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NAFTA and Industrial Pollution: Some General Equilibrium Results

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Abstract

In recent years, a surge of interest in the linkages between trade and the environment has occurred in the contexts of both regional and multilateral trade agreements. In this paper, we utilize a three-country, applied equilibrium (AGE) model of the North American economy and data from the World Banks Industrial Pollution Projection System (IPPS) to simulate the industrial pollution impacts of trade liberalization under NAFTA. We find that the most serious environmental consequences of NAFTA occur in the base metals sector. In terms of magnitude, the greatest impacts are in the United States and Canada. The Mexican petroleum sector is also a significant source of industrial pollution, particularly in the case of air pollution. For specific pollutants in specific countries, the transportation equipment sector is also an important source of industrial pollution. This is the case for both volatile organic compounds and toxins released into the air in Canada and the United States. Finally, the chemical sector is a significant source of industrial toxin pollution in the United States and Mexico, but not in Canada.

- **JEL Classifications:** F15, Q2, C6
- **Key Words:** NAFTA, Pollution, Applied General Equilibrium

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I. Introduction

In recent years, a surge of interest in the linkages between trade and the environment has occurred in the contexts of both regional trade agreements such the North American Free Trade Area (NAFTA) and multilateral trade agreements such as the Uruguay Round. On the whole, however, the debate over trade and the environment has been more rhetorical than empirical. This is unfortunate because, as has been amply demonstrated (e.g. Runge, 1994, Beghin and Potier, 1997, and Beghin, Roland-Holst, and van der Mensbrugghe, 1997), *a priori* reasoning alone cannot predict whether trade liberalization will have an overall positive or negative impact on the environment. This fact has prompted Beghin, Roland-Holst, and van der Mensbrugghe (1997) to call for "detailed sectoral modeling and estimation" of the linkages between trade and the environment in specific policy contexts.

A few empirical studies do exist. The case of trade and transboundary pollution has been examined by Whalley (1991) and Perronni and Wigle (1994). Economy-wide models of domestic pollution have been developed by Beghin, Roland-Holst, and van der Mensbrugghe (1995) for the case of Mexico, by Lee and Roland-Holst (1997a,b) in the case of Indonesia and Japan, and by Ferrantino and Linkins (1999) for the case of the Uruguay Round. Examination of these studies provides further testimony to the usefulness of detailed, empirical analysis.

This paper focuses on the industrial pollution impacts of NAFTA. We utilize a three-country, applied equilibrium (AGE) model of the North American economy and make use of the World Banks Industrial Pollution Projection System (IPPS) to generate results for a detailed set of industrial sectors and pollutants. We simulate the liberalization of tariffs and non-tariff barriers (NTBs) that accompanies NAFTA and provide results for the changes in emissions by industrial sector and pollutant. The results allow us to identify where some of the major environmental impacts of NAFTA are to be found.

We begin in Section II by briefly reviewing the sparse empirical literature on NAFTA and the environment. We then describe in Section III the structure of the AGE model we use to simulate the industrial pollutant effects of NAFTA. We present our simulation results in Section IV and our conclusions in Section V. An appendix describes the construction of the social accounting matrix that comprises the benchmark equilibrium data set of the model.

II. NAFTA and the Environment

As is the case with the general subject of trade and the environment, the literature on NAFTA and the environment is lacking in empirical results. One very notable exception to this is the study by Grossman and Krueger (1993). These authors combined the output effects of NAFTA as simulated by Brown, Deardorff and Stern (1992) with data from the U.S. Environmental Protection Agency on toxic pollution. With regard to the direct impacts of trade liberalization (as opposed to liberalization-induces increases in investment), these authors found that the greatest increases in toxic pollution occur in the U.S. chemicals sector and the Canadian base metals and rubber and plastics products sectors. Other significant trade-induced increases in toxic pollution occurred in the Mexican electrical equipment sector, the U.S. paper products sector, and the Canadian transportation equipment sector.

A second notable exception is the study by Beghin, Roland-Holst, and van der Mensbrugghe (1995). These authors employ a single-country, dynamic AGE model of Mexico. In one simulation scenario, the authors consider “a piecemeal unilateral trade liberalization, along with a modest increase in export prices to mimic terms-of-trade effects that would follow from NAFTA, and increased access to North American markets” (p. 781). The results suggest that trade liberalization contributes to increases in pollution levels, especially in the energy sector. Beghin, Roland-Holst, and van der Mensbrugghe show, however, that these negative pollution impacts can be offset by appropriate abatement policies.

A final empirical study by Abler and Pick (1993) focuses narrowly on the Mexican horticultural sector. Using econometric techniques, these authors conclude that NAFTA contributes to a slight increase in pollution in the Mexican horticultural sector but a slight decrease in pollution in the U.S. horticultural sector. Whether these results can be generalized to the agricultural sector as a whole is not clear.

The present study complements the above studies in providing empirical results for a detailed set of pollutants for all three North American economies. The following section details our modeling approach.

III. AGE Model Structure

The AGE model used to simulate the industrial pollution effects of North

American trade liberalization is a three-country, 26-sector model.[1] The trade specification follows that of de Melo and Robinson (1989). In each sector of each country, domestic demand is constituted of goods which are differentiated by origin (domestic good, imports from each North American trading partner, and imports from the rest of the world). These goods are aggregated using a non-nested, CES functional form into a single consumption good for both intermediate and final use. Also in each sector of each country, domestic production is allocated using a non-nested CET functional form among differentiated destinations (domestic good, exports to each North American trading partner, and exports to the rest of the world).[2] With regard to each countrys relationship to the rest of the world, we maintain the small-country assumption. Exchange rates are flexible, while trade balances are fixed.

Production in each sector of each country utilizes physical capital and labor. These factors are assumed to be perfectly mobile among the sectors of each country but immobile among countries. Production takes place under constant returns to scale using CES functional forms for value added and Leontief intermediates. Final demand in each country is modeled using the LES functional form. All markets are perfectly competitive.

The trade-liberalizing experiments we conduct use observed tariff rates for our base year 1991. In addition, we consider very rough estimates of non-tariff barriers using UNCTAD data on trade control measures. As is general practice (e.g. Gaston and Trefler, 1994), we use NTB coverage ratios as *ad valorem* equivalents. For this reason, our simulations must be interpreted as merely *suggestive* of the impacts of NAFTA on trade, production, and pollution.

The three-country model is calibrated to a 1991 North American social accounting matrix (SAM). The construction of this matrix and its data sources are documented in the appendix. The IPPS effluent data are utilized at the 2- and 3-digit ISIC levels to create *satellite environmental accounts* to this SAM as suggested by Barker (1992), United Nations (1993a,b), and de Haan and Keuning (1996). As is recommended by their compilers, IPPS effluent data are utilized in

[1]Most AGE modelers have included only one or two of the North American countries in their model. An exception to this is Brown, Deardorff and Stern (1992).

[2]In contrast to the approach taken here, Brown et al. (1992) use a firm-level product differentiation approach. One advantage of the country-level product differentiation approach is that it allows for econometric estimation of trade substitution elasticities. Indeed, we make use of the estimates of Shiells and Reinert (1993) in our calibration of the CES import aggregation functions. That said, we have no quarrel with the firm-level differentiation specification. Both approaches have strengths and weaknesses.

Table 1. The IPPS Pollutants

Name	Symbol	Description
Particulates	PT	Fine airborne particles that can damage respiratory systems.
Carbon Monoxide	CO	A poisonous gas that inhibits the ability of blood to carry oxygen.
Sulfur Dioxide	SO2	A gas that can contribute to respiratory disease and acid rain.
Nitrogen Dioxide	NO2	A gas that contributes to both respiratory disease and to the formation of acid rain and ozone.
Volatile Organic Compounds	VOC	A class of chemicals associated with skin reactions, nervous system effects, sick-building syndrome, and multiple chemical sensitivity. Many are also suspected carcinogens.
Bio-accumulative Metals	MetAir, MetWat, MetLand	Metals, including mercury, lead, arsenic, chromium, nickel, copper, zinc, and cadmium. They contribute to mental and physical birth defects.
Toxic Pollutants	ToxAir, ToxWat, ToxLand	A class of chemicals that can damage internal organs and neurological functions, cause reproductive problems and birth defects. Many are also suspected carcinogens.
Biological Oxygen Demand	BOD	Organic water pollutants that remove dissolved oxygen. They can damage aquatic species and promote the growth of algae and pathogens.
Total Suspended Solids	TSS	Non-organic, non-toxic particles that can damage aquatic ecosystems and promote the growth of pathogens.

Source: World Bank Industrial Pollution Projection System

their per-employee form. Table 1 describes the IPPS pollutants.[3] In the case of air pollution, the IPPS data include particulates, carbon monoxide, sulfur dioxide, nitrogen dioxide, and volatile organic compounds. In the case of industrial bio-accumulative metals and toxins, the data distinguish among transmission to air, water, and land. Finally, in the case of water pollution, the data distinguish between biological oxygen demand and total suspended solids. The result is a significant amount of detail in both sectoral and pollutant dimensions which complement the earlier work of Grossman and Krueger (1993).

The calibration of the model also requires a set of behavior parameters. Elastici-

[3]On the IPPS, see Hettige, Lucas and Wheeler (1992) and the references therein. See also the web-site listed in our data sources at the end of the paper.

ties of substitution between labor and capital were taken from Reinert and Roland-Holst (1995) for the United States and Mexico and from Delorme and Lester (1990) for Canada. The elasticities of substitution among imports and do-mestic goods were taken from Shiells and Reinert (1993) for the United States and Canada and from Sobarzo (1992) for Mexico. Elasticities of transformation among exports and domestic supply were taken from Reinert and Roland-Holst (1995).

IV. Simulation Results

For the purposes of this paper, we focus a simulation exercise closest to that considered by Brown, Deardorff and Stern (1992) and, therefore, by Grossman and Krueger (1993). We consider the removal of both tariffs as measured by their observed values and NTBs as measured by coverage ratios. We assume that each North American trading partner maintains its existing protection with respect to the rest of the world. Additionally, as is standard practice in most trade policy models, we assume that total labor supply is fixed in each country. The results of these simulations for each industrial sector and IPPS pollutant are presented in

Table 2. Industrial Air Pollution (thousands of pounds)

Sector	Can	Can	Can	Can	Can	US	US
	PT	CO	SO2	NO2	VOC	PT	CO
petrol	4,384	14,077	27,710	16,248	12,220	1,067	3,426
foodpr	325	97	354	355	92	2,782	828
bever	25	20	383	244	414	–37	–30
tobac	2	10	123	74	24	–4	–19
textl	–55	–48	–261	–343	–157	180	158
cloth	0	0	3	1	1	0	0
leath	11	1	20	5	35	140	18
paper	–1,821	–10,609	–9,323	–5,141	–2,044	33	192
chem	–293	–2,630	–1,552	–1,516	–1,279	1,276	11,472
rubber	99	37	856	294	1,123	137	51
nmtmn	–476	–119	–688	–541	–64	–111	–28
bsmetl	5,016	30,825	40,248	5,759	2,543	12,374	76,052
wdmetl	637	1,159	253	493	1,325	2,920	5,314
nelcmc	1	9	9	4	10	71	518
elcmc	33	168	305	150	204	–10	–53
trnseq	3,266	5,561	7,908	4,109	29,531	3,531	6,013
othmn	2	1	3	3	18	1	0
Total	11,156	38,558	66,352	20,199	43,997	24,349	103,913

Table 2. Continued

Sector	US	US	US	Mex	Mex	Mex	Mex	Mex
	SO2	**NO2**	**VOC**	**PT**	**CO**	**SO2**	**NO2**	**VOC**
petrol	6,743	3,954	2,974	15,322	49,196	96,840	56,783	42,705
foodpr	3,035	3,042	791	341	101	372	372	97
bever	–570	-363	–616	39	31	598	381	646
tobac	–239	–145	–48	0	2	19	12	4
textl	857	1,126	515	351	309	1,674	2,199	1,007
cloth	–3	–1	–1	0	0	1	0	0
leath	254	64	442	8	1	14	3	24
paper	169	93	37	–197	–1,149	–1,009	–557	–221
chem	6,770	6,614	5,581	845	7,598	4,484	4,381	3,696
rubber	1,188	408	1,559	11	4	94	32	124
nmtmn	–160	–126	–15	1,892	475	2,735	2,150	253
bsmetl	99,301	14,209	6,275	1,344	8,261	10,786	1,543	682
wdmetl	1,162	2,261	6,077	763	1,388	304	591	1,588
nelcmc	479	215	545	25	184	170	76	193
elcmc	–96	–47	–64	36	185	337	166	226
trnseq	8,550	4,443	31,930	294	500	711	370	2,656
othmn	2	1	9	3	1	6	6	37
Total	127,442	35,750	55,991	21,076	67,088	118,136	68,509	53,716

Sectors are: petroleum; food processing; beverages; tobacco; textiles; clothing; leather; paper; chemicals; rubber; non-metalic mineral products; base metals; wood and metal products; non-electrical machinery; electrical machinery; transportation equipment; and other manufactures.
Pollutants are: PT- particulates; CO- carbon monoxide; SO2- sulfur dioxide; NO2- nitrogen dioxide; VOC- volatile organic compounds.

Tables 2 through 5.[4]

Table 2 presents the changes in industrial *air pollution* caused by trade liberalization in North America for each industrial sector of the model. The evidence presented in this table suggests that the industrial air pollution generated as a result of NAFTA will be concentrated in a few particular sectors. These are petroleum, base metals, and transportation equipment. For particulates, carbon monoxide, sulfur dioxide, and nitrogen dioxide, the greatest increases occur in the U.S. base metals sector and in the Mexican petroleum sector.[5] In the case of

[4]Missing from our analysis is the impact of NAFTA on pollution emissions from the Canadian, U.S., and Mexican agricultural sectors. We refer readers to Abler and Pick (1993) for the case of horticulture in Mexico.

[5]Pollution associated with the petroleum sector in Mexico has been a significant part of the debate over NAFTA and the environment. See Beghin, Roland-Holst, and van der Mensbrugghe (1995) and Commission for Environmental Cooperation (1996).

Table 3. Industrial Bio-accumulative Metals Pollution (thousands of pounds)

Sector	Can Met-Air	Can Met-Wat	Can Met-Land	US Met-Air	US Met-Wat	US Met Land	Mex Met-Air	Mex Met-Wat	Mex Met-Land
petrol	8	3	84	2	1	20	30	12	292
foodpr	0	0	1	0	0	5	0	0	1
bever	0	0	3	0	0	–5	0	0	5
tobac	0	0	0	0	0	0	0	0	0
textl	0	0	–6	1	0	21	3	0	41
cloth	0	0	0	0	0	0	0	0	0
leath	0	0	12	0	0	151	0	0	8
paper	–2	–3	–9	0	0	0	0	0	–1
chem	–3	–3	–99	13	12	432	8	8	286
rubber	2	0	95	2	1	132	0	0	10
nmtmn	–1	0	–8	0	0	–2	4	0	31
bsmetl	261	19	7,482	644	47	18,459	70	5	2,005
wdmetl	2	0	53	9	2	243	2	0	63
nelcmc	0	0	2	5	0	94	2	0	33
elcmc	2	0	68	–1	0	–22	2	0	76
trnseq	93	2	1,142	101	2	1,234	8	0	103
othmn	0	0	3	0	0	1	0	0	6
Total	362	19	8,821	776	65	20,765	130	26	2,960

Sectors are: petroleum; food processing; beverages; tobacco; textiles; clothing; leather; paper; chemicals; rubber; non-metalic mineral products; base metals; wood and metal products; non-electrical machinery; electrical machinery; transportation equipment; and other manufactures.
Pollutants are: Metals to air, water, and land.

volatile organic compounds, however, the transportation equipment sectors of Canada and the United States are large sources. In terms of total air pollution emissions, the greatest increases are of carbon monoxide and sulfur dioxide in the United States and sulfur dioxide in Mexico. Significant reductions in air pollution occur in the Canadian and Mexican paper sectors and in the Canadian chemicals sector.

Table 3 addresses industrial *bio-accumulative metals pollution*. Here, the petroleum sector plays a less important role than base metals and transportation equipment. The largest emissions are to land, and these occur in the Canadian and U.S. base metals and transportation equipment sectors and in the Mexican base metals sector. In terms of total emissions, the United States leads both Canada and Mexico, primarily as a result of changes in its base metals sector. Again the Canadian chemicals sector registers improvement in emissions, although these are

Table 4. Industrial Toxin Pollution (thousands of pounds)

Sector	Can Tox-Air	Can Tox-Wat	Can Tox-Land	US Tox-Air	US Tox-Wat	US Tox-Land	Mex Tox-Air	Mex Tox-Wat	Mex Tox-Land
Petrol	1,140	80	4,334	277	20	1,055	3,984	280	15,147
Foodpr	14	4	54	122	34	467	15	4	57
Bever	15	2	11	–22	–3	–17	23	3	18
Tobac	26	0	3	–51	0	–5	4	0	0
Textl	–106	–20	–63	349	65	208	682	126	406
Cloth	1	0	1	–1	0	–1	0	0	0
Leath	46	2	89	589	20	1,125	32	1	60
Paper	–1,906	–437	–726	35	8	13	–206	–47	–79
Chem	–967	–287	–2,230	4,217	1,253	9,729	2,793	830	6,443
Rubber	899	2	331	1,247	3	459	99	0	36
Nmtmn	–28	–1	–37	–6	0	–9	110	3	145
Bsmetl	2,867	305	9,479	7,072	752	23,388	768	82	2,540
Wdmetl	364	8	189	1,669	37	867	436	10	227
Nelcmc	6	0	4	348	9	230	124	3	82
Elcmc	284	3	284	–90	–1	–90	315	3	315
Trnseq	15,861	61	6,843	17,149	66	7,399	1,427	5	615
Othmn	31	0	15	15	0	7	62	1	29
Total	18,549	–277	18,581	32,920	2,261	44,826	10,668	1,304	26,044

Sectors are: petroleum; food processing; beverages; tobacco; textiles; clothing; leather; paper; chemicals; rubber; non-metalic mineral products; base metals; wood and metal products; non-electrical machinery; electrical machinery; transportation equipment; and other manufactures.
Pollutants are: Toxins to air, water, and land.

slight.

Table 4 presents the changes in industrial *toxin pollution*. Here, transmission to air is important along with transmission to land. This is especially the case for the transportation equipment sector in Canada. The base metals sector is also important for the transmission of toxins to land in this country.[6] In the United States and Mexico, the chemical sector appears as significant sources of toxins. Importantly, this is *not* the case for Canada where this is a *reduction* of toxin emissions in the chemical sector.[7] As was the case in Tables 2 and 3, this result demonstrates the importance of the general equilibrium analysis of trade and the environment. If reflects the comparative advantage of the U.S. and Mexican chemical sectors over their Canadian counterpart. The U.S. base metals and

[6]Qualitatively, these results for Canada agree with those of Grossman and Krueger (1993).
[7]Grossman and Krueger (1993) show a decrease in toxin pollution from the Mexican chemicals sector in their trade-liberalization alone case, but an increase in the trade and investment liberalization case.

Table 5. Industrial Water Pollution (thousands of pounds)

Sector	Can BOD	Can TSS	US BOD	US TSS	Mex BOD	Mex TSS
Petrol	271	1,335	66	325	948	4,664
Foodpr	483	120	4,136	1,032	506	126
Bever	164	297	–245	–441	257	463
Tobac	0	0	0	0	0	0
Textl	0	0	0	0	0	0
Cloth	0	0	0	0	0	0
Leath	8	17	104	216	6	12
Paper	–5,004	–16,838	91	305	–542	–1,823
Chem	–365	–1,224	1,594	5,341	1,056	3,537
Rubber	170	466	236	647	19	51
Nmtmn	–1	–13	0	–3	6	51
Bsmetl	2,245	152,998	5,540	377,481	602	41,003
Wdmetl	18	140	81	642	21	168
Nelcmc	0	1	2	38	1	13
Elcmc	12	17	–4	–5	13	19
Trnseq	14	102	15	110	1	9
Othmn	0	414	0	204	0	825
Total	–1,986	137,832	11,615	385,891	2,893	49,120

Sectors are: petroleum; food processing; beverages; tobacco; textiles; clothing; leather; paper; chemicals; rubber; non-metalic mineral products; base metals; wood and metal products; non-electrical machinery; electrical machinery; transportation equipment; and other manufactures.
Pollutants are: BOD- biological oxygen demand; and TSS- total suspended solids.

transportation equipment sectors and the Mexican petroleum sector are also significant sources of toxins,[8] and in terms of total emissions, the U.S. leads with toxic emissions to land and air.

Finally, Table 5 presents the simulation results for *water pollution*. The base metals sector is again a crucial source of effluents. This is particularly the case for total suspended solids in all three countries. In the case of biological oxygen demand, there is actually an overall decrease in Canada due to the contraction of the paper products sector. The Mexican petroleum sector is a significant source of total suspended solids, but this is an order of magnitude less than in its base metals sector. By far, the greatest concern with regard to water pollution as a result of NAFTA trade liberalization is the increase in total suspended solids from the base metals sector of the United States.

[8]Here, our results are in contradiction to those of Grossman and Krueger (1993). This is most likely due to the different way we model NTBs compared to Brown, Deardorff and Stern (1992).

V. Conclusions

The results presented in this paper need to be interpreted with caution. The NTB measures used are in coverage ratio form and thus involve a degree of inaccuracy. Further, the IPPS data are based on conditions in the United States. Although there is evidence that the ranking of pollution intensities is invariant among OECD countries (Hettige, Lucas and Wheeler, 1992), this is obviously not the case with the cardinal values themselves. In our view, the results of Tables 2 through 5 must be considered in ordinal terms as indicating where the most vexing pollution consequences of NAFTA exist. In this sense, the results provide some strong conclusions.[9]

The most serious environmental consequences of NAFTA occur in the base metals sector. In terms of magnitude, the greatest impacts are in the United States and Canada, and this is the case for most of the pollutants considered. As alleged in the debate over NAFTA and the environment, the Mexican petroleum sector is a significant source of industrial pollution, particularly in the case of air pollution. For specific pollutants in specific countries, the transportation equipment sector is also an important source of industrial pollution. This is the case for both volatile organic compounds and toxins released into the air in Canada and the United States. Finally, as suggested by Grossman and Kruegers (1993) results, the chemical sector is a significant source of industrial toxin pollution in the United States and Mexico, but not in Canada. The general equilibrium impact of North American trade liberalization result in a *reduction* of toxin pollution in the Canadian chemicals sector.

It is hoped that the results of this paper will contribute to the ongoing discussions of the impacts of NAFTA on the environment and to the work of relevant organizations such as the Montreal-based Commission for Environmental Cooperation (CEC). The results suggest that it may be necessary to develop environmental policies that target specific industrial sources of pollution caused by increased economic integration among the three North American economies.

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[9]It is certainly not the case, as suggested by Kaufman, Pauly, and Sweitzer (1993), that one can say very little about the probable impacts of NAFTA on the environment.

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Appendix: SAM Construction

This appendix provides a brief description of the construction of the 1991 social accounting matrix (SAM) of North America. Construction of the 1991 North American SAM began with the transformation of 1991 national accounts for each country into three separate macroeconomic SAMs. For this purpose, Canadian macroeconomic data were taken from Statistics Canada (1993a and 1993b), U.S. macroeconomic data were taken from U.S. Department of Commerce (1992b) and Mexican macroeconomic data were taken from OECD (1992), Banco de México (1993), Instituto National de Estadística, Geographía e Informática (1992) and International Monetary Fund (1993). Next, individual macroeconomic SAMs were joined together into a North American macroeconomic SAM using market exchange rates from International Monetary Fund (1993) and aggregate trade flows taken from International Monetary Fund (1992). Adjustments for maquiladora trade were made with data from Banco de México (1993) and factor service and capital flows were added using data from U.S. Department of Commerce (1992a) and Statistics Canada (1993b).

The next stage of SAM construction involved estimation of the 26 sectoral accounts of each country. Labor value added, property value added, indirect business taxes, value added taxes (for Mexico), domestic final demand, imports, exports, and inter-industry transactions were disaggregated for each country into the 26 sectors. For labor value added, property value added, indirect business taxes, value added taxes, and domestic final demand, this was done using shares from input-output accounts. For Canada, we used 1990 Statistics Canada input output accounts. For the United States, we used 1987 U.S. Department of Labor

[10]These are census based. At the time of the work on the SAM, the 1987 U.S. Department of Commerce input-output accounts were not available.
[11]SECOFI is the acronym for Secretaría de Comercio y Fomento Industrial.

input-output accounts.[10] In the case of Mexico, we used 1989 SECOFI input output accounts.[11] For imports and exports, the disaggregation was conducted using 10-digit HTS data for the United States and 3-digit SITC data for all three countries. The former were obtained from U.S. Department of Commerce data tapes, and the latter were obtained from United Nations data tapes. Canadian tariffs were estimated from the 1990 input-output data, U.S. tariffs were estimated from the Department of Commerce data, and Mexican tariffs were estimated from data presented in General Agreement on Tariffs and Trade (1993).

For Canada and the United States, 1991 interindustry transactions were estimated using make and use tables for 1990 and 1987, respectively. Make and use tables were balanced using 1991 gross activity output and the RAS procedure.[12] We then removed activity accounts using the Pyatt (1985) procedure. For Mexico, the 1989 transactions matrix was updated to 1991 using 1991 value added, final demand, import and export data.

[12]On the RAS procedure, see Schneider and Zenios (1990).