dates at which they occur are endogenously determined.

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[13] Here we suppose that the transition function is the same in all equations because we impose a common regime switching for all equations.

[14] This procedure allows for structural change in a system of equations that occurs at an unknown date and that can affect the regression coefficients, the covariance matrix of the errors, or both. The estimation method is a quasi-maximum likelihood estimator assuming normal errors which admits the presence of conditional heteroskedasticity and autocorrelation.

Furthermore, confidence intervals around the dates of the breaks can be computed to see whether they encompass RTA implementation dates.

3. Data and econometric estimation

The Canadian time series used in our analysis come from Statistics Canada and the International Monetary Fund and cover the period 1970-2005.[15] The data for the U.S. economy are obtained from the U.S. Bureau of Economic Analysis and cover the period 1970-2007. While the translog functional form offers the advantage of being flexible enough to provide a second degree approximation of any technology, this advantage comes at a cost because the number of parameters to be estimated increases rapidly with the numbers of products (I) and factors (J). This is why most studies about the GNP function have relied on a few broadly-defined products and factors.

Following Kohli and Werner (1998) and Kohli (2004), we rely on two factors of production, capital (K) and labour (L), and three outputs, exports (X), domestic sales (D) and imports (M). Imports are considered as intermediate products, requiring various domestic services such as unloading, transportation, storage, repackaging, marketing and retailing, before being consumed. Kee et al. (2008) and Yi (2003) contend that a large part of the growth in world trade can be attributed to vertical specialization. In this context, the treatment of imports as intermediate products is an appealing feature of the GNP function framework. Because exports must be tailored to suit the specificities of importing countries, they are differentiated from domestic goods. Details about the construction of the dataset are presented in appendix 1.

Figures 1 and 3 illustrate trends in relative Canadian and U.S. import and export prices using the price of domestic goods as the numéraire. Figure 1 displays cyclical

[15] It was impossible for us to begin our analysis prior to 1970 because Statistic Canada changed its methodology to generate aggregate data for the economy in 1997. Using pre-1970 data would have meant ending our sample in 1997.

movements in Canadian relative prices, beginning with an ascending phase during the 1970s that preceded a 10-year declining trend which was followed by a shorter upward trend and another downturn. Figure 3 illustrates U.S. relative import and export prices increasing in the 1970s, but the declining trend that ensued was longer-lasting than in Canada's case. Figures 2 and 4 illustrate the rates of growth in capital intensity[16] for Canada and the U.S. over the sample period. Canada began experiencing faster growth after 1989 following the implementation of CUSTA came into force while U.S. growth began after 1994 when NAFTA came into force.

Tables 1 and 2 present descriptive statistics of the key variables in the model. The negative sign associated with the import share is explained by the treatment of imports as intermediate inputs, which means that some transformation is needed before imports could be marketed to consumers (Kohli, 1991, p.62). Table 1 reveals substantial increases from one sub-sample to another in the mean share of capital in the Canadian economy. In contrast, the US pre-CUSTA and post NAFTA shares are quite similar. As expected, greater integration brought the capital-labour ratios of Canada and the U.S closer. The larger change in the capital-labour ratio experienced by Canada simply reflects larger terms of trade adjustments. .

We estimated a three-equation system that includes *I*-1 product shares and *J*-1 factor shares. We relied on the iterative seemingly-unrelated estimator to account for contemporaneous correlation between the residuals of the three equations. The main hypothesis is that CUSTA brought about a major structural change that impacted the parameters of Canada's GNP function. This could have occurred through a gradual process whose beginning anticipated CUSTA and lasted several years due to various short run

[16]For the specify economy, it is the ratio between the stock of capital and the volume of labour evaluate in terms of total of worked hours.

constraints. Preliminary estimations revealed autocorrelation problems that led us to estimate the system of share equations in first differences:

$$\Delta s_i = \sum_{j=1}^{I} \gamma_{ij} \Delta \ln P_j + \sum_{j=1}^{J} \delta_{ij} \Delta \ln V_j \qquad i \in \{M, X, D\} \tag{14}$$

$$\Delta s_j = \sum_{h=1}^{J} \phi_{jh} \Delta \ln V_h + \sum_{i=1}^{I} \delta_{ji} \Delta \ln P_i \qquad j \in \{L, K\} \tag{15}$$

Keeping in mind that $Y_t = (y_{1t}, ..., y_{Ht}), X_t = (X_{1t}, ..., X_{Ht})$, and h = 1, …, H, equation (13) becomes :

$$\Delta y_{ht} = \theta_{1,h} \Delta X_{ht} + \theta_{2,h} \Delta X_{ht} \times F(t, \gamma, \mu) + \Delta \varepsilon_{ht} \tag{16}$$

We can test for a linear specification against the smooth transition regression in two ways. We can test the null hypothesis of linearity by restricting the parameters in $\theta_{2,h}$ to equal zero or alternatively we can restrict the coefficients in such a way as to set F to zero ($\gamma = 0$). In that case, the null hypothesis of linearity in (16) can be expressed as :

$$H_0 : \gamma = 0 \text{ against } H_0 : \gamma > 0$$

$$\text{Or as } H_0 : \theta_{2h} = 0 \text{ against } H_0 : \theta_{2h} \neq 0$$

The challenge is that some parameters are not identified under the null hypothesis and thus the distribution of the standard tests follows non-standard distributions. Luukkonen et al. (1988) proposed to replace the transition function by a Taylor approximation of an appropriate order to overcome the identification issue.[17] We use a first degree Taylor approximation around $\gamma = 0$ and then replace $F(t, \gamma, \mu)$ by:

$$T_1(t, \gamma, \mu) = \gamma \left. \frac{\partial F(t, \gamma, \mu)}{\partial \gamma} \right|_{\gamma \equiv 0} + R_1(t, \gamma, \mu)$$

[17] Alternatively, Hansen (1996) proposed to approximate the limit distribution by generating p-values through simulation methods.

where $R_1(t,\gamma,\mu)$ is the remainder term.[18] Substituting $T_1(t,\gamma,\mu)$ for $F(t,\gamma,\mu)$ in (16) and rearranging terms yields the auxiliary model:

$$y_h = \beta_{0,h}X + \beta_{1,h}Xt + \beta_{2,h}Xt^2 + \nu_h \tag{17}$$

with $\nu_h = \theta_{2,h}X \cdot R_1(t,\gamma,\mu) + \varepsilon_h$, $\beta_{0,h} = \theta_{1,h} + \mu^2\gamma\theta_{2,h}$, $\beta_{1,h} = -2\mu\gamma\theta_{2,h}$ and $\beta_{2,h} = \theta_{2,i}\gamma\theta_{2,h}$.

The null hypothesis of linearity can be summarized as $H_0 : \beta_{l,h} = 0; l = 1,2; h = i, j$ and it is equivalent to $H_0' : \theta_{2,h} = 0$ or $H_0'' : \gamma = 0$. We note that $\nu_h = \varepsilon_h$ under the null hypothesis. A Lagrange multiplier test distributed with $df = 6 \times 2 = 12$ degrees of freedom can be computed. To avoid the problem of spurious rejection of linearity due to heteroskedasticity of an unknown form, we use heteroskedastic-consistent standard errors.

For Canada, the LM statistic for the non-linearity test is 26.25 and it exceeds the corresponding 5% critical value of 21.03. As a result, we reject the null hypothesis of linearity and consider from this point on that Canada's GNP function has undergone a process of gradual structural change. Table 2 reports the estimated parameters and the fit of the model. The coefficient of determination for the model is high (R^2 = 0.78).[19] The two parameters of the transition function are statistically significant and we have $\gamma = 3.52$ for the speed of adjustment and $\mu = 0.07$ for the threshold, corresponding to the year 1997.[20] As illustrated by the graph of the transition function in Figure 5, the structural break started around 1984 and adjustments continued until 2005. Stability characterizes the 1970-1984 period. In 1984, the Canadian economy embarked on a transition phase, reached the second regime in 1997 and then began moving back toward the first regime.

[18] Van Dijk et al. (2002) note that using higher approximations involves a trade-off between including more variables in the auxiliary regression versus potential precision. Tests based on first-order approximations have been shown to have as much power as tests based on second-order approximations.
[19] The system R^2 is computed by the method proposed by McElroy (1977) for the SUR model.

[20] We normalized the time trend and price variables to their 1997 values.

Overall, the characterization of structural change is reminiscent of the results reported in Magee (2008) and Baier and Bergstrand (2007) who found that bilateral trade flows had begun adjusting prior to the implementation of CUSTA and kept on adjusting for years afterward. We can divide our sample to focus on the regimes prior to and after the beginning of the transition period. Going back to Table 1, we can compare statistics before and after 1984 as opposed to CUSTA's implementation date. The reduction (increase) in labour's (capital's) input share is more pronounced than when we compare pre-CUSTA to post-CUSTA input shares.

Table 4 reports the parameters estimates and the fit for the U.S. model. The coefficient of determination is high (R^2 = 0.80) and many parameters are significant. The two parameters of the transition function are statistically significant. For the speed of adjustment, we have $\gamma = 0.082$, which is higher than for Canada, and the threshold estimate ($\mu = 1.091$) suggests that regime II occurred later than for Canada. The transition function is displayed in Figure 6. It shows that the structural break might have started in 1995 and did not last long. However, the LM statistic for the non-linearity test is 8.17, well below the 10% critical value of 18.55. The statistical evidence does not support the gradual structural change hypothesis. However, the plot in Figure 6 suggests that the hypothesis of an abrupt structural change is worth considering.

Very quick transitions might be easier to detect with a procedure that search for abrupt changes so we implemented the procedure of Qu and Perron (2007) to estimate the date(s) of abrupt structural change(s). We found evidence of one structural break in the U.S. system. The estimated date of break is 1995 and the 90% lower and upper bounds of the confidence interval for the break date are 1991 and 1999 (i.e, ± 4 years). We divided our sample into two sub periods around 1995. The estimation results conducted over these two subsamples and the full sample are presented in Table 5. Most of the parameters are statistically significant and quite different across samples. The fit measured by the system R^2 is quite good. We are confident that NAFTA, not CUSTA, had a significant impact on the U.S.

Canada and the U.S. have responded differently to regional integration initiatives. Canada's structural change occurred around the adoption of CUSTA and lasted several years whereas the U.S. experienced an abrupt structural change only after NAFTA came into force. It could be argued that the U.S. economy is more flexible than the Canadian economy and did not need as much time for transition. However, because Canada began adjusting prior to CUSTA and the USA did not, we can infer that Canada's terms of trade significantly changed under CUSTA while U.S. terms of trade did not. As the small country trading with a very large one, Canada did most of the adjusting, but could have enjoyed most of the gains.[21] A glance at figure 3 shows that the spread between import and export prices for the US is essentially constant between 1984 and 1994, thus implying constant terms of trade. In contrast, the lines in figure 1 cross more than once over the same period and we reckon that Canada's terms of trade experienced more changes.

4. Goods and Factors Linkages: When Friends become Enemies and Enemies become Friends

We present the Stolper-Samuelson (*SS*), Rybczynski (*R*), output and factor demand elasticities Tables 6 and 7. These are estimated at the mean of each subsample. Confidence intervals are reported using the simulation method of Krinski and Robb (1986) which relies on 1,000 random draws from the joint distribution of the estimates. It should be noted that the elegant and well-known results obtained with the classic 2x2x2 Heckscher-Ohlin-Samuelson model do not automatically generalize to models with more outputs and/or inputs.[22] The Rybcynski

[21] Country size matters as argued by Syropoulos (2002). Starting from a Nash tariff equilibrium, moving to free trade makes the small (large) country better (worse) off.

[22] Choi and Harrigan (2003) is a useful reference for higher dimensionality issues.

theorem does not hold when there are more factors than goods while a generalized version of the Stolper-Samuelson theorem continues to hold (Feenstra, 2004; p. 71),.

The point estimates for elasticities in the two regimes for Canada or the two periods for the USA are generally consistent with those reported in the literature and most of them are statistically significant. Comparing results across regimes, one can observe sign reversals which imply that goods that were friends to a particular factor have become enemies of that factor (and vice-versa). We also observe a scale effect that inflates the responses of the import demand, export supply and inverse factor demands.

The results for the Canadian economy are reported in Table 6. The SS elasticities of the first regime indicate that an increase in the price of exports has a negative effect on the price of labour, and that an increase in the price of imports decreases the price of capital. In contrast, wages tend to rise in response to increases in the price of imports and in the price of domestic goods. The price of capital increased following increases in the prices of exports and domestic goods. Given that trade liberalization typically induces higher export prices and lower import prices that combine to improve the terms of trade, labour unions had reasons to be sceptical about the alleged benefits of CUSTA for their members as opposed to owners of capital who were generally pro-CUSTA. These results are consistent with Beaulieu's (2002) analysis of survey data in the year preceding the implementation of CUSTA.

The elasticities for the period following the transition are quite different. In the second regime, the price of labour reacted negatively (positively) to increases in the price of imports (exports) while the opposite can be said about the price of capital. However, insofar as imports and exports prices have declined following the implementation of CUSTA, the net combined effect on the price of labour is positive, confirming the results of Trefler (2004, p. 885) that tariff reductions increased earnings and wages of all workers. Because the price of capital increased in the post-transition period, we can infer from the simultaneous reductions in imports and exports prices that export price reductions ended up having a stronger positive effect on the price of capital. Finally, our estimates show that increases in the price of domestic goods tended to boost wages and the rental rate of capital in both regimes. Kohli and Werner (1998) report similar effects for South Korea.

Turning our attention to the U.S. *SS* elasticities, we notice in Table 7 that an increase in the price of imports has a negative effect on the prices of labour and capital in the first period. This means that imports were enemies of labour and capital. If we consider imports as intermediate inputs, we can say that they were substitutes for labour and capital in the U.S. before 1995. In contrast, exports and domestic goods are friends of the two inputs. The elasticities pertaining to the inverse factor demand of labour vary substantially across regimes. We can observe sign reversals as imports became a friend of labour and exports became an enemy. In contrast, the inverse labour demand for domestic goods did not change. As for the SS effects on the price of capital, the signs remain the same across regime, but the elasticities have increased in the second period for the three goods. Following the terminology of Jones and Scheinkman (1977), domestic and export goods are friends of capital.

In the period preceding CUSTA transition for Canada, *R* elasticities indicate that an increase in labour endowment had a significant positive effect on domestic sales, but a negative effect on imports and exports. An increase in capital endowment had a significant positive effect on imports, exports and domestic sales. As illustrated in Figure 2, the Canadian economy experienced large increases in its capital-labour ratio during the transition years, which increased the production capacity of the Canadian economy. Comparing the “before” and “after” regimes, we observe a sign reversal in the *R* elasticities for imports and exports. In regime II, labour favours all three GNP components, but capital hurts imports and exports. Knowing that the amount of capital has increased significantly during the transition period, we can conclude that observed endowment changes supported consumption of domestic products at the expense of imports and exports as in Kohli and Werner (1998). Canada experienced rapid growth in imports and exports as in South Korea. In the case of Canada, the evolution of import, domestic and export prices ended up offsetting the effects of structural change.

The second part of Table 7 reveals that the R elasticities in the U.S. only changed for imports and exports. There is a sign reversal in the impact of labour endowment on the demand of import and the production of exports goods. In the first period, an increase in labour endowment induced increases in imports and exports. However, in the second period, the result is opposite as the production of traded goods fell in response to increases in labour endowment. Comparing, we see that the impact of an increase in the stock of capital had a stronger positive effect on the production of traded goods after NAFTA came into force. We find no evidence of change in the quantity elasticities of domestic goods when we compare the two periods. The U.S. non-trading sector is very large and this might explain why it was seemingly oblivious to NAFTA.

Looking at the Canadian import demand and output supply prices elasticities, Table 6 shows that the export and domestic supplies are inelastic ($\varepsilon^{I}{}_{XX} = 0.72$, $\varepsilon^{I}_{DD} = 0.33$) while the import demand elasticity is not statistically different from zero in regime I. However, the import demand elasticity ($\varepsilon^{II}{}_{MM} = -2.05$) is significantly different from zero in the second regime. Prior to the transition, higher import prices increased exports, thus mimicking the effects of a currency devaluation, and decreased domestic production which suggests that the latter relies on foreign inputs. In the second regime, increases in export prices triggered increases in imports and in domestic production, which suggests that imports are increasingly used as inputs in export manufacturing and that exports and domestic goods are complements in production. In the case of the U.S., import demand and output supplies are inelastic. In the first period, the demand for imports is sensitive to the prices of the three goods. The supply of export goods is sensitive to changes in the price of imports and exports, but the price elasticities for domestic goods are near zero. The demand for imports decreases when the price of imports goes up and increases when the price of exports goes up. The production of export goods reacts negatively to increases in the domestic price and positively with the price of imports and exports. The most notable change appears for the cross price elasticities between exports and domestic goods. In the first period, this elasticity is near zero and in the second period, it falls below minus one, which means that exports and domestic goods became complementary goods after 1995.

In terms of Canadian factor demands, the own-price elasticities for labour and capital have the expected negative signs before and after CUSTA. However, we notice sizeable scale effects that render these demands more elastic over time ($\varepsilon^{I}{}_{KK} = -0.31, \varepsilon^{II}{}_{KK} = -0.72, \varepsilon^{I}{}_{LL} = -0.22, \varepsilon^{II}{}_{LL} = -0.73$). The elasticities for the U.S. have the same signs as the Canadian ones, but their size differs as well as their changes across regimes ($\varepsilon^{I}{}_{KK} = -0.57, \varepsilon^{II}{}_{KK} = -0.65, \varepsilon^{I}{}_{LL} = -1.09, \varepsilon^{II}{}_{LL} = -1.04$).

5- Conclusion

Recent studies on the trade creation effects of RTAs have focused on the dynamic impacts of RTAs. Magee (2008) showed that RTA effects could be long lasting and can anticipate the implementation phase. Our analysis innovates by searching for endogenous transitions and structural changes in GNP functions for Canada and the United States. Our main hypothesis is that the Canada U.S. Trade Agreement (CUSTA) and the North American Free Trade Agreement (NAFTA) triggered different adjustments in the Canadian and U.S. economies. Because the Canadian economy is much smaller and more dependent on trade (especially with the U.S.), it was anticipated that CUSTA had a stronger impact on Canada than on the U.S.. Relying on a multivariate smooth transition regression framework, we found that the Canadian economy was stable during the 1970-1984 period before embarking on a slow transition process. The transition toward the new regime predated the implementation of CUSTA and lasted until 1997, at which point a slow reverting path followed. The same procedure was used for the U.S. GNP function, but we found little evidence of a transition path similar to the Canadian one (around NAFTA or CUSTA). We then searched for endogenous abrupt structural changes using the procedure of Qu and Perron (2007). This procedure identified a structural break in 1995 with a confidence interval of plus or minus 4 years, thus spanning the NAFTA negotiations and implementation date. The contrasts in the nature and timing of the structural changes in the U.S. and Canadian GNP functions suggest that the much smaller Canadian economy was confronted to larger terms of trade changes and more volatile terms of trade. The fact that the U.S. economy is so much larger, yet more flexible (particularly its labour market), rationalizes the abrupt structural change finding.

The GNP function is often used to analyze the relationships between output and factor prices and relationships between factor endowments and output levels. We computed Stolper-Samuelson or *SS* elasticities and Rybcynski or *R* elasticities to ascertain how CUSTA and NAFTA might have affected the aforementioned relationships. Some of the benefits of RTAs are well-documented, yet RTAs have been controversial. Part of the opposition is motivated by the expected effects of output price variations on factor prices, especially wages. Stolper-Samuelson and Rybcynski elasticities have attracted much attention in the literature and it seems most pertinent to ascertain how they were impacted by CUSTA and NAFTA. We found sign reversals in *SS* and *R* elasticities. Prior to CUSTA, imports were friends of Canadian workers while exports were enemies, thus rationalizing the fierce opposition that Canadian labour unions entertained toward CUSTA prior to its implementation. However, after the transition period, Canadian exports have turned into friends and imports into enemies while the opposite holds for the USA. This change should make it easier for Canada to negotiate new RTAs, like the one with the European Union.

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Appendix: Data construction

The variables were constructed as in most empirical studies using GNP functions and following some recommendations from Kohli (1991, chap 8).

Working at an aggregate level, to evaluate domestic production or GNP, we used the income and expenditure approaches. According to the income approach, the gross national product is equal to the sum of the value of exports and national expenditures minus imports. Imports and exports are evaluated net of foreign transfers. The volumes of imports and exports were extracted from StatCan's CANSIM II database and related prices. The volume of national expenditures was extracted from CANSIM II and the prices associated with the consumption aggregate are the Canadian national consumer price index.

In the implementation of the second approach, we assume that the gross national product can be calculated like the sum of the factors' remuneration. This relation gives us an estimate of the remuneration of capital for the economy. After approximating the remuneration of labour by the total of salary paid per year in the economy, we obtain the amount of the remuneration of the capital by simple deduction. Then, with the volume (or stock) of capital obtained from the StatCan's database, we can estimate the price of capital. The price of labour was computed by dividing the remuneration of labour by the volume of work. The latter is defined as the product of the employment level and the hours worked per week.

Table 1: Descriptive statistics of output shares and input shares for Canada

	Full Sample (1970-2005)		Pre-CUSTA (1970-1989)		Post-CUSTA (1989-2005)		Regime I (1970-1984)		Regime II (1985-2005)	
	Mean	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
Output shares										
Imports	-0.195	0.077	-0.133	0.031	-0.265	0.045	-0.119	0.019	-0.300	0.012
Exports	0.258	0.081	0.201	0.031	0.324	0.069	0.192	0.028	0.376	0.029
Consumption	0.936	0.022	0.931	0.014	0.941	0.029	0.928	0.013	0.925	0.024
Input shares										
Labour	0.545	0.042	0.578	0.026	0.510	0.024	0.587	0.022	0.492	0.010
Capital	0.454	0.042	0.422	0.026	0.490	0.024	0.413	0.022	0.508	0.010

Table 2: Descriptive statistics of output shares and input shares for USA

	Full Sample		Pre-CUSTA		Post-CUSTA		Regime I (1970-1995)		Regime II (1996-2007)	
	Mean	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
Output shares										
Imports	-0,123	0,032	-0,099	0,020	-0,148	0,022	-0,106	0,021	-0,160	0,017
Exports	0,103	0,018	0,088	0,014	0,117	0,008	0,095	0,017	0,119	0,009
Consumption	1,021	0,020	1,011	0,014	1,031	0,021	1,011	0,012	1,042	0,018
Input shares										
Capital	0,356	0,032	0,350	0,014	0,362	0,042	0,342	0,019	0,387	0,032
Labour	0,644	0,032	0,650	0,014	0,638	0,042	0,658	0,019	0,613	0,032

Figure 1: Terms of trade from 1970 to 2005 for Canada

PXR : Relative price of exports; PMR : Relative price of imports.

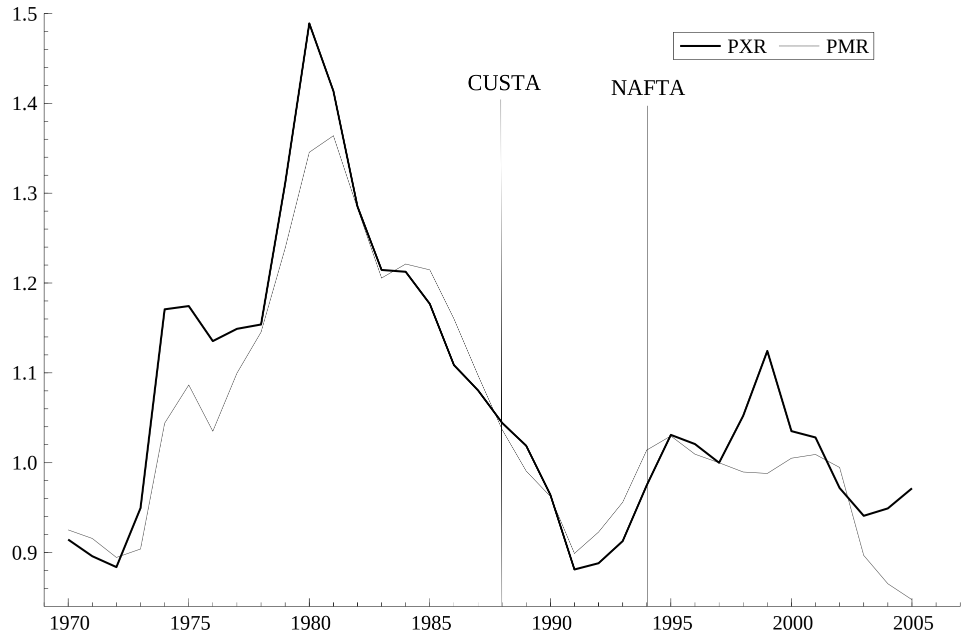

Figure 2: Growth of capital intensity ratio from 1970 to 2005 for Canada (2000 = 100)

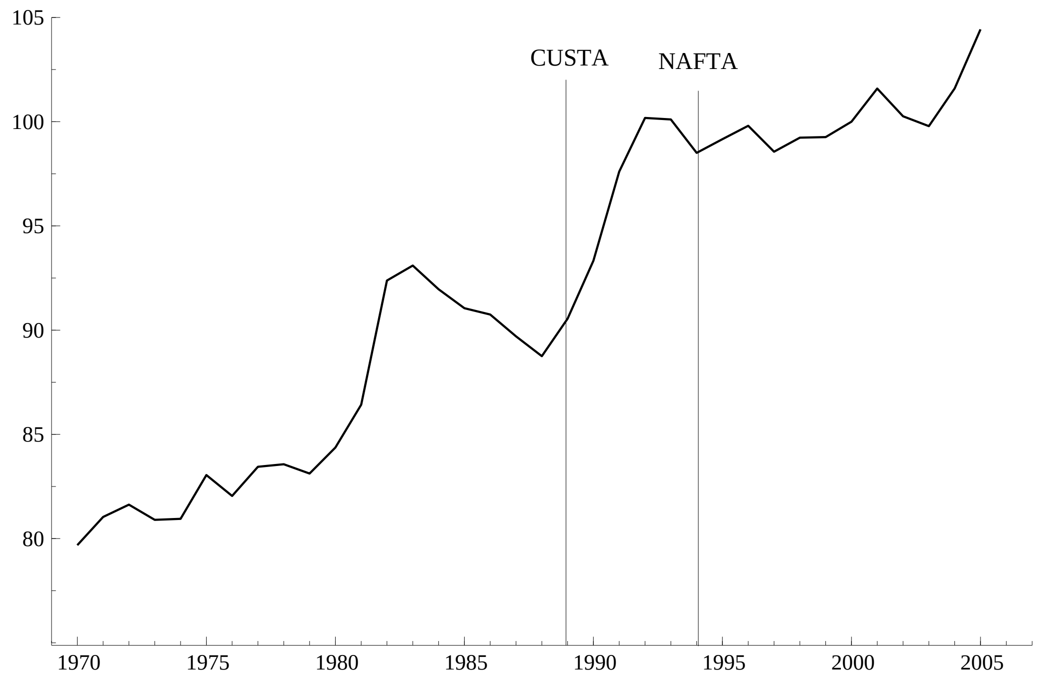

Figure 3: Terms of trade from 1970 to 2007 for USA

PXR : Relative price of exports; PMR : Relative price of imports.

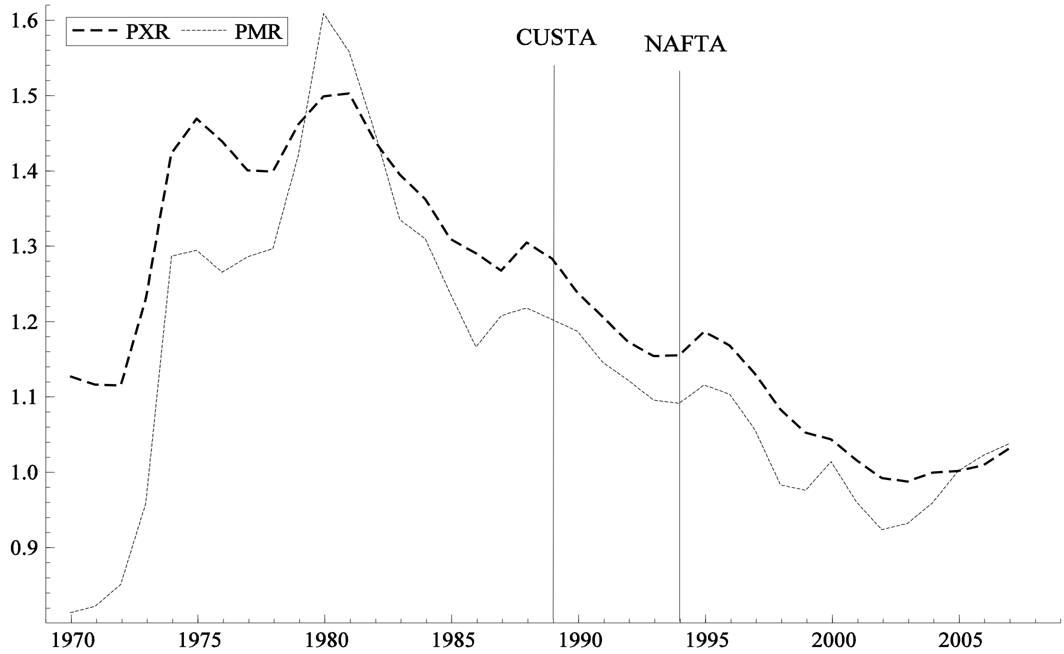

Figure 4: Growth of capital intensity ratio from 1970 to 2007 for USA (2000 = 100)

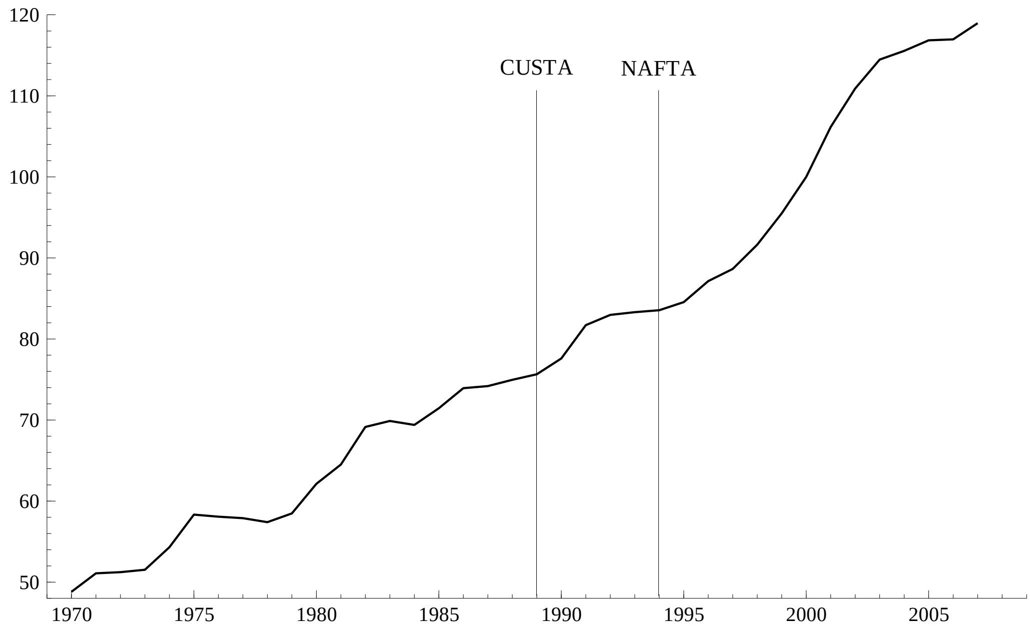

Table 3: Smooth Transition Regression model for Canada

Parameters	Regime I (1970-1984)		Regime II (1985-2005)	
	Estimate	Standard Errors	Estimate	Standard Errors
γ_{MM}	-0.228***	0.066	0.218*	0.114
γ_{MX}	0.166**	0.069	-0.212**	0.093
δ_{ML}	0.162***	0.051	-0.266**	0.123
γ_{XX}	0.277***	0.095	-0.191*	0.116
δ_{XL}	-0.252***	0.022	0.333***	0.082
ϕ_{LL}	0.115	0.087	-0.116	0.161
Gamma	0,007**	0,003		
Mu	3.517**	1.479		
System Fit : R^2		0.777		
Number of observations :		*T= 35*		

*Note: ***, **,* Parameters significant at 1%, 5%, 10% level, respectively*

Table 4: Smooth Transition Regression model for USA

Parameters	Regime I (1970-1995)		Regime II (1996-2007)	
	Estimate	Std Errors	Estimate	Std Errors
γ_{MM}	-0.363***	0.075	0.265	0.078
γ_{MX}	0.057	0.049	0.011	0.059
δ_{ML}	0.142**	0.062	-0.149	0.070
γ_{XX}	0.508**	0.217	-0.489	0.229
δ_{XL}	-0.100	0.068	0.073	0.074
ϕ_{LL}	0.166*	0.091	-0.394	0.140
Gamma	0.083*	0,031		
Mu	1.091**	0.526		
System Fit : R^2		0.800		
Number of observations :		*T= 37*		

*Note: ***,**,* Parameters significant at 1%, 5%, 10% level, respectively*

Table 5: Regression model with abrupt structural change

Parameters	All sample		Period 1		Period 2	
	Estimate	Std Errors	Estimate	Std Errors	Estimate	Std Errors
γ_{MM}	-0,113***	0,016	-0,106***	0,016	-0,271***	0,037
γ_{MX}	0,075***	0,022	0,068***	0,024	0,100***	0,030
δML	0,000	0,025	-0,008	0,026	0,106***	0,036
γ_{XX}	0,025	0,037	0,025	0,041	0,157	0,121
δXL	-0,011	0,022	-0,016	0,026	-0,053	0,049
ϕ_{LL}	-0,159**	0,084	-0,150**	0,070	-0,164	0,202
System Fit : R^2	0,670		0,740		0,790	
Log likelihood	394,500		277,950		127,680	
T	38		26		12	

*Note: ***, ** Parameters significant at 1%, 5% level, respectively*

Figure 5: Timing and Speed of the Transition between Regimes for Canada

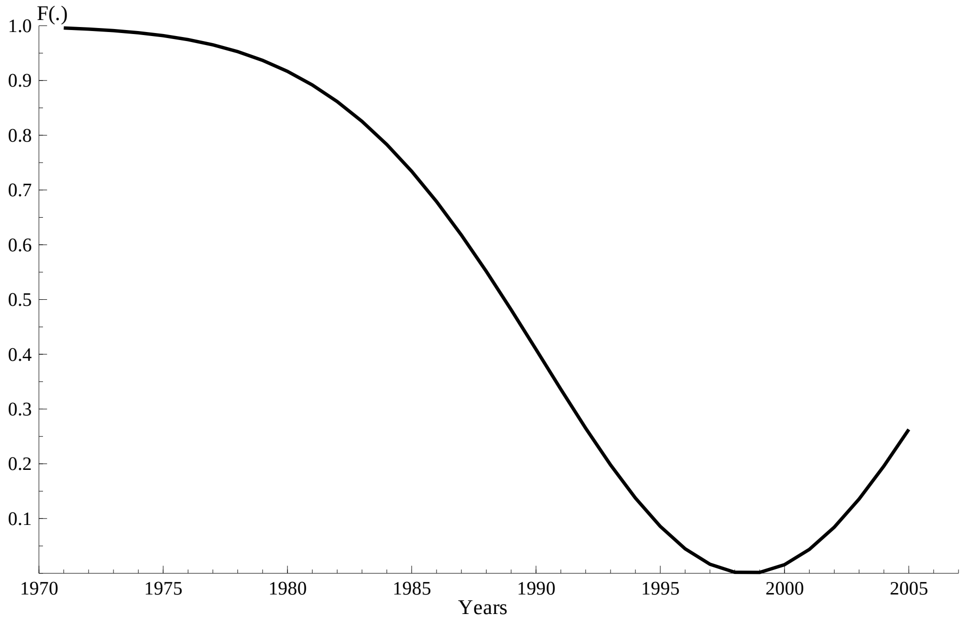

Figure 6: Timing and Speed of the Transition between Regimes for USA

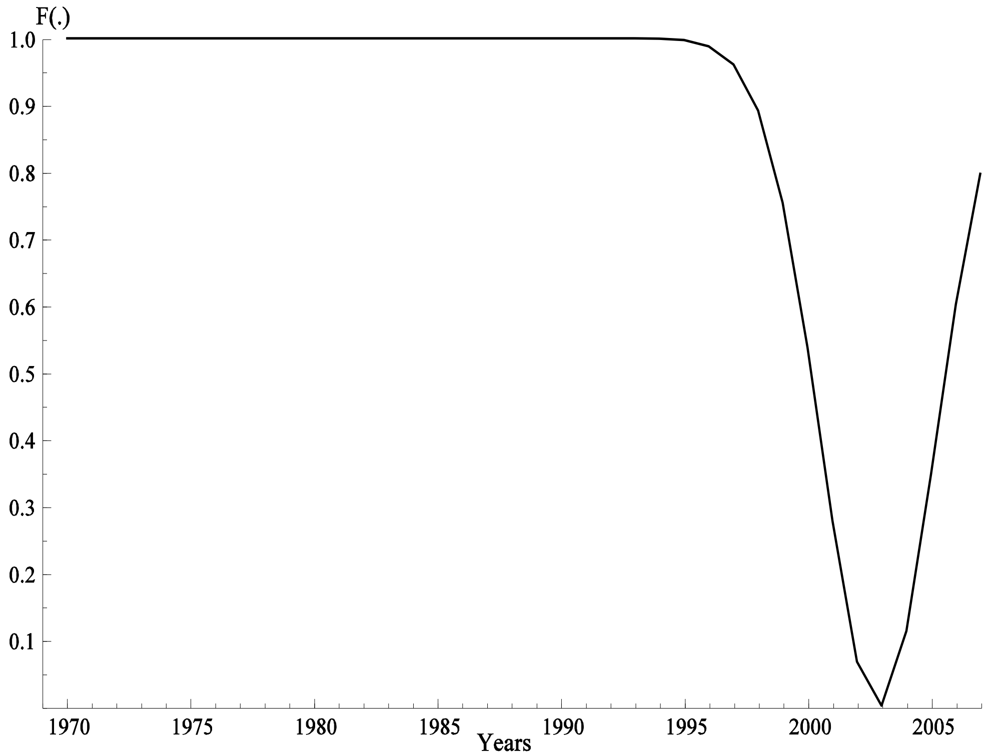

Table 6 : Elasticities Before and After the CUSTA Transition (Canada)

	Regime I			Regime II		
	Estimate	90% Confidence Interval*		*Estimate*	90% Confidence Interval*	
		Lower bound	*Upper bound*		*Lower bound*	*Upper bound*
i) Price elasticities of inverse factor demands - Stolper-Samuelson elasticities						
LM	0,160	0,014	0,298	-0,827	-1,223	-0,414
LX	-0,250	-0,314	-0,187	1,026	0,753	1,298
LD	1,089	0,966	1,217	0,801	0,527	1,049
KM	-0,509	-0,706	-0,302	0,235	-0,165	0,617
KX	0,792	0,702	0,883	-0,307	-0,571	-0,046
KD	0,717	0,535	0,892	1,071	0,831	1,333
ii) Quantity elasticities of outputs supplies - Rybczynski elasticities						
ML	-0,814	-1,516	-0,076	1,416	0,708	2,089
MK	1,814	1,071	2,515	-0,416	-1,093	0,291
XL	-0,815	-1,026	-0,611	1,446	1,062	1,830
XK	1,815	1,611	2,026	-0,446	-0,830	-0,067
DL	0,684	0,606	0,764	0,420	0,276	0,550
DK	0,316	0,236	0,394	0,580	0,450	0,722
iii) Price elasticities of import demand and output supply						
MM	0,852	-0,065	1,816	-2,045	-2,705	-1,416
MX	-1,251	-2,283	-0,244	1,087	0,543	1,631
MD	0,399	-0,262	1,046	0,958	0,532	1,384
XM	0,805	0,155	1,466	-0,895	-1,344	-0,450
XX	0,721	-0,182	1,590	-1,198	-1,760	-0,656
XD	-1,526	-1,867	-1,178	2,094	1,847	2,338
DM	-0,049	-0,130	0,030	-0,294	-0,425	-0,164
DX	-0,293	-0,359	-0,226	0,779	0,687	0,870
DD	0,343	0,259	0,426	-0,485	-0,582	-0,385
iv) Quantity elasticities of inverse factor demands						
LL	-0,216	-0,449	0,040	-0,743	-1,279	-0,263
LK	0,216	-0,041	0,446	0,743	0,261	1,279
KL	0,308	-0,058	0,635	0,720	0,253	1,239
KK	-0,308	-0,638	0,057	-0,720	-1,240	-0,254

*Note: *Confidence Intervals are computed using the method proposed by Krinski and Robb (1986);*

Table 7 : Elasticities at the sample mean according to the abrupt structural change (USA)

	Regime I			Regime II		
	Estimate	90% Confidence Interval*		Estimate	90% Confidence Interval*	
		Lower bound	Upper bound		Lower bound	Upper bound
i) Price elasticities of inverse factor demands-Stolper-Samuelson elasticities						
LM	-0,131	-0,254	-0,008	0,114	-0,041	0,260
LX	0,048	-0,077	0,179	-0,018	-0,227	0,189
LD	1,083	0,946	1,215	0,905	0,705	1,114
KM	-0,094	-0,157	-0,030	-0,333	-0,427	-0,236
KX	0,120	0,051	0,184	0,205	0,074	0,336
KD	0,974	0,905	1,045	1,128	0,996	1,254
ii) Quantity elasticities of outputs supplies-Rybczynski elasticities						
ML	0,421	0,026	0,817	-0,274	-0,633	0,097
MK	0,579	0,183	0,974	1,274	0,901	1,629
XL	0,171	-0,276	0,642	-0,060	-0,743	0,616
XK	0,829	0,353	1,275	1,060	0,381	1,740
DL	0,366	0,320	0,411	0,336	0,262	0,414
DK	0,634	0,589	0,680	0,664	0,586	0,738
iii) Price elasticities of import demand and output supply						
MM	-0,111	-0,342	0,126	0,528	0,144	0,907
MX	-0,540	-0,878	-0,174	-0,504	-0,818	-0,199
MD	0,651	0,435	0,852	-0,024	-0,361	0,316
XM	0,603	0,190	0,981	0,683	0,269	1,105
XX	-0,643	-1,318	0,066	0,443	-1,326	2,169
XD	0,040	-0,386	0,460	-1,126	-2,547	0,263
DM	-0,068	-0,090	-0,046	0,004	-0,049	0,055
DX	0,004	-0,036	0,043	-0,128	-0,290	0,030
DD	0,065	0,023	0,105	0,124	0,005	0,245
iv) Quantity elasticities of inverse factor demands						
LL	-1,097	-1,435	-0,755	-1,038	-1,885	-0,195
LK	1,097	0,752	1,435	1,038	0,193	1,879
KL	0,570	0,390	0,745	0,655	0,122	1,187
KK	-0,570	-0,745	-0,392	-0,655	-1,190	-0,123

*Note: *Confidence Intervals are computed using the method proposed by Krinski and Robb (1986);*