Evaluating the Success of a CGE Model of the Canada-U.S. Free Trade Agreement *

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Abstract

Although CGE models have been used extensively to evaluate the potential impact of economic policy reforms, few efforts have been made to assess the empirical accuracy of these models. Following Kehoe et al. (1994), this paper considers the performance of Brown and Stern (1989), a CGE study of the Canada-U.S. Free Trade Agreement. I find that the basic model performs well for changes in trade flows, but not for changes in sectoral output or employment. Adding appropriate macroeconomic shocks to the model yields dramatically better simulation results for output and employment, while leaving trade flows relatively unaffected.

1 Introduction

Over the years, countless hours have been spent developing and implementing computable general equilibrium (CGE) models for exercises in policy evaluation. However, little has been done to study the success of these endeavors. Indeed, as Patrick and Timothy Kehoe (1994) note:

> Although a large amount of energy and resources has gone into constructing AGE[1] models and using them to analyze policy changes over the past two decades, relatively little has gone into evaluating the performance of these models after such policy changes have actually occurred. To trust the results of AGE models and even justify the effort put into them, we would like to know that they really explain and, to some extent, predict the crucial changes that occur in an economy as a result of a policy change. (p. 13)

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[1]AGE is the abbreviation for Applied General Equilibrium and is synonymous with Computable General Equilibrium (CGE).

The authors go on to challenge other model builders to review their creations: "Modelers of the U.S.-Canada FTA, such as Cox and Harris (1985) and Brown and Stern (1989), should rerun their models taking explicit account of how the external shocks affected the United States and Canada in 1989 and afterward." (p. 14) Timothy Kehoe, Clemente Polo and Ferran Sancho (1994) back up these words with deeds, reassessing the success of their model of Spain's entry into the European Community (EC).

Thomas Hertel (1999) finds such exercises in historical simulation grounds for optimism about the future of CGE modeling. He declares that "[t]his is the kind of research that is essential if our work is to establish credibility with decision-makers."

My paper aims to address the challenge laid down by Kehoe and Kehoe: to test the changes due to the U.S.-Canada FTA as modeled by Brown and Stern (1989) (noted in this paper as B&S) using an adaptation of the Michigan Model of World Production and Trade. The paper first considers two policy experiments: the original case of full tariff removal, and a second experiment of partial tariff removal, reflecting tariff levels as of 1992.

In the post-agreement period, both the U.S. and Canadian economies experienced substantial macroeconomic shocks. As Kehoe and Kehoe point out above, it is necessary to take "explicit account" of these external shocks. I then proceed accordingly to adjust the model for such macroeconomic shocks.

As a last exercise, the Michigan Model's market structure is adjusted to match that currently in use by the Michigan modeling team.[2] Each of these adjustments to the model results in some measure of improvement, some more dramatic than others. I conclude that the results of the fully adjusted model are considerably better than the original unadjusted model.

A brief review of the structure of the Michigan Model follows in Section 2, along with a description of its specific implementation to analyze the U.S.-Canada FTA. Next, Section 3 discusses the data sources used to conduct the original simulations and to complete the reassessment. The computational execution of the U.S.-Canada model is then laid out in Section 4. Section 4.1 considers the performance of the model with regard to changes in U.S.-Canada trade, employment, and output. In Section 5, various macroeconomic shocks reflecting unanticipated fluctuations in the two economies are applied to the modeling framework. These macro shocks are then combined with the policy shocks and the simulation results are then compared to the actually observed outcomes. Section 6 considers the effects of an alternative specification of market structure in the model. Lastly, Section 7 presents a summary of the conclusions drawn from the various

[2] See, for example, Brown et al. (1996).

simulations.

2 Michigan Model

The following is a brief description of the version of the Michigan Model of World Production and Trade as it is used in this paper. The purpose of the original modeling exercise was to simulate the effect of a reciprocal removal of all tariffs between the United States and Canada as a result of the proposed Canada-U.S. Free Trade Agreement. The model therefore posed as the counterfactual a drop in tariffs from the prevailing rate to zero across all sectors. Other exogenous variables of the model, such as each country's total capital stock, total labor supply, and balance of trade, were assumed not to change.

The implementation here differs slightly from Brown and Stern (1989). In the original paper, an additional market structure, namely market segmentation, was used to model some of the sectors. I treat those sectors as monopolistically competitive with no entry. The data on which the simulations are based also differ from the original paper for two reasons. First, the complete original data set is no longer available. Second, since the goal of this exercise is to test the the model structure, the data set was updated to provide a snapshot of the economies immediately before the U.S.-Canada FTA came into effect. Therefore, data from 1988 have been used when possible.

2.1 Countries and Regions

The full version of the Michigan Model, as discussed in Deardorff and Stern (1986), has 34 separate countries and a Rest of World aggregate. In this version of the model, the country coverage is substantially simplified. The United States and Canada are modeled individually, while the other 32 countries of the full model are aggregated into one region, Other 32.[3] As in the full model, all other countries are combined to form a Rest of World trading bloc.

2.2 Sectoral and Market Structure

The model consists of 29 sectors, 22 of which are tradable. Each sector is modeled according to one of the following competitive structures: perfect competition, monopolistic competition with barriers to entry, or

[3] The countries aggregated include: Australia; Austria; Belgium-Luxembourg; Denmark; Federal Republic of Germany; Finland; France; Ireland; Italy; Japan; the Netherlands; New Zealand; Norway; Sweden; Switzerland; the United Kingdom; Argentina; Brazil; Chile; Colombia; Greece; Hong Kong; India; Israel; Mexico; Portugal; Singapore; South Korea; Spain; Taiwan; Turkey; and Venezuela.

monopolistic competition with no barriers to entry. Table 1 shows the breakdown of competitive structure and market entry by sector.

The treatment of most tradable sectors as monopolistically competitive minimizes the need to use the Armington assumption to explain consumers' preferences for different varieties. Under the monopolistic competition assumption, each firm's product is assumed to be an imperfect substitute for other firms' products. Thus, consumers are assumed to buy a bundle of goods, including both imported and domestically produced varieties. The Armington assumption applies to those sectors classified as perfectly competitive and traded, namely Agriculture (1), Leather Products (323), and Wood Products (331).

2.3 Expenditure

Consumers and producers use a two-stage method to allocate expenditures. In the first stage, consumers maximize a Cobb-Douglas utility function. This determines the consumption budget for each of the 29 goods. Producers demand intermediate inputs of these same goods in fixed proportions. The demands of producers and consumers are then added to determine total demand. In the second stage, total demand for each sector is allotted across the competing varieties, or between domestic and imported versions in the case of perfect competition, according to a CES function. As in B&S, the elasticity of substitution between varieties is set to 15 for all sectors and countries.[4]

2.4 Production

The production function is separated into two stages. In the first stage, intermediate inputs and a primary composite of capital and labor are used in fixed proportions. In the second stage, capital and labor are combined through a CES function to form the primary composite. To determine prices, perfectly competitive firms set price equal to marginal cost. Monopolistically competitive firms maximize profits by setting price to a fixed markup over marginal cost. The monopolistically competitive sectors are modeled following the technique developed in Dixit and Stiglitz (1977).

Under monopolistic competition, the number of firms in each industry is assumed to satisfy the zero profit condition in the case of free entry. In those sectors with no entry, the initial equilibrium is parameterized to satisfy the zero profit condition.

[4] According to Brown and Stern (1989, p. 106, fn. 7), "Values of the elasticity of substitution below 15 imply a value for fixed capital's share of total capital outside the interval (0,1)."

2.5 Capital and Labor Markets

Capital and labor are assumed to be perfectly mobile between sectors, but not between countries. Returns to capital are assumed to be flexible. A single rate of return to capital is determined for each country. As in the original work by B&S, wages are assumed to be fixed and equal across sectors.

2.6 World Market and Price Equalization

World markets determine equilibrium prices such that all markets clear. Total demand for each firm or sector's product must equal total supply of that product.

Prices paid by consumers or received by sellers are linked to world prices through exchange rates and tariffs. The world price is denominated in the numeraire currency, the U.S. dollar. The price paid by a consumer is the world price translated into the local currency, plus the ad valorem tariff wedge, if any. Exchange rates are set such that the balance of trade is maintained at its initial level.

2.7 Model Closure

In order to achieve model closure, I must choose several variables to be exogenous. The choices are the same as in B&S: balance of trade for Canada and Other 32; capital stock and labor supply in all three model countries; the U.S. exchange rate (the U.S. dollar is taken to be the numeraire currency); and the wage rate for all three countries. Fixing the wage rate, as in B&S, allows us to use the labor market equation in place of an explicit national expenditure equation.

Given the B&S choice of closure, I have decided to consider the model as simulating the economies' behavior in the medium-run. The intersectoral mobility of capital and labor seems to rule out a short-run model , while the fixity of wage rates and the international immobility of capital rule out a long-run perspective. Since the trade liberalization is in fact phased in over a total of 10 years, setting the time frame at a medium-run of four years allows me to capture a greater portion of the actual tariff liberalization.

2.8 Model Implementation in GEMPACK

The original B&S model was implemented in FORTRAN-G under the MTS operating system formerly used at the University of Michigan. However, with the passing of MTS, it became necessary to migrate the model to a new platform. For the sake of transparency and ease of use, the decision was made to move to one of the available general equilibrium modeling systems. The computational model is implemented here using the GEMPACK General Equilibrium Modeling Package as described by Harrison and Pearson (1996).

GEMPACK allows the user to specify the model's equations using a high-level, readable language. A model is composed of three main sections: declaration of variables and fixed parameters; initialization of the values of the variables and parameters; and the equations of the model. The equations may be specified either in levels or in percentage change terms. The U.S.-Canada model used here is implemented in percentage change. GEMPACK then translates this high-level description of the model into a FORTRAN program capable of performing simulations. The FORTRAN program is compiled and then run using a command file describing the data to be used, the specification of exogenous variables to ensure closure, the desired solution method, and the shocks to be made to the system.

Simulations of the model are carried out using the Johansen method, which solves the linearized equations of the model. This is of course an approximation that might or might not be a good one. This method has been used here to maintain consistency with B&S. Because of the nature of the Johansen solution method, we know that the approximation yields better results for smaller shocks. Given the relatively low prevailing tariffs between the United States and Canada, this is probably a reasonable treatment.

3 Data Sources

3.1 Trade Data

The original B&S paper derived trade flows from UN reported trade for 1980. All trade flows used here are derived from Statistics Canada's World Trade Database, as published in Feenstra et al. (1997). The World Trade Database is ultimately based on the same UN trade data as B&S. The data set contains annual bilateral goods trade flows, adjusted to eliminate importer and exporter reporting discrepancies and concorded at the SITC 4-digit level. Data are available for the years 1980-1992. All trade flows are reported in current U.S. dollars. These data are concorded in several steps to the Deardorff and Stern classification (DSC) used in the U.S.-Canada model (see Deardorff and Stern (1986) for a discussion of the classification scheme). The data are then aggregated according to the B&S country groupings (United States, Canada, Other 32 Countries, Rest of World).

As a first step, the trade data are concorded to 24 DSC sectors. These are the 22 traded sectors of the U.S.-Canada model, plus two additional sectors that are treated as nontraded in this model: Mining and Quarrying (2); and Electricity, Gas, and Water (4). Trade flows that do not fall into one of these 24 classifications are combined into a 25th sector, Not Elsewhere Classified (NEC).[5] In the second step, the NEC sectors are trade-weight distributed across the 24 identified sectors. Next, trade in sectors 2 and 4 is discarded to maintain comparability with B&S.

The resulting data set consists of bilateral trade among four entities, divided into 22 sectors. This concordance procedure is followed for each of the years 1980-1992. All of the simulations of the CGE model are performed using the 1988 trade data set.

3.2 Input-Output Tables

The input-output tables used in the model are the same ones used in the original B&S paper. That is, the U.S. 1972 table is used for both the United States and the Other 32 country grouping. Canada's table dates from 1976. In each case, the table is scaled according to the RAS method to match trade and gross output, labor, and capital measures for 1988.

3.3 Deflators

Since B&S is a real model, all simulation results are in terms of real changes in the respective variables. In order to compare actual changes to the model simulations, it is necessary to deflate the observed changes. Gross output and GDP are deflated using the GDP deflator series for the United States and Canada available in the *World Tables* (World Bank, 1995). Trade flows have been deflated using a different series (available from the DRI Basic Economics Database), the U.S. Implicit Price Deflator for exports of Goods and Services, series GDEX.

3.4 Production

Production data for manufactured goods come from the STAN Database as published by the OECD. These production data are aggregated to the appropriate DSC manufacturing sectors (310 through 38A). Gross output for the non-manufacturing sectors 1, 2, and 4 through 9 is derived from two sources. When available,

[5] The NEC sectors are SITC codes 9, 9110, 9310, and 9999.

gross output as reported by the United Nations (United Nations Statistical Office, 1992, 1993) is used. However, gross output is not available for U.S. sectors 7, 8, or 9. Additionally, no gross output figures at all are available for 1992. To estimate these missing numbers, value added data were scaled. [6]

3.5 Employment

Data on number of employed workers for manufactured goods sectors come from the STAN database. Other sectoral data come from OECD (1995).

3.6 Population

The population data come from the latest available version of the Penn World Tables, Mark 5.6. A full description of the Mark 5 database is available in Summers and Heston (1991). The latest version of the Penn World Tables is available electronically from `http://www.pwt.econ.upenn.edu`.

4 Simulation Results

In what follows, I report the results of the five experiments listed in Table 2. The first experiment involves simultaneous removal of all bilateral U.S.-Canadian tariffs, using the aforementioned data constructs.

The ad valorem tariffs in effect at the time of the agreement are listed in Table 3. As can be seen, Canada's tariff level against the United States was higher than the U.S. reciprocal tariffs in 21 of the 22 sectors listed. The sole exception was the Transportation Equipment (384) sector, which was free of all tariffs as a result of the 1965 Auto Pact. While U.S. and Canada pre-agreement bilateral tariffs were already low, there were several significant exceptions. Textiles (321), Wearing Apparel (322), Footwear (324), and Furniture (332) received substantial protection in Canada. The United States also maintained significant, though lower, barriers to Canadian exports from these sectors.

The experiment run in the GEMPACK model, then, consists of reducing these 44 tariffs to zero. It should be noted that this differs from the actual terms of the agreement, where tariffs are gradually removed

[6] The valued added data for 1988-1991 come from the same UN sources, while data for 1992 come from the OECD National Accounts Detailed Tables (OECD, 1995). For sectors 7, 8, and 9, U.S. value added is scaled by the Canadian ratio of gross output to value added. The Canadian ratio is used because the U.S. gross output series in these sectors is incomplete. The Canadian factor is established by taking the sum of gross output over the period 1988-1991 and dividing it by the sum of value added over the same period. All gross output numbers are converted to U.S. dollars and scaled by the U.S. GDP Deflator series, GDPD.

over a phase-in period of several years. For this reason, it is appropriate to compare the results generated by the model to trade several years after the implementation of the agreement.

4.1 Evaluation of B&S Model Results

Once results are obtained from the model, I compare them to the actual changes observed in the economies over the four years subsequent to the accord. For this purpose, I consider the changes in the U.S. and Canada reciprocal imports, sectoral output, and sectoral employment. Since the FTA went into effect on January 1, 1989, all changes reported are changes relative to the base year 1988.

In order to measure the goodness of fit, the model calculations for sectoral changes in trade, output, and employment are regressed against the actually observed changes between 1988 and 1992. Two measures of goodness of fit are considered: the weighted correlation, r, between the calculated and observed vectors of changes, as well as the R^2 resulting from the weighted regressions of the calculations of the model against actual outcomes.

The first measure, r, was also used by Kehoe et al.:

$$r = \frac{\sum_i w_i^2 y_i \hat{y}_i}{\sqrt{\sum_i w_i^2 y_i^2 \sum_i w_i^2 \hat{y}_i^2}} \tag{1}$$

The parameter w_i is the weight for sector i. The weight is derived by rescaling the observed 1988 level of the variable such that the vector of weights sums to the number of observations. For example, in the case of trade, the weight for a given sector is that sector's proportion of 1988 trade times the number of traded sectors, 22. The observed percentage change of the variable in question is y_i, and $\hat{y}_i$ is the simulated percentage change in that variable. Like any correlation measure, r rewards simulation results that have the right signs and relative magnitudes, but it does not take into account the *absolute* magnitude of the changes.

Kehoe et al. also used an R^2 statistic calculated using the following equation:

$$R^2 = 1 - \frac{\sum_i w_i^2 (y_i - \hat{y}_i)^2}{\sum_i w_i^2 y_i^2} \tag{2}$$

This is a reasonable measure of goodness of fit *if the weighted mean of y_i is equal to the weighted mean of $\hat{y}_i$*. This is the case in Kehoe et al. by construction. If the weighted mean of the simulation does not match the weighted mean observation, the R^2 calculated according to this formula can easily be negative. Since these weighted means are not necessarily equal in the B&S framework, I take a slightly more flexible approach and estimate the following equation:

$$y_i \sqrt{w_i} = \beta_1 \hat{y}_i \sqrt{w_i} + \epsilon_i \sqrt{w_i} \tag{3}$$

The R^2 from this weighted regression is then reported in the tables below, along with the fitted value and standard error for β_1. This ensures that the R^2 has a lower bound of zero, while also providing the β_1 as an additional diagnostic measure. If β_1 exceeds 1, then we know that the simulation calculates changes of a magnitude lower than those observed, while if β_1 is less than 1, then the simulated changes are greater than the actually observed changes.

In addition to comparing the CGE model results to observed data for trade, I consider an alternative hypothesis, namely that sectoral trade follows a simple secular trend. For each of the 22 traded sectors and each direction of trade, a simple OLS regression is fitted over time to the nine inflation-adjusted observed trade flows from 1980-1988. The parameters resulting from these regressions are then used to project the change in trade through the year 1992. Column (0) in Table 5 lists the summary statistics of these OLS forecasts, while Tables 6 and 7 list the full results.

Evaluation of changes in gross output and employment is done in a fashion similar to trade flows, although no simple OLS alternative is considered. Weighted regressions are calculated for each series, and weighted correlations are also provided.

4.2 Full Tariff Removal

Table 5 shows the calculations of U.S. imports from Canada for all experiments (full results are given in Table 6). For the moment I will limit my attention to the results for the base CGE model (Column (1)) and the OLS model (Column (0)). The CGE simulation yields results with a weighted r of 0.265 for the observed change in imports between 1988 and 1992. The goodness of fit regression gives us more diagnostics on the simulation. The R^2 statistic reaches 0.305, while the β_1 coefficient equals 0.374. This value for β_1 means that the model over-estimates the magnitude of changes in imports by 167 per cent.

The OLS simulation (Column (0)) fares slightly worse, yielding a weighted r of 0.138 and a weighted R^2 of 0.301. However, the simple OLS projection provides a β_1 estimate of 0.447. This implies that the OLS regression estimates changes 124 per cent higher than the observed changes.

Next I consider the the results for Canada's imports (full detail in Table 7). By comparison to the other direction of trade, the CGE model performs substantially better. The weighted correlation is 0.816, while the weighted R^2 is 0.785. The results for β_1 also indicate simulated change closer to that observed; the fitted value of 0.687 suggests that the model is over-estimating magnitude by 46 per cent.

OLS performs much worse than in the case of Canada's imports from the United States. The r statistic is negative and the R^2 is near zero. These results are driven by the Transport Equipment sector (384), which accounts for almost 34 per cent of 1988 imports. Excluding this sector raises the r statistic to 0.136. We see that the CGE model results have the correct sign and that the magnitude of import changes in Transport Equipment is markedly better.

Next let us consider the results for changes in sectoral employment (detailed results available in Table 8 for the United States and Table 9 for Canada). These results are poor. While the results of the Canadian full tariff removal simulation (Column (1)) are positively correlated with the observed change in employment between 1988 and 1992, the R^2 is quite low. It is also clear that the CGE model results show far more modest changes in employment levels than are observed. The results for the United States are even worse, showing a negative correlation and R^2 near zero.

It is clear that much more is happening in the two economies than is captured by the B&S model. While employment grew by 2.34 per cent in the United States and by 0.70 per cent in Canada over the 1988-92 period, this growth was far from uniform across sectors (see column entitled "1988-92 % Chg.", in Tables 8 and 9). Agriculture (Sector 1) and most manufacturing sectors experienced declines in employment. Most expansion in employment took place in service sectors 7, 8, and 9. Employment in Community, Social and Personal Services (9)—the largest sector in both countries—grew by 10.73 per cent in the United States and by 7.95 per cent in Canada. Finance, Insurance and Real Estate (8) exhibited similar expansion. Labor clearly moved from manufacturing to services over the four-year period.

In order to model these labor-market shifts more effectively, other factors must be taken into account. First, the B&S model assumes that the labor supply is fixed. Second, labor in both countries moved out of the manufacturing sectors and into services. Some of these changes must be due either to factor accumulation or to technological change. Consider the case of Agriculture (1): U.S. employment fell by 2.9 percent from 1988 to 1992, while output rose 4.33 percent. These issues are addressed by adjusting for macroeconomic shocks in the CGE experiments discussed in Section 5 below.

As in the case of sectoral employment, the results for changes in sectoral gross output (summary in Table 5, detail in Tables 10 and 11) indicate very small changes in sectoral output for both countries, with low measured R^2. While Canada's r statistic is positive, the U.S. coefficient is negative.

As with sectoral employment, the CGE model results fail to capture the observed changes in sectoral output. The observed change over the four-year period is an order of magnitude larger than the results of the model. Real U.S. GDP grew by 5.8 per cent from 1988 to 1992, while gross output rose by 2.5 per cent. Canada's economic performance was less robust, exhibiting a slight rise in real GDP of 0.8 per cent and a decline in gross output of 2.6 per cent over the period.

4.3 Partial Tariff Removal

The results of the original tariff removal experiment, listed in Column (1) of Table 5, indicate that the CGE model results show greater changes in trade flows than are actually observed, but greatly underestimates the magnitude of changes in sectoral employment and output. The overestimation of the trade impact may be due to the fact that the computational experiment is a complete removal of bilateral tariffs, whereas the treaty called for the gradual removal of tariffs. Following the actual agreement, according to Morici (1989),

> Tariffs will be eliminated in three groups—immediately (January 1989), five-year staging, and ten-year staging. Import-sensitive sectors were generally accorded ten-year staging to conclude by January 1998; these include most agricultural and fish products, most wood products, textiles and apparel, footwear, steel, lead, zinc, rail cars, tyres, consumer appliances, and precision instruments. (p. 52)

Tariffs falling under ten-year staging correspond to the following sectors in the B&S Michigan Model: a portion of Agriculture, Forestry, and Fishing (1); Wood Products (331); Textiles (321); Wearing Apparel (322); Footwear (324); and portions of Iron and Steel (371); Nonferrous Metals (372); Rubber Products (355); Electrical Machinery (383); and Miscellaneous Manufacturing (38A). Our first adjustment to the model is therefore to take into account the fact that some tariff reductions will have been only partially implemented by the last year of data available, 1992.

Since 1992 represents the fourth year after the implementation of the accord, the second experiment consists of reducing certain of the sectoral tariffs by only 40 percent, assuming a straight-line phase-in of the tariff reductions. Only those sectors cited by Morici (1989) which correspond closely to complete Michigan Model sectors are made subject to the reduced shock. The sectors chosen include: Textiles (321), Wearing Apparel (322), Footwear (324), Wood Products (331), and Iron and Steel (371). All other traded sectors remain subject to complete removal of tariffs. The goodness of fit measures for this simulation are listed in Column (2) of Table 5.

The partial tariff removal experiment yields mixed results for sectoral trade flows. The r and R^2 statistics improve modestly for Canada, and the estimated β_1 rises to 0.790, closer to the desired value of 1. The U.S. results are mixed. While β_1 has risen from 0.375 to 0.417, both r and R^2 have worsened. When considering only the sectors subject to partial tariff removal, the results are also ambiguous. The simulation results improve in three of the six sectors in both the United States and Canada. For example, in the case of U.S. imports from Canada, the partial tariff reduction scenario does attenuate the largest changes in trade. This reduces the extreme results in Wearing Apparel (322), Footwear (324), and Iron and Steel (371) (see Table 6). However, the simulation results for Agriculture (1) and Textiles (321), which were already too small in the full tariff removal case, are made lower still.

Column (2) in Table 5 also shows the changes in employment under the partial tariff removal scenario. Since the changes in employment with full tariff removal were already too low, one should expect the partial tariff removal case to be smaller yet. The R^2 and r statistics show little change compared to the results in Column (1). The simulated changes in output resemble those for employment: the partial tariff experiment results in even smaller simulated changes in output across sectors.

5 Adjusting for Macroeconomic Shocks

As Kehoe and Kehoe (1994) suggest, the model should be adjusted for exogenous shocks that occurred in 1989 and after. The original counterfactual experiment in Brown and Stern (1989) assumed no change in these variables. The next three experiments address this concern.

The model assumes that total capital and labor in each country are fixed; there is no endogenous factor accumulation. In order to take into account the changes in total employment and capital stock, an exogenous shock is applied to the model to mirror the observed change in capital stock and work force between 1988 and 1992. The shocks applied are listed in Table 4. The observed change in sectoral and total capital stock for the United States and Canada are drawn from OECD (1997a). The growth in U.S. capital stock is based on chained quantity indices, while the Canadian figures are based on a constant price measure of capital stock. The growth in the total capital stock of the Other 32 countries is drawn from data collected by The World Bank (1997).[7]

[7] The figures for total capital stock for the Other 32 countries for 1988 and 1992 are derived by taking the reported Gross Domestic Investment in Constant Dollars over the period 1960-1992 and discounting the stream following method 3 set forth by Leamer (1984, pp. 220-34). This involves using as long a series of investment flows as possible and then depreciating by 13.3 per cent per year. Because of the complications of Germany's reunification in 1991, that country was dropped from the calculation of percentage change of capital stock.

The data for the change in labor supply in the United States and Canada are derived from the OECD STAN database. The change in labor supply for Other 32 was derived principally from statistics collected by the ILO (International Labour Office, 1997). Data for Mexico and Luxembourg were drawn from OECD (1997b). Labor force for India was estimated from World Bank (1998), while that for Taiwan was drawn from Taiwan's 1998 Statistical Yearbook (Republic of China, Directorate-General of Budgeting, Accounting and Statistics, 1998). Total labor supply is shocked to match the observed change in total employment from 1988 to 1992.

Additionally, the model assumes that the balance of trade for each country remains unchanged. In order to take into account the observed change in the balance of trade, the observed trade flows for 1988 and 1992 are used to calculate the change in the balance of trade. The balances of trade for the United States, Canada and Other 32 are then shocked by the amounts listed in Table 4. Note that the trade balance for Rest of World is not shocked because it is uniquely identified by the other three shocks. The implied balance of trade for the Rest of World is a deficit of $148,329 million for 1988, growing to a deficit of $190,394 million for 1992, and thus implying a 28.4 per cent rise in the Rest of World balance of trade.

5.1 Experiment with Macro Shocks Only

As a first step, I present the results of the experiment where only the macro shocks (listed in Table 4) are applied to the model. The summary results of this experiment are given in Column (3) of Table 5.

I first consider the performance of macro shocks in the context of trade flows. The macro shock simulation does not seem to capture changes in trade flows. The R^2 for U.S. imports is 0.003, while that for Canada is 0.018. Both goodness of fit regressions yield a negative β_1.

Once we turn to sectoral employment, however, it appears that the macro shocks explain a substantial portion of the observed changes. In the U.S. case, Column (3) of Table 5 shows a correlation of 0.556 and R^2 of 0.352. The β_1 coefficient is 1.346, much closer to the desired value of 1. The results for Canada are similar. The value for r is 0.516, and R^2 is 0.264. Again, the value for β_1 is a more reasonable 1.947. This implies that the model is still under-estimating the magnitude of change in employment by 49 percent.

The macro shocks also prove effective at simulating the change in sectoral output. Table 5 indicates that the correlation with observed values is substantial, and the goodness of fit regression likewise demonstrates a positive relationship. The reported R^2 for the United States is 0.346, while that for Canadian sectoral output is 0.198.

The simulation of macro shocks indicates that exogenous changes in capital stock, labor supply, and balance of trade clearly have an impact on the sectoral composition of employment and output. At the same time, these shocks do not exhibit a strong relationship to observed changes in sectoral trade flows. The next natural experiment to consider is the combination of a macro shock adjustment combined with tariff removal.

5.2 Combining Macro Shocks and Tariff Removal

Column (4) in Table 5 shows the results of the combined experiment of full tariff removal and shocks to capital, labor, and balance of trade. The results for trade improve slightly for the United States compared to those from the full removal of tariffs only (Column (1)). However, those for Canada worsen modestly. The sectoral employment results also differ for the two countries. While combining macro shocks with full tariff removal had little effect on the R^2 for U.S. sectoral employment, the results for Canada improved from 0.264 for the macro shock only to 0.347 for the combination of macro and tariff adjustments. Results for sectoral output follow those for sectoral employment; the U.S. results are virtually unchanged from Column (3) to Column (4). However, the results for Canada improve slightly from an R^2 of 0.198 to 0.213.

The combination of the full tariff removal experiment with the capital, labor and balance of trade shocks yields overall better results across the range of variables considered. While model performance in individual variables might be better in either the tariff-only or the macro-shock-only experiments, the combination of the two sets of shocks results in a simulation that better describes all of the variables under consideration.

Next I briefly consider the results of the combination of macro shocks with the partial tariff removal scenario outlined above. Column (5) in Table 5 lists these results. The performance of the model is similar to that observed in Simulation 4, macro shocks with full tariff removal. In the case of the United States, the only significant difference is that the simulation results for imports from Canada improve. The r increases from 0.452 in the previous simulation to 0.475, while β_1 rises from 0.458 to 0.543, reducing the overestimation of trade flows from 121 per cent to 81 per cent. The R^2 measure also improves, from 0.346 to 0.359. The results for employment and output are essentially unchanged.

The experiment shows similar improvement in trade simulation for Canada, with r improving from 0.745 to 0.762, β_1 rising from 0.660 to 0.755, and R^2 increasing from 0.729 to 0.746. However, unlike the results for the United States, employment and output measures for Canada have worsened slightly. The R^2 for employment fell from 0.347 to 0.333, while that for output declined from 0.213 to 0.208.

5.3 Macro Shock Summary

Adding capital stock, labor supply, and balance of trade shocks to the model clearly improves the overall performance of the simulation. While the ability of the model to capture changes in trade flows remains relatively unaffected, the performance of the model in simulating sectoral changes in employment and output is dramatically improved by the inclusion of macro shocks. This result provides support for the view that tariff changes have a relatively small effect on the composition of output and employment. Other phenomena, such as factor accumulation, appear to play a much larger role in this regard.

Additionally, the performance of the macro shock experiments lends credibility to the general equilibrium model that B&S used. Given a shock to total factor endowments, the model performs reasonably well at allotting those additional factors across sectors.

6 Alternative Market Specification

More recent work using the Michigan Model differs from the original B&S specification in another aspect: current model implementations consider all monopolistically competitive sectors to be subject to free entry. As an alternative exercise, all the experiments performed above were repeated under the assumption of free entry in all monopolistically competitive sectors. The detailed results are not presented here, but are available from the author on request. The results for trade show that compared to the original market specification in Table 5, the performance of the model with free entry in simulating trade flows is almost uniformly better across all measurement parameters. The results for R^2 are superior in 9 out of 10 cases, and often by a wide margin. The correlation measure r is better in 7 out of 10 cases, while the results for β_1 are closer to 1 in 9 out of 10 simulations.

The performance with respect to sectoral employment is less clear cut. While the model worsens slightly for the United States, the results for Canada are mixed. While r and R^2 improve for the macro shock simulations, the corresponding estimated β_1 is further from 1. The results for sectoral output are also ambiguous. The r and R^2 statistics are better in simulations (4) and (5), but β_1 has worsened. In the Canadian estimates, r and β_1 have improved, though R^2 has fallen slightly.

These results suggest that the move away from monopolistic competition with no entry as a market structure is a reasonable one, at least in the case of this policy experiment. These results could of course be driven by our consideration of a longer adjustment period; no entry could still be a valid assumption in this model with a time horizon shorter than the four years considered here.

7 Conclusion

The aim of this paper has been to test the B&S model calculations of changes in trade, output and employment as a result of the Canada-U.S. Free Trade Agreement. All told, the B&S model, even without adjustments, does a reasonable job of capturing changes in trade flows. It performs especially well in simulating Canada's trade response to the tariff reductions. The results for U.S. imports are less persuasive, but the model does seem to capture some of the pattern of change. Since U.S.-Canada trade represents a much greater force in Canada as compared to the United States, we should expect to see the impact of trade liberalization on the Canadian economy much more clearly, as indeed is the case. Changing the experiment from full tariff removal to partial tariff removal has a modestly positive effect on the model's performance.

While the basic model yields far smaller changes in output and employment than those actually observed, this does not necessarily mean that the model is deficient. Rather, since the introduction of macro shocks in the model framework dramatically improves performance, we can conclude that the influence of tariff reductions alone on sectoral output and employment are small in magnitude. Factor accumulation and the business cycle appear to have a much more profound effect on sectoral changes in output and employment than do tariff reductions. The ability of the model to account for changes in the sectoral distribution of capital and labor in response to factor accumulation strengthens our confidence in the structure of the model.

Through a series of adjustments to the original model, I find that the Michigan Model performed quite well at simulating the actual changes in sectoral trade that occurred in the four years following the implementation of the Canada-U.S. Free Trade Agreement. Performance of the model with respect to output and employment, while substantial, is less persuasive. The strength of the model lies in capturing changes in trade composition. In some sense, it performs well at simulating changes in employment and output, given the assumptions of the experiment. The model says that little change in employment and output can be directly attributed to tariff reductions. Although such small changes are not consistent with those actually observed, the observed changes in sectoral output and employment can be partially explained using the model structure to apply shocks to capital stock and labor supply.

In conclusion, this paper suggests that the B&S model represents a useful framework for analyzing changes in trade policy. It also suggests that factors such as capital accumulation and labor supply play a profound role in determining the sectoral composition of output and employment. The utility of the model for predictive purposes, then, depends on the quality of the counterfactual. For example, if the question were to predict sectoral employment and output several years after the implementation of the Free Trade Agreement rather than to predict the changes *due only* to the Free Trade Agreement, then the correct experiment to run should probably have included some sort of projection of the changes in labor supply and capital stock. However, for the purposes of analyzing the effects of the tariff reductions alone on output and employment, the analysis here suggests that the B&S model framework is correct in implying that little of the actual changes in the sectoral composition of output and employment are attributable to the Free Trade Agreement.

Table 1: Industry Structure of Brown/Stern Michigan Model

ISIC Sector		Competition	Entry
Traded Sectors			
1	Agriculture, forestry, and fishing	Perfect	Free
310	Food, beverages, and tobacco	Monopolistic	Free
321	Textiles	Monopolistic	None
322	Wearing apparel	Monopolistic	Free
323	Leather products	Perfect	Free
324	Footwear	Monopolistic	Free
331	Wood products	Perfect	Free
332	Furniture and fixtures	Monopolistic	Free
341	Paper and paper products	Monopolistic	Free
342	Printing and publishing	Monopolistic	Free
35A	Chemicals	Monopolistic	None
35B	Petroleum and related products*	Monopolistic	None
355	Rubber products*	Monopolistic	None
36A	Nonmetallic mineral products	Monopolistic	Free
362	Glass and glass products	Monopolistic	None
371	Iron and steel*	Monopolistic	Free
372	Nonferrous metals	Monopolistic	Free
381	Metal products	Monopolistic	Free
382	Nonelectrical machinery	Monopolistic	Free
383	Electrical machinery	Monopolistic	Free
384	Transport equipment	Monopolistic	None
38A	Miscellaneous Manufacturing	Monopolistic	Free
Nontraded Sectors			
2	Mining and quarrying*	Monopolistic	None
4	Electricity, gas, and water*	Monopolistic	None
5	Construction	Perfect	Free
6	Wholesale and retail trade	Monopolistic	Free
7	Transportation, storage, and comm.	Monopolistic	Free
8	Finance, insurance, and real estate	Monopolistic	None
9	Commercial, social, and personal services	Perfect	Free

*Modeled according to Market Segmentation in B&S.

Table 2: Simulations Run using the CGE Model

Simulation	Description
1	Original B&S Full Tariff Removal
2	Partial Removal of Tariffs
3	Shocks to Capital Stock, Labor Supply, and Balance of Trade
4	Combination of Simulations 1 and 3
5	Combination of Simulations 2 and 3

Table 3: Pre-Agreement Bilateral Tariffs

Sector		Canada	U.S.
1	Agriculture, forestry, and fishing	2.2	1.6
310	Food, beverages, and tobacco	5.4	3.8
321	Textiles	16.9	7.2
322	Wearing apparel	23.7	18.4
323	Leather products	4.0	2.5
324	Footwear	21.5	9.0
331	Wood products	2.5	0.2
332	Furniture and fixtures	14.3	4.6
341	Paper and paper products	6.6	0.0
342	Printing and publishing	1.1	0.3
35A	Chemicals	7.9	0.6
35B	Petroleum and related products	0.5	0.4
355	Rubber products	8.9	8.4
36A	Nonmetallic mineral products	4.4	0.3
362	Glass and glass products	7.7	6.9
371	Iron and steel	7.4	4.4
372	Nonferrous metals	3.3	0.5
381	Metal products	8.6	4.0
382	Nonelectrical machinery	4.6	2.2
383	Electrical machinery	7.5	4.5
384	Transport equipment	0.0	0.0
38A	Miscellaneous Manufacturing	5.0	0.9

Source: Adapted from Magun et al. (1987), pp. 25 and 141-53.

Table 4: Macroeconomic Shocks Applied to the Model

Variable	1988	1992	Pct. Change
Capital Stock			
United States (Chained Quantity Index)	92.77	100.00	7.79
Canada (Millions of 1986 Canadian Dollars)	754,521	852,924	13.04
Other 32* (Millions of 1995 U.S. Dollars)	13,956,782	16,517,004	18.34
Labor Supply (Thousands of Workers)			
United States	109,431	111,992	2.34
Canada	12,544	12,632	0.70
Other 32	698,752	753,604	7.85
Balance of Trade (Millions of 1988 U.S. Dollars)			
United States	-88,782	-14,139	-84.10
Canada	8,891	1,290	-85.60
Other 32	228,220	203,783	-10.70

*Excludes Germany

Table 5: Summary of Goodness of Fit Measures

Variable	(0) OLS	Simulation (1) Full Tariff	(2) Partial Tariff	(3) K,L,BT Shock	(4) K,L,BT + Full	(5) K,L,BT + Partial
United States						
Pct. Change in Imports from Canada						
Weighted r	0.138	0.265	0.251	0.246	0.452	0.475
β_1	0.447	0.374	0.417	-0.051	0.458	0.543
s.e.	(0.148)	(0.123)	(0.139)	(0.204)	(0.137)	(0.159)
R^2	0.301	0.305	0.300	0.003	0.346	0.359
Pct. Change in Sectoral Employment						
Weighted r		-0.265	-0.159	0.556	0.551	0.552
β_1		-53.209	-39.685	1.346	1.339	1.340
s.e.		(38.084)	(51.328)	(0.345)	(0.346)	(0.346)
R^2		0.065	0.021	0.352	0.348	0.349
Pct. Change in Sectoral Output						
Weighted r		-0.059	-0.093	0.545	0.540	0.540
β_1		-7.679	-11.465	1.647	1.632	1.631
s.e.		(16.404)	(17.802)	(0.428)	(0.429)	(0.429)
R^2		0.008	0.015	0.346	0.341	0.341
Canada						
Pct. Change in Imports from the United States						
Weighted r	-0.543	0.816	0.836	-0.625	0.745	0.762
β_1	0.161	0.687	0.790	-0.481	0.660	0.755
s.e.	(0.471)	(0.079)	(0.083)	(0.778)	(0.088)	(0.096)
R^2	0.006	0.785	0.810	0.018	0.729	0.746
Pct. Change in Sectoral Employment						
Weighted r		0.285	0.275	0.516	0.594	0.582
β_1		3.198	3.795	1.947	2.154	2.142
s.e.		(2.041)	(2.516)	(0.614)	(0.559)	(0.573)
R^2		0.081	0.075	0.264	0.347	0.333
Pct. Change in Sectoral Output						
Weighted r		0.183	0.164	0.535	0.591	0.584
β_1		1.289	1.186	2.076	1.998	2.008
s.e.		(2.043)	(2.297)	(0.789)	(0.727)	(0.741)
R^2		0.014	0.009	0.198	0.213	0.208

Weighted r above is the weighted correlation between the vector of observed sectoral changes and the vector of simulated sectoral changes weighted by the observed level of the variable in the base year.

The measures β_1, standard error of β_1, and R^2 come from the estimation of the equation $y_i\sqrt{w_i} = \beta_1\hat{y}_i\sqrt{w_i} + \epsilon_i\sqrt{w_i}$. See Section 4.1 for a full description.

Table 6: Calculated and Observed Changes in U.S. Imports from Canada

(Percentage Change in Real Imports)

		Simulation						Observed	
		(0)	(1)	(2)	(3)	(4)	(5)		
			Full	Partial	K,L,BT	K,L,BT	K,L,BT	1988-92	1988 Base
ISIC	Sector Description	OLS	Tariff	Tariff	Shock	+ Full	+ Partial	% Chg.	($Million)
1	Agr., for., & fish.*	21.4	17.6	3.9	26.6	44.2	30.5	70.1	1,439.8
310	Food, bev., & tob.	35.1	50.1	50.2	10.5	60.6	60.7	38.5	2,812.9
321	Textiles*	35.1	48.9	13.6	-18.6	30.3	-5.0	69.1	383.0
322	Wearing apparel*	44.2	225.3	86.7	-5.3	220.0	81.4	44.2	337.4
323	Leather products	25.8	31.8	32.3	-8.2	23.6	24.1	-1.4	43.2
324	Footwear*	24.3	120.1	46.6	-2.1	118.0	44.5	27.7	52.2
331	Wood products*	40.5	-0.3	-2.1	-1.5	-1.7	-3.6	20.6	4,079.5
332	Furniture & fixt.	38.3	60.5	60.8	-5.2	55.4	55.6	49.9	974.4
341	Paper & paper prod.	11.1	-4.4	-4.1	7.5	3.1	3.3	-6.4	8,942.3
342	Printing & pub.	50.2	-1.2	-0.7	-1.6	-2.8	-2.3	-13.4	478.8
35A	Chemicals	11.6	-31.8	-30.8	12.8	-19.0	-18.0	27.1	4,247.5
35B	Petrol. & rel. prod.	5.7	-1.5	-0.9	42.0	40.5	41.2	19.1	1,502.9
355	Rubber products	86.9	76.0	77.2	-17.0	59.0	60.2	138.9	479.0
36A	Nonmetal. min. prod.	32.4	-0.6	-0.1	12.2	11.7	12.1	-8.5	555.4
362	Glass & glass prod.	-17.0	60.1	61.4	14.6	74.8	76.0	1.3	284.4
371	Iron & steel*	14.5	56.8	19.9	30.2	87.0	50.2	10.3	1,972.9
372	Nonferrous metals	9.7	7.6	6.3	0.9	8.6	7.2	15.3	4,874.6
381	Metal products	21.3	55.1	54.7	3.1	58.2	57.8	-8.8	1,604.6
382	Nonelec. machinery	13.3	30.0	30.2	2.8	32.8	33.0	-5.7	6,380.2
383	Elec. machinery	26.0	64.7	64.9	10.6	75.3	75.5	63.6	5,087.4
384	Transport equip.	45.8	41.7	39.8	-44.7	-3.0	-4.9	8.0	29,663.4
38A	Misc. Manufact.	19.0	10.5	10.8	-9.0	1.5	1.8	44.7	1,842.4
Weighted r		0.138	0.265	0.251	0.246	0.452	0.475		
Estimation of $y_i\sqrt{w_i} = \beta_1 \hat{y}_i \sqrt{w_i} + \epsilon_i \sqrt{w_i}$									
	β_1	0.447	0.374	0.417	-0.051	0.458	0.543		
	Standard Error	(0.148)	(0.123)	(0.139)	(0.204)	(0.137)	(0.159)		
	R^2	0.301	0.305	0.300	0.003	0.346	0.359		

*Sectors subject to partial tariff removal in Simulations 2 and 5.

Table 7: Calculated and Observed Changes in Canada's Imports from the United States

(Percentage Change in Real Imports)

		Simulation						Observed	
		(0)	(1)	(2)	(3)	(4)	(5)		
			Full	Partial	K,L,BT	K,L,BT	K,L,BT	1988-92	1988 Base
ISIC	Sector Description	OLS	Tariff	Tariff	Shock	+ Full	+ Partial	% Chg.	($Million)
1	Agr., for., & fish.*	-14.9	35.1	16.8	-26.8	8.2	-10.1	65.7	1,703.7
310	Food, bev., & tob.	-5.7	77.8	77.7	-7.1	70.7	70.7	101.0	1,533.0
321	Textiles*	-3.0	225.2	94.4	15.7	240.9	110.1	61.4	946.9
322	Wearing apparel*	-16.5	286.4	117.7	16.5	303.0	134.2	182.4	122.7
323	Leather products	9.8	50.7	50.5	11.1	61.8	61.5	-13.6	99.2
324	Footwear*	21.7	260.0	104.8	16.8	276.8	121.6	110.7	42.1
331	Wood products*	3.0	35.7	16.1	6.9	42.7	23.0	53.9	689.9
332	Furniture & fixt.	-5.9	167.3	167.0	14.3	181.6	181.3	148.7	629.2
341	Paper & paper prod.	8.2	89.8	89.5	-9.4	80.4	80.0	60.5	1,228.7
342	Printing & pub.	4.2	21.3	20.8	7.5	28.9	28.3	77.6	949.4
35A	Chemicals	9.3	123.1	122.4	-9.5	113.6	112.8	72.7	4,023.4
35B	Petrol. & rel. prod.	64.5	14.3	13.7	-38.0	-23.7	-24.3	15.0	526.1
355	Rubber products	4.6	117.2	116.4	13.6	130.8	130.0	44.9	763.4
36A	Nonmetal. min. prod.	15.5	65.2	64.7	-7.4	57.8	57.3	2.1	447.1
362	Glass & glass prod.	8.4	98.5	97.8	-6.9	91.7	90.9	84.5	423.2
371	Iron & steel*	-29.6	98.0	41.9	-28.1	69.9	13.8	86.1	809.0
372	Nonferrous metals	-14.0	37.1	38.8	-1.1	36.0	37.7	7.2	1,901.1
381	Metal products	-0.3	109.6	110.1	2.5	112.1	112.6	80.1	1,518.2
382	Nonelec. machinery	-4.0	41.3	41.1	5.2	46.4	46.3	18.2	10,317.5
383	Elec. machinery	23.5	60.5	60.5	2.0	62.5	62.5	64.1	9,599.7
384	Transport equip.	34.2	-15.8	-15.1	19.6	3.8	4.5	-11.7	21,553.8
38A	Misc. Manufact.	6.2	48.8	48.6	8.9	57.6	57.5	73.6	3,721.5
Weighted r		-0.543	0.816	0.836	-0.625	0.745	0.762		
Estimation of $y_i\sqrt{w_i} = \beta_1 \hat{y}_i \sqrt{w_i} + \epsilon_i \sqrt{w_i}$									
	β_1	0.161	0.687	0.790	-0.481	0.660	0.755		
	Standard Error	0.471	0.079	0.083	0.778	0.088	0.096		
	R^2	0.006	0.785	0.810	0.018	0.729	0.746		

*Sectors subject to partial tariff removal in Simulations 2 and 5.

Table 8: Calculated and Observed Changes in U.S. Sectoral Employment

(Percentage Change in Sectoral Employment)

		Simulation					Observed	
		(1)	(2)	(3)	(4)	(5)		
		Full	Partial	K,L,BT	K,L,BT	K,L,BT	1988-92	1988 Base
ISIC	Sector Description	Tariff	Tariff	Shock	+ Full	+ Partial	% Chg.	(Workers)
1	Agr., for., & fish.*	0.04	-0.02	-1.51	-1.47	-1.53	-2.90	3,103,000
310	Food, bev., & tob.	0.00	0.00	-2.93	-2.94	-2.94	0.61	1,650,000
321	Textiles*	0.00	0.00	-1.60	-1.61	-1.61	-4.75	906,146
322	Wearing apparel*	0.00	0.00	-1.21	-1.21	-1.21	-10.83	905,108
323	Leather products	0.55	0.55	9.21	9.76	9.76	-7.94	51,898
324	Footwear*	-0.01	-0.01	-0.89	-0.90	-0.90	-29.29	77,848
331	Wood products*	0.38	0.28	4.93	5.31	5.22	-8.86	824,000
332	Furniture & fixt.	0.00	0.00	-1.45	-1.45	-1.45	-8.66	531,000
341	Paper & paper prod.	0.00	0.00	-2.18	-2.19	-2.19	0.44	678,000
342	Printing & pub.	0.00	0.00	-1.86	-1.86	-1.86	-3.38	1,540,000
35A	Chemicals	0.00	0.00	-2.48	-2.48	-2.48	-0.29	968,074
35B	Petrol. & rel. prod.	0.00	0.00	-2.81	-2.81	-2.81	-2.10	128,853
355	Rubber products	0.00	0.00	-2.02	-2.02	-2.02	-3.98	233,055
36A	Nonmetal. min. prod.	0.00	0.00	-2.39	-2.39	-2.39	-11.04	428,332
362	Glass & glass prod.	0.00	0.00	-1.69	-1.69	-1.69	-7.87	148,668
371	Iron & steel*	0.00	0.00	-1.15	-1.15	-1.15	-12.06	482,647
372	Nonferrous metals	0.00	0.00	-1.97	-1.97	-1.97	-8.45	281,353
381	Metal products	0.00	0.00	-1.91	-1.91	-1.91	-7.10	1,423,000
382	Nonelec. machinery	-0.01	0.00	-1.75	-1.76	-1.76	-8.33	2,112,000
383	Elec. machinery	-0.01	-0.01	-1.19	-1.19	-1.19	-13.61	1,756,000
384	Transport equip.	-0.01	0.00	-1.30	-1.30	-1.30	-9.79	2,032,000
38A	Misc. Manufact.	-0.01	-0.01	-3.97	-3.98	-3.98	-3.45	2,183,019
2	Mining & quarrying	0.00	0.00	-2.81	-2.81	-2.81	-11.96	736,000
4	Electricity, gas, & water	0.00	0.00	0.84	0.84	0.84	3.26	919,000
5	Construction	0.01	0.01	4.75	4.76	4.76	-8.96	6,453,000
6	Wholesale & retail trade	0.00	0.00	3.10	3.10	3.10	-0.20	25,436,000
7	Transport., storage, & comm.	0.00	0.00	2.42	2.41	2.41	1.41	4,693,000
8	Finance, ins., & real estate	-0.01	-0.01	2.01	2.00	2.00	6.37	15,831,000
9	Comm., soc., & pers. svcs.	-0.01	0.00	4.34	4.33	4.33	10.73	32,919,000
Weighted r		-0.265	-0.159	0.556	0.551	0.552		
Estimation of $y_i\sqrt{w_i} = \beta_1 \hat{y}_i \sqrt{w_i} + \epsilon_i \sqrt{w_i}$								
	β_1	-53.209	-39.685	1.346	1.339	1.340		
	Standard Error	38.084	51.328	0.345	0.346	0.346		
	R^2	0.065	0.021	0.352	0.348	0.349		

*Sectors subject to partial tariff removal in Simulations 2 and 5.

Table 9: Calculated and Observed Changes in Canadian Sectoral Employment

(Percentage Change in Sectoral Employment)

		Simulation					Observed	
		(1)	(2)	(3)	(4)	(5)		
		Full	Partial	K,L,BT	K,L,BT	K,L,BT	1988-92	1988 Base
ISIC	Sector Description	Tariff	Tariff	Shock	+ Full	+ Partial	% Chg.	(Workers)
1	Agr., for., & fish.*	-2.63	-1.98	1.87	-0.76	-0.11	-4.57	569,000
310	Food, bev., & tob.	0.02	0.02	-4.10	-4.08	-4.08	-5.00	236,585
321	Textiles*	-0.03	-0.01	-2.65	-2.69	-2.66	-24.27	67,484
322	Wearing apparel*	0.01	0.01	-2.31	-2.30	-2.30	-27.63	110,128
323	Leather products	-15.68	-15.18	-2.18	-17.86	-17.36	-35.15	5,830
324	Footwear*	-0.04	-0.02	-1.48	-1.52	-1.50	-35.50	14,251
331	Wood products*	-3.47	-2.81	4.30	0.83	1.48	-16.73	123,675
332	Furniture & fixt.	0.01	0.01	-2.43	-2.43	-2.42	-28.89	49,580
341	Paper & paper prod.	0.01	0.01	-3.95	-3.94	-3.94	-13.34	117,943
342	Printing & pub.	0.02	0.02	-3.40	-3.39	-3.39	-4.17	134,106
35A	Chemicals	-0.01	0.00	-4.16	-4.16	-4.16	-4.18	92,476
35B	Petrol. & rel. prod.	0.01	0.01	-3.03	-3.03	-3.02	-16.47	16,097
355	Rubber products	-0.22	-0.21	-2.52	-2.74	-2.73	-9.81	27,618
36A	Nonmetal. min. prod.	0.02	0.02	-4.85	-4.83	-4.82	-21.40	44,246
362	Glass & glass prod.	-0.21	-0.20	-3.88	-4.09	-4.08	-24.97	13,362
371	Iron & steel*	0.01	0.01	-2.13	-2.12	-2.13	-24.63	56,065
372	Nonferrous metals	0.00	0.00	-2.15	-2.16	-2.16	-13.80	45,399
381	Metal products	0.01	0.02	-3.45	-3.44	-3.43	-21.10	164,947
382	Nonelec. machinery	0.01	0.01	-3.10	-3.09	-3.09	-16.01	131,357
383	Elec. machinery	-0.01	-0.01	-4.05	-4.06	-4.06	-16.12	132,775
384	Transport equip.	0.05	0.05	-2.99	-2.93	-2.93	-8.71	232,613
38A	Misc. Manufact.	0.00	0.01	-3.27	-3.27	-3.27	-8.16	123,924
2	Mining & quarrying	0.03	0.04	-7.26	-7.23	-7.22	-14.29	189,000
4	Electricity, gas, & water	0.05	0.04	-1.47	-1.42	-1.43	16.53	121,000
5	Construction	0.45	0.38	2.34	2.80	2.73	-6.27	765,000
6	Wholesale & retail trade	0.19	0.15	1.96	2.15	2.10	1.55	3,026,000
7	Transport., storage, & comm.	0.10	0.09	1.59	1.69	1.67	-0.25	816,000
8	Finance, ins., & real estate	0.19	0.15	-0.39	-0.20	-0.24	7.12	1,418,000
9	Comm., soc., & pers. svcs.	0.19	0.14	1.72	1.91	1.86	7.95	3,700,000
Weighted r		0.285	0.275	0.516	0.594	0.582		
Estimation of $y_i\sqrt{w_i} = \beta_1\hat{y}_i\sqrt{w_i} + \epsilon_i\sqrt{w_i}$								
	β_1	3.198	3.795	1.947	2.154	2.142		
	Standard Error	2.041	2.516	0.614	0.559	0.573		
	R^2	0.081	0.075	0.264	0.347	0.333		

*Sectors subject to partial tariff removal in Simulations 2 and 5.

Table 10: Calculated and Observed Changes in U.S. Sectoral Output

(Percentage Change in Sectoral Output)

		Simulation					Observed	
		(1)	(2)	(3)	(4)	(5)		
		Full	Partial	K,L,BT	K,L,BT	K,L,BT	1988-92	1988 Base
ISIC	Sector Description	Tariff	Tariff	Shock	+ Full	+ Partial	% Chg.	($Million)
1	Agr., for., & fish.*	0.01	-0.04	-0.44	-0.43	-0.48	4.33	183,700
310	Food, bev., & tob.	-0.03	-0.03	-3.70	-3.73	-3.73	2.79	368,934
321	Textiles*	-0.32	-0.17	-2.91	-3.24	-3.08	-3.47	80,467
322	Wearing apparel*	-0.10	-0.05	-2.78	-2.88	-2.83	-7.61	48,477
323	Leather products	0.50	0.51	8.64	9.14	9.15	-5.88	4,808
324	Footwear*	-0.05	-0.03	-2.80	-2.85	-2.83	-20.63	4,514
331	Wood products*	0.36	0.27	4.81	5.17	5.08	-0.69	73,460
332	Furniture & fixt.	-0.08	-0.07	-2.91	-2.99	-2.98	-3.45	38,711
341	Paper & paper prod.	-0.07	-0.06	-2.98	-3.04	-3.04	-6.33	121,848
342	Printing & pub.	-0.02	-0.02	-2.86	-2.88	-2.88	-0.45	147,790
35A	Chemicals	-0.21	-0.21	-3.19	-3.40	-3.40	2.35	328,243
35B	Petrol. & rel. prod.	-0.02	-0.02	-4.12	-4.14	-4.14	-1.69	128,137
355	Rubber products	-0.25	-0.23	-3.10	-3.34	-3.33	-4.94	23,599
36A	Nonmetal. min. prod.	-0.04	-0.04	-3.21	-3.25	-3.25	-16.30	46,243
362	Glass & glass prod.	-0.14	-0.14	-2.66	-2.80	-2.80	-8.27	15,855
371	Iron & steel*	-0.02	-0.02	-2.59	-2.61	-2.61	-19.72	84,512
372	Nonferrous metals	-0.06	-0.06	-3.09	-3.15	-3.15	-21.03	65,354
381	Metal products	-0.06	-0.05	-2.68	-2.74	-2.73	-9.18	157,112
382	Nonelec. machinery	-0.07	-0.06	-2.73	-2.80	-2.80	-8.09	236,476
383	Elec. machinery	-0.08	-0.08	-2.67	-2.75	-2.75	0.71	180,583
384	Transport equip.	0.36	0.35	-3.10	-2.74	-2.75	-6.35	355,487
38A	Misc. Manufact.	-0.06	-0.06	-4.00	-4.06	-4.06	-0.77	150,181
2	Mining & quarrying	-0.01	-0.01	-2.42	-2.43	-2.43	-11.11	142,700
4	Electricity, gas, & water	-0.01	-0.01	1.21	1.20	1.20	-4.50	225,800
5	Construction	-0.02	-0.01	3.70	3.68	3.69	-10.83	501,100
6	Wholesale & retail trade	-0.01	-0.01	2.86	2.85	2.86	1.23	1,175,600
7	Transport., storage, & comm.	-0.01	-0.01	2.25	2.24	2.25	-0.34	506,662
8	Finance, ins., & real estate	-0.01	-0.01	2.36	2.35	2.35	8.13	1,334,109
9	Comm., soc., & pers. svcs.	-0.01	-0.01	3.77	3.76	3.77	13.27	2,019,088
Weighted r		-0.059	-0.093	0.545	0.540	0.540		
Estimation of $y_i\sqrt{w_i} = \beta_1 \hat{y}_i \sqrt{w_i} + \epsilon_i \sqrt{w_i}$								
	β_1	-7.679	-11.465	1.647	1.632	1.631		
	Standard Error	16.404	17.802	0.428	0.429	0.429		
	R^2	0.008	0.015	0.346	0.341	0.341		

*Sectors subject to partial tariff removal in Simulations 2 and 5.

Table 11: Calculated and Observed Changes in Canadian Sectoral Output

(Percentage Change in Sectoral Output)

		Simulation					Observed	
		(1)	(2)	(3)	(4)	(5)		
		Full	Partial	K,L,BT	K,L,BT	K,L,BT	1988-92	1988 Base
ISIC	Sector Description	Tariff	Tariff	Shock	+ Full	+Partial	% Chg.	($Million)
1	Agr., for., & fish.*	-2.29	-1.68	5.98	3.69	4.30	-11.71	28,430
310	Food, bev., & tob.	0.26	0.26	-4.42	-4.16	-4.16	-5.34	37,755
321	Textiles*	3.32	1.71	-1.57	1.75	0.15	-23.48	5,330
322	Wearing apparel*	0.18	0.34	-1.77	-1.59	-1.43	-23.72	5,677
323	Leather products	-15.43	-14.96	-1.88	-17.31	-16.84	-42.56	398
324	Footwear*	0.30	0.19	-1.46	-1.17	-1.28	-33.68	671
331	Wood products*	-3.27	-2.60	4.66	1.40	2.06	-13.63	12,595
332	Furniture & fixt.	0.75	0.74	-1.90	-1.16	-1.16	-25.88	3,796
341	Paper & paper prod.	0.72	0.70	-3.56	-2.84	-2.86	-28.65	21,019
342	Printing & pub.	0.45	0.41	-2.48	-2.03	-2.07	-8.60	10,552
35A	Chemicals	2.70	2.63	-3.96	-1.26	-1.33	-16.56	23,999
35B	Petrol. & rel. prod.	0.50	0.46	-7.01	-6.51	-6.55	1.28	12,197
355	Rubber products	2.30	2.24	-1.83	0.47	0.41	5.04	2,358
36A	Nonmetal. min. prod.	0.52	0.49	-3.97	-3.45	-3.48	-32.10	5,401
362	Glass & glass prod.	2.18	2.10	-3.58	-1.41	-1.49	-31.30	1,188
371	Iron & steel*	0.28	0.34	-5.19	-4.91	-4.84	-31.47	9,473
372	Nonferrous metals	0.01	0.17	-2.98	-2.97	-2.81	-30.98	13,140
381	Metal products	0.34	0.39	-2.82	-2.48	-2.43	-32.99	12,249
382	Nonelec. machinery	1.03	1.02	-2.61	-1.58	-1.60	-17.54	14,965
383	Elec. machinery	1.21	1.20	-3.36	-2.15	-2.17	7.15	12,327
384	Transport equip.	-2.90	-2.76	0.39	-2.50	-2.36	-10.48	44,052
38A	Misc. Manufact.	1.58	1.54	-2.54	-0.96	-1.00	-20.04	4,774
2	Mining & quarrying	0.40	0.37	-3.80	-3.40	-3.43	-11.69	30,744
4	Electricity, gas, & water	0.55	0.50	1.26	1.81	1.76	14.58	16,669
5	Construction	0.67	0.58	4.35	5.02	4.93	-13.22	73,270
6	Wholesale & retail trade	0.66	0.58	3.66	4.32	4.24	-2.55	95,668
7	Transport., storage, & comm.	0.51	0.46	3.45	3.96	3.91	3.60	47,298
8	Finance, ins., & real estate	0.67	0.59	2.74	3.41	3.33	9.77	131,554
9	Comm., soc., & pers. svcs.	0.74	0.64	4.27	5.01	4.91	12.75	151,874
Weighted r		0.183	0.164	0.535	0.591	0.584		
Estimation of $y_i\sqrt{w_i} = \beta_1 \hat{y}_i \sqrt{w_i} + \epsilon_i \sqrt{w_i}$								
	β_1	1.289	1.186	2.076	1.998	2.008		
	Standard Error	2.043	2.297	0.789	0.727	0.741		
	R^2	0.014	0.009	0.198	0.213	0.208		

*Sectors subject to partial tariff removal in Simulations 2 and 5.

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