Predicting the effects of NAFTA with the BDS, GTAP, and EK models

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Abstract

We use three computable general equilibrium (CGE) models of trade to simulate the removal of tariff and non-tariff barriers between U.S., Canada, and Mexico under NAFTA. The models are parametrized with pre-NAFTA data. Our paper has three objectives. First is to evaluate the predictions made by GTAP against the actual post-NAFTA changes in NAFTA trade. Recent literature (Kehoe, 2005; Shikher, 2012) finds that pre-NAFTA predictions of the effects of NAFTA on trade have little correlation with the actual changes. Therefore, we wanted to investigate whether GTAP could have produced accurate predictions if it were used before NAFTA. The second objective is to compare the predictions of GTAP against the predictions of a general equilibrium model based on the Eaton and Kortum (2002) methodology with heterogeneous producers. We wanted to investigate if the two models would produce different predictions and investigate the sources of these differences. The third objective is to analyze why the predictions of the BDS model are different from the actual changes in trade. We find that the changes in NAFTA trade predicted by GTAP using pre-NAFTA data are much closer to what actually happened after NAFTA than the changes predicted by the pre-NAFTA studies we looked at (Brown, Deardorff, and Stern, 1992; Roland-Holst, Reinert, and Shiells, 1994). GTAP's predictions are also close to those of the model with heterogeneous producers, though the latter's predictions are more closely correlated with the actual changes. We investigate the causes of the differences in predictions by BDS, GTAP and a model with heterogeneous producers. Among the various causes we look at are model equations, parameter values, sensitivity to parameter values, choice of base year, and solution methods.

JEL codes: F1

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1 Introduction

We use the North American Free Trade Agreement (NAFTA) as a large-scale historical experiment to compare the performance of three models of trade. The first is the Global Trade Analysis Project

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(GTAP) model, which is widely used in policy analysis. The other is the Brown-Deardorff-Stern model, also known as the Michigan Model of World Production and Trade. The third is a multi-industry multi-factor version of the Eaton-Kortum model of trade. All three are computable general equilibrium (CGE) models.

Evaluation of models by simulation is not as common in international trade as it is in macroeconomics, but it is a very useful tool. There are multiple reasons to evaluate the performance of CGE models in simulations. A commonly used approach to evaluating a model - fitting it do data and evaluating the fit - is problematic with large multi-equation models. For example, individual equations of the model may have good statistical fit, but the model as whole may perform poorly (Pindyck and Rubinfeld, 1998).

A model with few degrees of freedom, such as the model of this paper, may fit the data well, but perform poorly outside of the time interval used to parametrize it (Kehoe, 2005). Taking the model outside of this time interval tells us which aspects of the data the model can replicate (Canova and Ortega, 2000). Moreover, since the computable models are often used for forecasting purposes, a small forecasting error is an important criterion by which these models should be evaluated.

It is important to study model predictions of NAFTA because pre-NAFTA predictions regarding post-NAFTA changes in trade turned out to be significantly off in terms of overall magnitudes of predicted changes in trade and relative magnitudes of trade changes across industries and countries (Kehoe, 2005). The existing literature has not reached a conclusion with respect the source or sources of these errors.

Another important question that has not been answered in the literature is how well would the currently used models of trade have performed in predicting the effects of NAFTA had they existed at the time. This paper contributes to the literature in several ways: first, it evaluates the performance of GTAP, a widely used general equilibrium model of trade, in predicting the effects of NAFTA. Second, it compares the performance of GTAP to the performance of a model of trade with heterogeneous producers based on the Eaton and Kortum (2002) methodology. Third, it analyzes the performance of the Brown-Deardorff-Stern (BDS) model, which was used before NAFTA to study the possible effects of this trade agreement.

The GTAP framework is based on assumptions that are common in economic literature: perfect competition, constant returns to scale, and no change in the economy-wide employment of resources (Hertel, 1997). Each regional economy consists of several economic agents: on the final demand side of the model, a utility-maximizing household purchases commodities and it saves part of its income, which consists of returns to primary factors and net tax collections. On the production side of the model, cost-minimizing producers employ primary factor services and intermediate inputs to supply commodities. In the model, intermediate (and final demand) users of commodities are assumed to differentiate a commodity by its region of origin (i.e., the Armington specification is applied).

In each region, aggregate investment in new capital goods is represented by the output of a capital goods sector. Globally, the sum of household savings is equal to the sum of investment expenditures. Integrated into this treatment of production, demand, and trade, is a set of domestic support and trade policies, which are modeled as ad valorem equivalents. These policies affect the equilibrium computed by the model and when they change they induce changes by producers and consumers in all regions. The GTAP model is solved using the GEMPACK suite of software (Harrison and Pearson, 1994).

The Eaton and Kortum (2002) model is a Ricardian model of trade with a continuum of goods and many countries. It extends the Dornbusch-Fischer-Samuelson model to many countries by modeling productivity differences across goods by a statistical distribution. The Eaton-Kortum was extended to multiple industries by Shikher (2012), Shikher (2011), and Chor (2010). Since the industries in the Eaton-Kortum model are not homogeneous, there is no need for the Armington assumption to explain intra-industry trade. The Eaton-Kortum methodology incorporates a role for trade costs and trade in intermediate goods. We use the multi-industry multi-factor version of the Eaton-Kortum model developed by Shikher (2011). We call it the HPPC model ("heterogeneous producers, perfect competition"). It incorporates cross-industry linkages via the input-output table, which is typical of CGE models.

Unlike the GTAP and Eaton-Kortum models, the Brown-Deardorff-Stern model has some sectors with constant returns to scale and others with increasing returns. It incorporates imperfect competition and product differentiation. It has been used to study a variety of policy scenarios, such as NAFTA.

We use the latest version of the GTAP model together with the version 3 (1992) of the GTAP database. The HPPC model is parametrized with 1989 data. We simulate the removal of tariff and non-tariff barriers between U.S., Canada, and Mexico under NAFTA. The simulation results are compared with the the actual post-NAFTA changes in trade between 1989 and 2008.

2 Previous studies of NAFTA

The effects of NAFTA have been previously forecasted by several teams of researchers.[1] The forecasts employed computable general equilibrium models that utilized the Armington assumption. These models assumed either constant or increasing returns to scale.[2] Assuming IRS resulted in greater predicted effects of NAFTA. Some models had constant capital stock, while others allowed capital accumulation. Allowing international movement of capital typically caused large inflows of capital into Mexico.

The effects of NAFTA were simulated by removing the pre-NAFTA policy-related trade barriers. Some studies, such as Brown et al. (1992a) and Roland-Holst et al. (1994), simulated the removal of the non-tariff barriers (NTBs) in addition to the removal of tariffs, which resulted in greater predicted effects of NAFTA.[3]

Very few studies exist that systematically evaluate the predictions made by economic models regarding NAFTA. Instead, most post-NAFTA studies focus on analyzing the effects of NAFTA, typically using the gravity model rather than a CGE model.[4] These studies generally find that

[1] They include Sobarzo (1992), Roland-Holst, Reinert and Shiells (1994), Cox and Harris (1992), Brown, Deardorff and Stern (1992a), Bachrach and Mizrahi (1992), Shiells and Shelburne (1992), Hunter, Markusen and Rutherford (1992) (auto industry), and McCleery (1992). The pre-NAFTA studies were initially collected together by the U.S. International Trade Commission (1992). The updated versions of some of these studies, together with the several new ones were later collected in Francois and Shiells (1994) and Kehoe and Kehoe (1995b). Summaries of these studies are presented in Brown, Deardorff and Stern (1992b), Baldwin and Venables (1995), and Kehoe and Kehoe (1995a).

[2] See Baldwin and Venables (1995) for a review and classification of these models.

[3] Unfortunately, some studies did not report the size of the trade barriers that were removed during their simulations of NAFTA.

[4] The examples include Gould (1998) and Krueger (1999). Unfortunately, many of these studies do not use the theoretically-derived specification of the gravity equation of Anderson and van Wincoop (2003). Romalis (2007) uses a CGE model with the Armington assumption, parametrized with the post-NAFTA data, to study the effects of NAFTA. Reviews of the post-NAFTA literature can be found in Burfisher, Robinson and Thierfelder (2001) and Romalis (2007).

NAFTA had a relatively small effect on employment, prices, and welfare, as pre-NAFTA studies predicted. They also find that NAFTA had a large effect on trade, which is where the pre-NAFTA economic forecasts badly stumbled.

One paper that evaluates the performance of the pre-NAFTA forecasts is Kehoe (2005).[5] By systematically comparing model predictions to data, he finds that many of the predictions made before NAFTA turned out to be significantly off.[6] Specifically, the pre-NAFTA forecasts significantly underestimated the effects of NAFTA on trade, sometimes by several orders of magnitude. In addition, the models did poorly in explaining the variation of changes in trade flows across countries and industries.

3 NAFTA simulations

When simulating the effects of NAFTA, we remove tariffs and non-tariff barriers described in the next section. All the other parameters of the model remain at their base year levels. Therefore, we are not attempting to simulate all post-NAFTA changes in the NAFTA economies, but only those mandated by NAFTA.

We will compare the results predicted by the models to the actual post-NAFTA changes in trade, following the methodology described in the following sections.

The GTAP model will be used with three sets of Armington elasticities. The first is the set of standard GTAP elasticities. The second set has all elasticities equal to 8, while the third set has all elasticities equal to 3. Simulating GTAP with different sets of elasticities will show the sensitivity of the results to elasticities. Setting all elasticities to 8 makes the GTAP model more similar to the HPPC model, which has all elasticities of trade with respect to trade costs equal to 8, following Eaton and Kortum (2002).

The results of the BDS model in this preliminary version of the paper are taken from Brown et al. (1992a) and Kehoe (2005). In the near future, we hope to be able to reproduce these results using our own version of the BDS model

3.0.1 Policy-related trade barriers

In order to simulate the effects of NAFTA, it is necessary to know the extent of the policy-related trade barriers before its implementation. This includes both tariff and non-tariff barriers, the latter expressed in terms of ad-valorem tariff equivalents. Obtaining such data is not trivial.

The main source for the magnitudes of the pre-NAFTA policy-related trade barriers used in this paper is Nicita and Olarreaga (2007) that has information on both tariff and non-tariff barriers. This paper uses 1989 applied tariff data for Canada and the United States and 1991 data for Mexico, which is the closest available year.[7,8]

Compared to tariffs, the tariff equivalents of non-tariff barriers are much harder to collect and estimate. Consequently, there are fewer sources of this data. The earliest years for which the

[5] Fox (2000) evaluates the performance of CGE models in predicting the effects of U.S.-Canada free trade agreement.

[6] Kehoe reviews the forecasts of the Brown-Deardorff-Stern, Cox-Harris and Sobarzo models.

[7] Since Mexico has been liberalizing its trade even before NAFTA, using 1991 instead of 1989 trade barriers in the simulations may have reduced the forecasted growth in Mexican imports.

[8] Note that the trade barriers between the U.S. and Canada were not zero in 1989. Even though the U.S.-Canada FTA went into effect in 1988, it called for a gradual removal of all bilateral trade barriers. Therefore, many tariffs and NTBs were still in place in 1989.

ad-valorem equivalents of NTBs for Canada, Mexico, and the U.S. are available in Nicita and Olarreaga (2007) are 1999-2001. In the absence of other data, this paper uses the information from 1999-2001 to proxy for 1989 magnitudes. Due to NAFTA's reduction of NTBs, the average levels of NTBs for the NAFTA countries have probably fallen between 1989 and 1999-2001. Therefore, using the 1999-2001 levels results in smaller forecasted growth in trade due to NAFTA.[9] However, the pattern of NTBs across industries is less likely to have changed.

The tariffs and tariff equivalents of non-tariff barriers used in the simulations are presented in Tables 1(a)-(c). The average tariffs imposed by Canada, Mexico, and the United States on manufacturing goods, shown in the last column, were about 8.5%, 13.7%, and 4.7% respectively, while the tariff equivalents of NTBs were 3.3%, 17.7%, and 4.1%. The total policy-related barriers, therefore, were 11.8% in Canada, 31.4% in Mexico, and 8.8% in the United States.

Tables 1(a)-(c) also report tariffs and tariff equivalents of NTBs by industry. There is noticeable heterogeneity of protection levels across industries. The Textile industry is one of the most protected industries in all three countries with total policy-related barriers ranging between 16% in the United States to 40% in Mexico. The Paper industry is the least protected industry in all three countries with barriers ranging between 1.29% in the United States to 17% in Mexico.

The ranking of industries according to total protection levels varied across countries. For example, the Wood industry is fairly heavily protected in Canada, but relatively less protected in Mexico and the United States. The same is true of the Metals industry. On the other hand, the Nonmetals industry has less protection relative to other industries in Canada than it does in Mexico or the United States.

The prevalent type of policy-related protection also varied across industries and countries. For example, in the United States, the Textile and Nonmetals industries are protected mostly by tariffs, while the Food industry is protected mostly by NTBs. In Canada, the Chemicals and Nonmetals industries are protected mostly by tariffs, while the Metals industry is protected mostly by NTBs.

4 Evaluating the predictions of the models

The simulation of NAFTA performed in this paper entails the removal of all policy-related trade barriers reported in Table 1(c) between the three NAFTA countries, while maintaining all other trade barriers. This section evaluates the accuracy of the model's predictions regarding the changes in total manufacturing trade and trade in individual industries. The simulations results are compared with the actual post-NAFTA data and results of several previous NAFTA simulations.[10]

We compare model predictions against actual changes in trade for 1989-2008. The initial point (1989) is given by the year in which the models were parametrized.

The end year 2008 is determined by the following considerations. NAFTA was implemented in 1994 and provided for graduate bilateral trade barrier reductions between the participating countries. Both the tariff barriers and non-tariff barriers were to be reduced over a period of time.

The average length of phase-outs for U.S. tariffs was 1.4 years and Mexican tariffs 5.6 years (Kowalczyk and Davis, 1996). Therefore, by the year 2008, all trade barriers that were to be eliminated under NAFTA had been eliminated.

[9] Section 5 shows the trade forecasts if the NTB barriers are ignored altogether.

[10] The focus will primarily be on the predictions regarding trade, and not GDP, prices, or welfare. The reason is that it is difficult to find data on prices, and GDP and prices were both significantly affected by events other than NAFTA.

4.1 Results

Table 3 shows the overall effect of NAFTA: change in the share of NAFTA trade in the total trade of the NAFTA countries.[11] The HPPC model predicts that this share would grow 25.9% while it actually grew 26.1%. Relative to the total NAFTA income, the predicted growth in NAFTA trade is 62.2% while the actual growth is 77.5%. Therefore, the HPPC model accurately predicts the change in NAFTA trade relative to the total trade of the NAFTA countries, but underestimates somewhat the change in NAFTA trade relative to NAFTA income. This means that the total trade of the NAFTA countries relative to their income grew more than what the model predicts. This could be due to a decrease in non-policy related trade costs across the world, for example.[12] The GTAP model with the standard elasticities slightly overpredicts changes in NAFTA trade relative to the total trade of NAFTA countries.

Table 4 gives a more detailed look at the changes in trade of the NAFTA countries. It shows the actual and predicted percent changes in the total exports and imports of Canada, Mexico, and the United States, relative to their respective GDPs.

The first column shows the actual 1989-2008 changes. Mexican exports and imports have grown the most, followed by Canada's and then the United States'. The changes predicted by the BDS model are many times smaller than the actual changes. The GTAP model with standard elasticities also underpredicts trade changes, but not as much as the BDS model. It accurately predicts relative changes across the NAFTA countries: the correlation between actual and predicted changes is 0.95. The HPPC model performs the best: its predicted changes are the closest to the actual. Its predicted changes also exhibit a high correlation with the actual changes: 0.98.

Next, we investigate the accuracy of the models' forecasts at the industry level. Tables 5-8 show the predicted and actual percentage changes in the import shares for each pair of the NAFTA countries by industry. The share of country i in industry j imports of country n is X_{nij}/IM_{nj}, where X_{nij} are the imports of industry j goods by country n from country i and IM_{nj} are the total imports of industry j goods in n.

Tables 9 and 10 shows how well the predicted changes match the actual. Table 9 looks at the variation of trade flows across industries for each importer-exporter pair. To compare the actual and predicted changes, we regress the actual changes on predicted. Ideally, the coefficient of this regression would be 1, slope 0, and correlation (which is the square root of R^2) 1. We can see that the HPPC model does a good job predicting trade changes, except for trade between Canada and Mexico. In fact, all of the model produce big errors when predicting trade changes between those countries. It should be noted the Canada-Mexico trade is about 1% of total NAFTA trade. The pre-NAFTA trade between those countries was very small and post-NAFTA changes, in percentage

[11] Total NAFTA trade is the sum of all bilateral trade flows in NAFTA: $\sum_{\substack{n,i\in H \\ n\neq i}} \sum_j (X_{nij} + X_{inj})$, where H is the set of NAFTA countries. Total trade of the NAFTA countries is $\sum_{n\in H} \sum_j (EX_{nj} + IM_{nj})$, where EM_{nj} and IM_{nj} are total exports and imports of industry j goods in country n. Measuring bilateral trade relative to total trade or income helps to control for events other than NAFTA that affected the economies of the NAFTA countries during the post-NAFTA period. See Section 5 for the discussion of such events.

[12] As mentioned in footnote **??**, an unpublished extension of the HPPC model incorporates domestic accumulation and international mobility of capital. In the simulation of NAFTA, this extension predicts an accumulation of capital stock in the NAFTA countries, mostly due to a transfer from the non-NAFTA countries. It predicts that the capital stocks of Canada, Mexico, and the U.S. would grow 9.1, 10, and 0.65%, respectively. The total NAFTA trade relative to the total trade of the NAFTA countries in this case is predicted to grow 28.4% and the total NAFTA trade relative to the total income of the NAFTA countries is predicted to grow 66.2%. Therefore, allowing domestic accumulation and international mobility of capital has fairly small effects on these measures of NAFTA trade.

terms, were big. The big prediction errors can due to measurement errors in the data, which are more likely for small trade flows, or due to poor ability of the models to predict trade changes starting from a very low initial trade.[13]

The HPPC model does well predicting changes in trade between other export-importer pairs. The slope is close to one and correlation is between 0.72 and 0.98. The BDS model underpredicts changes in the U.S. imports from Mexico and Canadian imports from the U.S. At the same time, it overpredicts changes in the U.S. exports to Mexico and U.S. imports from Canada. The correlation across industries between actual and predicted trade changes is generally low.

Next, we look at the performance of the GTAP model. When used with its standard elasticities, the GTAP model underpredicts changes in the U.S. imports from Mexico and overpredicts all other trade changes. The correlation across industries for the four pairs of countries (excluding Canada-Mexico trade) is high.

GTAP performs better when all elasticities are set to equal to 8. The slope becomes 1 for changes in the U.S. imports from Mexico. However, the model begins to overpredict changes in the U.S. imports from Canada. The model still overpredicts changes in the Canadian imports from the U.S. When all elasticities are set to 3, the GTAP significantly underpredicts all trade changes. The GTAP model does a good job matching the variation of trade changes across industries. The cross-industry correlations are high for all country pairs, except Canada-Mexico trade.

Table 10 shows correlations between predicted and actual trade changes for all models. The correlations are calculated across 32 trade flows, which omit Canada-Mexico trade. The HPPC model does the best with correlation of 0.95. The GTAP model with elasticities set to 8 also does well, with correlation equal to 0.9. The GTAP model does well matching the variation of trade changes across industries, but not as well matching the variation of trade changes across country pairs. The BDS model is the worst performer, with correlation equal to 0.31.

5 Conclusion

Being a major event in recent North American economic history, NAFTA is a natural experiment that is useful for evaluating models of trade. This paper use NAFTA to evaluate three important computable general equilibrium models of trade: the Brown-Deardorff-Stern model, the GTAP model, and the multi-industry version of the Eaton-Kortum model. The paper compared the changes in bilateral import shares predicted by the model with the actual changes between 1989 and 2008. All models are parametrized with pre-NAFTA data and simulate removal of the same set of tariff and non-tariff barriers.

The results show that the multi-industry version of the Eaton-Kortum model performs the best. It is able to match the variation of trade changes across industries and countries observed in post-NAFTA data. The exception is the Canada-Mexico trade that none of the models is able to explain.

The GTAP model with all elasticities set to 8 performs similarly to the Eaton-Kortum model in matching the variation of trade changes across industries, but less well in matching variation of trade changes across country pairs. However, we note the setting all elasticities to 8 in GTAP produces overall better results than using standard GTAP elasticities.

[13] Canadian exports to Mexico were only \$400M in 1989 and \$1B in 2000. The 1989 Mexican Wood exports to Canada are reported at only \$8.2M. The small initial trade results in very large percentage trade changes post-NAFTA: the Wood industry data shows a 1385% increase in Mexican exports to Canada.

The BDS model makes the least accurate predictions. It does a poor job matching both cross-industry and cross-country variations of trade changes.

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Table 1 Policy-related trade barriers removed by NAFTA

Table 1(a) Tariffs

Country	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	Manuf.
Canada	8.83	17.65	8.48	3.46	8.26	7.78	4.83	5.63	8.51
Mexico	15.93	17.48	15.02	5.84	12.35	15.26	9.86	13.74	13.71
United States	2.14	10.64	2.47	0.62	4.48	7.43	3.04	3.37	4.68

Table 1(b) Tariff equivalents of non-tariff barriers

Canada	3.23	7.95	12.96	0.00	1.23	0.00	11.82	0.87	3.33
Mexico	26.68	22.89	8.39	11.12	17.09	18.11	4.03	19.21	17.70
United States	11.07	5.81	2.63	0.67	3.28	0.51	0.00	4.05	4.10

Table 1(c) Total policy-related trade protection

Canada	12.06	25.60	21.44	3.46	9.49	7.78	16.65	6.50	11.84
Mexico	42.61	40.37	23.41	16.96	29.44	33.37	13.89	32.95	31.42
United States	13.21	16.45	5.10	1.29	7.76	7.94	3.04	7.42	8.78

Table 2 Productivities in the HPPC model relative to the United States

	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
Canada	0.852	0.862	0.920	0.966	0.797	0.788	0.989	0.795
Mexico	0.571	0.564	0.422	0.447	0.609	0.570	0.629	0.500
U.S.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Australia	0.847	0.755	0.614	0.677	0.693	0.688	0.897	0.702
Austria	0.646	0.798	0.651	0.745	0.717	0.824	0.786	0.728
Finland	0.590	0.737	0.746	0.904	0.706	0.693	0.841	0.728
France	0.886	0.958	0.787	0.850	0.887	0.972	0.938	0.871
Germany	0.831	0.954	0.833	0.875	0.925	0.989	0.955	0.924
Greece	0.684	0.687	0.449	0.494	0.560	0.663	0.679	0.477
Italy	0.812	1.045	0.878	0.826	0.846	1.040	0.887	0.883
Japan	0.738	0.970	0.773	0.868	0.935	1.049	1.001	1.025
Korea	0.660	0.871	0.559	0.612	0.724	0.683	0.794	0.713
New Zeal.	0.883	0.709	0.625	0.682	0.658	0.567	0.706	0.603
Norway	0.758	0.660	0.656	0.776	0.741	0.670	0.869	0.701
Portugal	0.616	0.648	0.507	0.580	0.538	0.636	0.580	0.509
Spain	0.771	0.788	0.645	0.709	0.737	0.829	0.820	0.693
Sweden	0.662	0.721	0.733	0.848	0.746	0.750	0.845	0.785
Turkey	0.595	0.621	0.392	0.374	0.548	0.604	0.648	0.429
U.K.	0.838	0.871	0.704	0.805	0.848	0.878	0.881	0.822

Table 3 Actual vs. predicted percent changes in NAFTA trade

Measure	Actual 1989-2008	Predicted HPPC	Predicted GTAP(std)
NAFTA trade relative to the total trade of the NAFTA countries	24.8	25.9	28.7
NAFTA trade relative to the total income of the NAFTA countries	66.5	62.2	

Note: NAFTA trade is the sum of all bilateral trade flows between the NAFTA countries. The total trade of the NAFTA countries is the sum of their exports and imports. The total income of the NAFTA countries is the sum of their GDPs.

Table 4 Actual vs. predicted percent changes in total exports and imports

	Actual	Predicted		
Variable	1989–2008	HPPC	GTAP(std)	BDS
Canadian exports	66.7	45.4	23.6	4.3
Canadian imports	58.2	37.1	16.9	4.2
Mexican exports	120.3	130.4	79.4	50.8
Mexican imports	64.2	58.3	42.2	34.0
U.S. exports	39.2	24.0	11.0	2.9
U.S. imports	46.2	17.5	7.7	2.3
Correlation with data		0.98	0.95	0.86

Note: Exports and imports are measured relative to GDP. The Brown-Deardorff-Stern (BDS) model has increasing returns to scale. The model with heterogeneous producers (HPPC) described in this paper has constant returns to scale.
Note: GTAP results are not relative to GDP (though GDP changes are very small relative to trade changes)

Actual vs. predicted changes in bilateral industry-level trade

Table 5 Percent changes in import shares predicted by the HPPC model

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	36.3	188.2	21.0	14.9	23.7	21.1	16.0	65.6
Canada	U.S.	16.0	64.5	9.9	2.4	6.9	10.2	17.1	6.5
Mexico	Canada	-9.6	-36.3	-41.8	-24.9	-23.6	-22.9	-3.9	-2.8
Mexico	U.S.	19.6	21.1	2.1	4.0	13.7	25.5	9.0	18.7
U.S.	Canada	32.6	121.0	5.5	-2.8	30.5	26.5	11.3	49.0
U.S.	Mexico	107.1	337.9	60.1	37.2	73.8	69.0	28.9	129.1

Note: Each observation is a share of country *i* in country *n*'s imports of industry *j*.

Table 6a Percent changes in import shares predicted by the GTAP model with GTAP elasticities

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	28.2	147.9	13.6	9.1	19.8	12.4	36.4	47.6
Canada	U.S.	20.7	125.1	14.3	1.3	8.5	10.9	20.2	8.4
Mexico	Canada	24.5	32.6	2.5	0.7	13.3	21.9	10.8	24.1
Mexico	U.S.	33.2	37.3	10.0	6.2	18.0	32.7	17.6	28.8
U.S.	Canada	41.1	141.9	7.0	-1.6	17.2	23.0	3.7	28.5
U.S.	Mexico	60.6	176.0	14.0	11.7	34.7	35.8	24.7	80.8

Table 6b Percent changes in import shares predicted by the GTAP model with all elasticities set to 8

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	90.7	237.9	38.5	48.4	82.7	41.5	76.2	84.0
Canada	U.S.	33.7	142.4	17.8	3.2	16.8	15.8	26.6	10.1
Mexico	Canada	32.0	43.2	8.4	2.4	22.4	29.5	20.8	32.4
Mexico	U.S.	40.7	38.9	12.1	11.0	27.6	38.8	23.5	30.6
U.S.	Canada	77.1	190.3	13.3	-2.6	42.7	38.4	11.2	39.1
U.S.	Mexico	168.0	292.2	37.6	51.1	131.4	80.8	57.7	127.6

Table 6c Percent changes in import shares predicted by the GTAP model with all elasticities set to 3

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	28.0	72.3	19.4	15.4	24.4	17.7	27.2	23.6
Canada	U.S.	13.9	53.1	9.2	1.3	7.2	6.5	12.3	4.3
Mexico	Canada	23.3	24.0	5.7	3.6	14.4	20.1	10.1	18.4
Mexico	U.S.	25.0	23.7	6.6	5.5	15.4	21.8	10.5	17.6
U.S.	Canada	28.6	51.5	5.3	-0.3	16.6	15.2	4.7	15.5
U.S.	Mexico	46.4	70.0	16.0	15.4	36.3	29.0	18.9	35.7

Table 7 Percent changes in import shares predicted by the BDS model

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	10.0	11.0	22.7	15.0	-7.5	5.1	11.2	15.7
Canada	U.S.	7.4	24.3	3.4	3.0	2.2	3.8	2.9	1.6
Mexico	Canada	-7.0	5.6	12.1	0.8	7.0	156.0	6.2	14.4
Mexico	U.S.	7.4	10.5	11.3	2.0	2.2	7.1	5.7	10.8
U.S.	Canada	8.1	23.3	1.4	-0.1	2.8	58.9	8.0	4.2
U.S.	Mexico	10.3	14.7	4.4	4.4	-6.1	-23.6	14.8	41.9

Table 8 Percent changes in import shares found in data (1989-2008)

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	92.71	202.83	1580.50	185.78	413.43	208.89	-59.72	254.06
Canada	U.S.	36.15	72.85	16.11	8.95	14.56	25.98	6.83	2.82
Mexico	Canada	20.83	-65.01	846.37	-40.81	5.36	-68.86	-70.19	-35.60
Mexico	U.S.	18.29	22.85	-10.96	-1.35	8.55	3.86	-7.76	4.73
U.S.	Canada	73.45	93.67	-4.37	-11.19	5.78	17.65	-9.06	-5.69
U.S.	Mexico	81.93	291.84	52.06	-1.31	45.92	31.01	19.95	141.12

Table 9 Relationships between actual (1989-2008) and predicted changes

		HPPC model			BDS model		
Importer	Exporter	Correlation	Intercept*	Slope	Correlation	Intercept*	Slope
Canada	Mexico	-0.15	423.10	-1.31	0.41	111.09	23.89
Canada	U.S.	0.91	5.71	1.04	0.95	5.54	2.88
Mexico	Canada	-0.57	-185.64	-12.53	-0.14	93.82	-0.81
Mexico	U.S.	0.72	-9.46	1.00	0.10	2.54	0.31
U.S.	Canada	0.77	-7.59	0.81	0.28	12.26	0.58
U.S.	Mexico	0.98	-15.70	0.93	0.44	65.84	2.23

		GTAP(std) model			GTAP(8) model		
Importer	Exporter	Correlation	Intercept*	Slope	Correlation	Intercept*	Slope
Canada	Mexico	-0.23	458.71	-2.51	-0.29	558.96	-2.28
Canada	U.S.	0.90	9.69	0.51	0.92	7.47	0.47
Mexico	Canada	-0.49	295.40	-13.58	-0.47	336.41	-10.99
Mexico	U.S.	0.78	-13.37	0.79	0.79	-17.41	0.80
U.S.	Canada	0.86	-4.69	0.76	0.91	-10.79	0.60
U.S.	Mexico	0.98	-11.24	1.72	0.90	-38.32	1.02

		GTAP(3) model		
Importer	Exporter	Correlation	Intercept*	Slope
Canada	Mexico	-0.20	520.72	-5.65
Canada	U.S.	0.92	5.96	1.27
Mexico	Canada	-0.46	351.60	-18.57
Mexico	U.S.	0.85	-15.92	1.31
U.S.	Canada	0.93	-19.25	2.29
U.S.	Mexico	0.89	-69.73	4.56

Table 10 Correlation between actual and predicted industry-level bilateral trade flows, except those between Canada and Mexico (32 trade flows in total)

HTTP	0.95
GTAP (std)	0.86
GTAP (8)	0.90
GTAP (3)	0.83
BDS	0.31