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North–South Trade and Occupational Wages: Some Evidence from North America

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Abstract

The issue of trade and wages in general, and of North–South trade and wages in particular, has recently received a great deal of attention by economists and public policy analysts. This paper offers some empirical evidence of the effects of North–South trade on occupational wages in North America. Using a detailed, applied general equilibrium model, results are obtained indicating that it is possible for trade liberalization among the North American countries to entail real wage benefits for most occupational groups in all three countries. An exception to this general pattern is the case of agricultural laborers in Mexico.

1. Introduction

The issues of trade and wages in general and of North–South trade and wages in particular have recently received a great deal of attention by economists and public policy analysts. Most of the discussion has taken place in the context of the Heckscher–Ohlin (HO) model of international trade and its associated Stolper–Samuelson and factor price equalization theorems. Much of the debate surrounding the issue has addressed the proper means of testing econometrically the influence of trade on wages. Researchers have focused on the factor content of trade or on the influence of product prices.[1] Other evidence comes from general equilibrium simulations of trade liberalization. For example, in their reviews of applied general equilibrium (AGE) simulations of the North American Free Trade Area (NAFTA), Brown (1992), Brown, Deardorff, and Stern (1992b), and Hinojosa-Ojeda and Robinson (1992) note that few of the AGE models show a decline in US wages as a result of trade liberalization with Mexico. This contradicts the expected HO result.

Our focus in this paper is on AGE simulations. Our investigation is bounded by the AGE methodology as well as by its regional context: North America. For this reason, and others spelled out in the paper, we make no claims of generality. Our purpose is to demonstrate that the results implied by the Stolper–Samuelson and factor price equalization theorems of the HO model of trade do not necessarily obtain in the more elaborate structures of AGE models. Because these latter structures are not arbitrary but reflect salient features of the modeled regions, the attenuation or absence of HO results is noteworthy.

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2. Theoretical Considerations

As mentioned in the introduction, AGE models of NAFTA often fail to generate wage results predicted by HO theory. If such discrepancies exist in simulations of NAFTA or other examples of increased North–South trade, then these discrepancies must have their roots in divergences of the AGE model specifications from the HO specification. One obvious divergence that has been adopted is fixing the nominal or real wage in Mexico to capture Lewisian excess supply of labor. Another divergence is the introduction of economies of scale with imperfect competition or contestable markets. Both of these specifications have been utilized in AGE simulations of NAFTA.[2] In this section, however, we will consider a specification which represents a stepping stone between the HO model and an AGE model based on *product differentiation by country of origin*. Similar specification have been considered by Jones (1974) and Devarajan et al. (1990). The extension here is the inclusion of factor markets.[3]

Consider a three-good model of a Home country. Good 1 is a pure export good produced in the Home country using labor and capital under constant-returns-to-scale technology. The unit cost function is set equal to the world price which, following Jones (1974), we take as our *numéraire*:

$$c_1(w,r) = 1, \tag{1}$$

where w is the wage rate and r is the rental rate on capital. Good 2 is a pure import good not producted in the Home country. Its domestic price, p_2, is related to the world price, π_2, as follows:

$$p_2 = (1+t)\pi_2, \tag{2}$$

where t is an *ad valorem* tariff. Good 3 is a nontraded, domestic good produced in the Home country using labor and capital under constant-returns-to-scale technology. Its unit cost function is set equal to p_3 as follows:

$$c_3(w,r) = p_3. \tag{3}$$

As summarized by Jones (1974), this specification assumes "that residents in each country have no effective demand for the commodity which that country exports and produce no commodity similar to the one being imported" (p. 121). The usefulness of this approach here is that it is equivalent to the specification of AGE models incorporating product differentiation by country of origin.[4]

This model reverts to a HO framework when we apply the condition that p_3 is equal to p_2. Equation (3) then becomes:

$$c_3(w,r) = p_2 \tag{3-HO}$$

Assume that production of good 1 is capital-intensive relative to good 3. The unit cost functions can then be represented in (w,r) space as in Figure 1. The hatched outer envelope of these contours represents the feasible factor price frontier, and we assume a labor–capital ratio l that is tangential to this envelope allowing for an initial equilibrium at A where both goods are produced.[5]

Trade liberalization involves a reduction in the *ad valorem* tariff. In the HO framework, equations (1), (2) and (3-HO) are relevant. Trade liberalizations shifts the good-3 contour in Figure 1 downward to the contour labeled HO with an equilibrium at B.[6] In the AGE framework with product differentiation by country of origin, however,

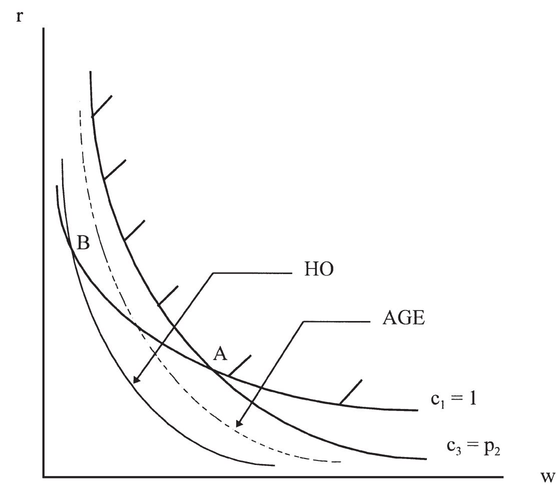

Figure 1. Home Country Factor Price Determination

equation (3) is maintained. The price of good 3 is related to p_2 via an elasticity of substition (the Armington elasticity):

$$p_3 = p_3(p_2;\sigma). \tag{4}$$

In this case, the reduction of t causes substitution away from good 3, putting downward pressure on p_3. However, unlike in the HO case, the amount of the fall in p_3 depends on σ; the effect of the change in p_2 is only *partially* transmitted to p_3. Thus, the good-3 unit cost contour in Figure 1 moves only to the position of the dashed curve, attenuating the Stolper–Samuelson effects on w and r.[7]

Trade liberalization can cause terms-of-trade effects. In the specification here, this can occur as an increase in π_2. As discussed by Jones (1974) and Devarajan et al. (1990), this adverse change in the terms of trade has two effects. The substitution effect will tend to increase p_3, offsetting the substitution effect of the trade liberalization just discussed. The income effect will tend to decrease p_3, enhancing the substitution effect of the trade liberalization. It is important to note that the very parameter which accentuates the substitution effect of the tariff reduction, the elasticity of substitution between goods 2 and 3, also accentuates the substitution effect of the terms-of-trade deterioration.[8] In an instance of regional integration between Home and Foreign, it is possible that the terms of trade of the Home country would *improve*. In this case, the effects described above would work in the opposite directions.

The importance of the above discussion is to establish that, in a model based on product differentiation by country of origin, the Stolper–Samuelson effects of tariff changes are attenuated. This leaves room for other effects of tariff liberalization to potentially work against the Stolper–Samuelson effects. There are three effects which we mention here, all of which are present in the AGE model used in this paper. First, countries often have significant systems of *indirect taxes* in addition to tariffs. Since indirect taxes are a claim on value-added expressed in *ad valorem* form, changes in sectoral activity can change total indirect tax revenue and move the unit cost contours of Figure 1. Second, economies are characterized by complex sets of input–output relationships. Therefore, price changes in one sector have implications for value-added and, therefore, value-added contours in other sectors. Third, economies are characterized by interindustry wage differentials. The assumption of constant labor productivity across sectors inherent in the HO formulation is not present in AGE models.[9]

3. AGE Model Structure

We now describe the main features of an AGE model used to simulate the wage and employment effects of North American trade liberalization. The model is a three-country, 26-sector model.[10] 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

Table 1. Behavioral Parameter Estimates

	ϕ			σ			τ		
	USA	*Canada*	*Mexico*	*USA*	*Canada*	*Mexico*	*USA*	*Canada*	*Mexico*
1 Agriculture	0.68	0.77	0.68	1.50	1.50	2.25	3.79	3.79	3.79
2 Mining	0.90	0.95	0.90	1.06	1.06	0.78	1.05	1.05	1.05
3 Petroleum	0.86	0.86	0.86	0.66	0.66	0.58	0.89	0.89	0.89
4 Food Processing	0.71	1.10	0.71	0.89	0.89	1.01	0.75	0.75	0.75
5 Beverages	0.71	1.10	0.71	0.33	0.33	0.73	0.49	0.49	0.49
6 Tobacco	0.71	1.10	0.71	1.01	1.01	1.01	0.78	0.78	0.78
7 Textiles	0.90	1.10	0.90	0.92	0.92	1.02	0.39	0.39	0.39
8 Apparel	0.90	1.10	0.90	0.48	0.48	0.80	0.13	0.13	0.13
9 Leather	0.90	1.10	0.90	1.01	1.01	1.07	1.16	1.16	1.16
10 Paper	0.90	1.10	0.90	0.97	0.97	0.73	0.43	0.43	0.43
11 Chemical	0.96	1.10	0.96	0.90	0.90	0.70	0.37	0.37	0.37
12 Rubber	0.96	1.10	0.96	1.03	1.03	0.76	0.28	0.28	0.28
13 NonMetMinProd	0.90	1.10	0.90	1.15	1.15	0.83	0.22	0.22	0.22
14 Iron and Steel	0.74	1.10	0.74	0.93	0.93	0.72	0.42	0.42	0.42
15 NonFer Metals	0.74	1.10	0.74	0.83	0.83	0.66	0.50	0.50	0.50
16 WoodMetal Prod	0.81	0.81	0.81	0.89	0.89	0.59	0.54	0.54	0.54
17 NonElec Mach	0.74	0.74	0.74	1.01	1.01	0.69	0.38	0.38	0.38
18 Electrical Mach	0.74	0.74	0.74	1.04	1.04	0.71	0.31	0.31	0.31
19 Transport Eqp	0.87	0.87	0.87	0.98	0.98	0.68	1.01	1.01	1.01
20 Other Manufact	0.74	0.74	0.74	0.55	0.55	0.46	0.41	0.41	0.41
21 Construction	0.90	0.50	0.90	1.50	1.50	1.20	0.50	0.50	0.50
22 Electricity	0.52	0.30	0.52	1.50	1.50	1.20	1.10	1.10	1.10
23 Commerce	0.80	0.30	0.80	1.50	1.50	1.20	1.10	1.10	1.10
24 TransptCommun	0.50	0.30	0.50	1.50	1.50	1.20	1.10	1.10	1.10
25 FinInsRlEstate	0.80	0.80	0.80	1.50	1.50	1.20	1.10	1.10	1.10
26 Other Services	0.80	0.80	0.80	1.50	1.50	1.20	1.10	1.10	1.10

Notes: ϕ is the elasticity of substitution between labor and capital taken from Reinert and Roland-Holst (1991) for the United States and Mexico and from Delorme and Lester (1990) for Canada. σ is the elasticity of substitution between imports and domestic competing good taken from Shiells and Reinert (1993) for the United States and Canada and from Sobarzo (1992) for Mexico. τ is the elasticity of transformation between domestic supply and exports taken from Reinert and Roland-Holst (1995).

production is allocated using a non-nested CET functional form among differentiated destinations (domestic market, exports to each North American trading partner, and exports to the rest of the world).[11] With regard to each country's relationship to the rest of the world, the small-country assumption is maintained. Exchange rates are flexible, while trade balances are fixed. Final demand in each country is modeled using the LES functional form.

Production in each sector of each country utilizes physical capital and five types of labor. The five labor types are: professional and managerial; sales and clerical; agricultural; craft; and operators and laborers. Physical capital and each type of labor are assumed to be perfectly mobile among the sectors of each country but immobile among countries.[12] Production takes place under constant returns to scale using CES functional forms for value-added and Leontief intermediates. All markets are perfectly competitive. For each labor type, the real wage elasticity of labor supply is varied in sensitivity analysis within reasonable ranges. No account is made of cross-wage elasticities of labor supply.[13]

The trade-liberalizing experiments we conduct use observed tariff rates for our base year, which is 1991. In addition, we consider nontariff barriers as very rough approximations using UNCTAD data on trade control measures. As is general practice (e.g. Gaston and Trefler, 1994), we use NTB coverage ratios directly as *ad valorem* equivalents.[14] For this reason, the results of our NTB experiments must be interpreted as merely *suggestive* of the types of differences NTBs might make to simulation results. They should not be interpreted as reflecting actual *ad valorem* equivalents.

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 SAM is similar is structure to that described in Reinert et al. (1993). The calibration of the model also requires a set of behavioral parameters. These are presented in Table 1. We make use of the non-nested Armington elasticities estimated by Shiells and Reinert (1993).

4. Simulation Results

Using the model described in section 3, we conduct a number of alternative simulations of regional economic integration among the three North American countries. We consider the removal of tariffs as well as the removal of tariffs *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. It is apparent from these simulations that the pattern of adjustment in each economy would vary significantly between tariff-only and tariff-and-NTB liberalizations. It is also apparent that real

Table 2. Experiment 4 Labor Supply Elasticities

	Occupational categories				
Country	*profmngr*[a]	*slscler*[b]	*agricult*[c]	*craft*	*operlab*[d]
United States of America	0.2	0.3	0.3	0.5	0.5
Canada	0.2	0.3	0.3	0.5	0.5
Mexico	0.2	2.0	2.0	2.0	2.0

[a] Professional and managerial. [b] Sales and clerical. [c] Agricultural. [d] Operators and laborers.

wage elasticities of labor supply are important in determining the resource reallocation responses of the three economies to regional trade liberalization. We present the results in three stages, beginning with a description of the experiments, followed by presentation of aggregate results for several experiments, and ending with a discussion of some detailed sectoral results.

Simulation Experiments

The results presented below were obtained with five simulation experiments. The first two experiments simulate different liberalization scenarios under high real-wage elasticities of labor supply: 10 for each occupation in each country. Experiment 1 is a tariff-only liberalization under this high real-wage elasticity, while experiment 2 is a tariff-and-NTB liberalization. Experiments 3, 4, and 5 represent the tariff-and-NTB liberalization under different labor supply assumptions. Experiment 3 assumes that all occupations in all countries have unitary real wage elasticities of labor supply. Experiment 4 uses the set of labor supply elasticities presented in Table 2. Finally, Experiment 5 assumes that all occupations in all countries have zero real wage elasticity of labor supply.

Aggregate Results

The aggregate results of the five experiments are summarized in Table 3. It is apparent that North American trade liberalization is beneficial to the regional economies in most cases. Only Mexico suffers a small decline in the equivalent variation (EV) measure of welfare in Experiments 1 and 5.[15] Trade expands significantly in all three countries, particularly in Canada and Mexico who possess the larger levels of regional trade dependence. Mexico experiences real exchange rate depreciation since its prior protection was higher than the North American average. The US real exchange rate appreciates in all five experiments, and the Canadian real exchange rate appreciates in Experiments 1, 4, and 5.

Aggregate employment effects vary with the assumed labor supply elasticities. Let us focus attention on Experiments 3 and 5 which bracket the labor supply elasticities on the [0,1] interval.[16] For these experiments, the United States experiences up to one half a million gain in employment. Canada and Mexico experience up to 300 thousand and 150 thousand, respectively. For detailed occupational groups, the only losers are Mexican agricultural workers, which shed 10 thousand workers in Experiment 3.

Real wages rise in all three economies and in all occupation groups except among Mexican agricultural workers. In the United States of America, agricultural workers are the biggest wage beneficiaries in relative terms, primarily because of new regional export opportunities. They are followed by the two blue-collar worker groups, both of which have average or above-average wage growth. This result indicates that NAFTA liberalization appears to raise the wages of farm and blue-collar workers faster than white-collar and clerical workers, indicating that regional trade liberalization may have progressive income effects in the United States. *This result is robust over all five experiments.* Except for agriculture, this is also the case in Canada and Mexico, where percentage wage gains in blue-collar occupations are significantly greater than those enjoyed by white-collar workers. These results bring us back to our discussion of section 2. The attenuation of Stolper–Samuelson effects in an AGE model such as the one used here leaves room for other effects of regional trade liberalization to come to

Table 3. Aggregate Simulation Results

	Experiment 1			*Experiment 2*			*Experiment 3*			*Experiment 4*			*Experiment 5*		
	USA	*Canada*	*Mexico*	*USA*	*Canada*	*Mexico*	*USA*	*Canada*	*Mexico*	*USA*	*Canada*	*Mexico*	*USA*	*Canada*	*Mexico*
EV Income (%)	0.07	0.11	–0.06	1.42	4.66	0.69	0.77	2.00	0.23	0.55	1.09	0.27	0.39	0.51	–0.21
Real GDP	0.05	0.06	0.30	1.07	6.32	1.99	0.46	3.20	1.52	0.26	2.13	1.60	0.12	1.45	1.05
Imports	0.34	0.33	1.18	7.66	16.19	10.04	6.53	14.28	9.35	6.16	13.65	9.20	5.86	13.20	8.88
Exports	0.22	0.14	3.47	5.41	24.71	19.37	4.66	20.91	18.63	4.41	19.64	18.69	4.23	18.75	17.95
Real ER	–0.06	–0.30	2.06	–0.44	1.85	5.82	–0.25	0.12	5.90	–0.20	–0.50	6.17	–0.14	–0.89	5.74
Employment (thousands)															
Total	72	8	83	1544	915	304	560	323	152	232	127	198	0	0	0
Prof&Mgmt	18	2	7	372	284	38	132	99	19	35	26	5	0	0	0
SalesCler	29	3	26	599	342	137	210	119	70	79	44	102	0	0	0
Agriculture	1	0	23	51	15	–19	21	2	–10	9	0	–12	0	0	0
Crafts	10	2	19	208	199	103	77	76	51	43	42	72	0	0	0
OperLab	14	1	8	314	74	44	119	27	22	67	15	31	0	0	0
Wages (%)															
Average	0.01	0.01	0.08	0.18	0.71	0.31	0.70	2.51	1.55	0.89	3.02	1.32	1.04	3.44	2.85
Prof&Mgmt	0.01	0.01	0.06	0.14	0.72	0.33	0.49	2.57	1.72	0.64	3.38	2.28	0.67	3.58	3.22
SalesCler	0.01	0.01	0.06	0.13	0.69	0.33	0.45	2.48	1.69	0.56	3.11	1.21	0.61	3.45	3.16
Agriculture	0.00	0.00	0.09	0.27	0.29	–0.07	1.15	0.33	–0.37	1.55	–0.02	–0.22	1.82	–0.46	–0.75
Crafts	0.01	0.01	0.09	0.18	0.95	0.47	0.68	3.78	2.36	0.80	4.58	1.66	0.98	5.71	4.31
OperLab	0.01	0.01	0.09	0.20	0.89	0.47	0.76	3.39	2.36	0.90	4.04	1.66	1.11	4.94	4.31

Experiment 1: Tariff removal only, high labor supply elasticities. Experiment 2: Tariff and NTB removal, high labor supply elasticities. Experiment 3: Experiment 2 with unitary labor supply elasticities. Experiment 4: Experiment 2 with empirical labor supply elasticities. Experiment 5: Experiment 2 with zero labor supply elasticities.

Table 4. *United States: Employment Changes by Sector and Occupation (Experiment 5)*

	Thousands of annual FTE workers					*Percent of base employment*				
	Prof & Mngr	*Sales & Cler*	*Agriculture*	*Crafts*	*OperLab*	*Prof & Mngr*	*Sales & Cler*	*Agriculture*	*Crafts*	*OperLab*
1 Agriculture	3.996	4.132	16.032	1.417	3.015	3.671	3.796	1.352	3.036	2.769
2 Mining	1.208	0.851	–0.010	0.385	–0.186	0.775	0.896	–1.480	0.158	–0.102
3 Petroleum	0.281	0.204	0.000	0.076	–0.048	0.752	0.873	0.000	0.135	–0.124
4 Food Processing	1.953	3.604	–0.114	2.103	3.980	1.433	1.555	–0.836	0.812	0.551
5 Beverages	0.071	0.170	–0.047	–0.145	–0.733	0.296	0.417	–1.948	–0.318	–0.576
6 Tobacco	–0.028	–0.014	–0.004	–0.099	–0.261	–0.325	–0.205	–2.555	–0.935	–1.192
7 Textiles	0.709	1.388	0.000	1.317	3.984	1.810	1.933	0.000	1.186	0.924
8 Apparel	0.235	0.705	0.000	–0.137	–2.698	0.486	0.607	0.000	–0.129	–0.388
9 Leather	0.509	1.210	0.000	1.536	4.404	6.897	7.026	0.000	6.242	5.967
10 Paper	1.559	3.145	–0.039	–0.661	–3.849	0.407	0.529	–1.838	–0.207	–0.466
11 Chemicals	2.460	1.938	–0.048	0.258	–0.403	0.744	0.866	–1.509	0.127	–0.132
12 Rubber	1.532	1.796	0.000	1.380	3.905	1.636	1.759	0.000	1.014	0.752
13 NonMetal Minerals	0.296	0.430	0.000	–0.041	–0.868	0.578	0.699	0.000	–0.038	–0.297
14 Iron and Steel	1.885	1.788	0.000	3.496	5.895	3.611	3.736	0.000	2.977	2.710
15 NonFerrous Metals	0.937	0.897	0.000	1.636	2.661	2.809	2.933	0.000	2.179	1.915
16 Wood & Metal Prod	4.282	5.033	–0.339	5.440	8.961	1.585	1.708	–0.687	0.963	0.702
17 NonElec Machinery	4.649	3.245	0.000	1.421	0.184	0.906	1.028	0.000	0.288	0.028
18 Electric Machinery	1.486	1.066	0.000	–0.826	–3.115	0.364	0.485	0.000	–0.251	–0.509
19 Transport Equip	50.800	22.068	0.000	42.223	57.269	9.723	9.855	0.000	9.051	8.769
20 Other Manufactures	1.623	1.299	0.000	–0.578	–1.891	0.396	0.517	0.000	–0.219	–0.477
21 Construction	–1.532	–0.696	–0.113	–20.529	–12.218	–0.260	–0.140	–2.491	–0.871	–1.127
22 Electricity	1.060	1.557	–0.034	–0.487	–0.490	0.468	0.589	–1.779	–0.147	–0.406
23 Commerce	–0.427	17.854	–2.123	–10.334	–17.893	–0.017	0.104	–2.253	–0.629	–0.886
24 Transport & Comm	–0.941	–0.165	0.000	–5.001	–15.213	–0.131	–0.011	0.000	–0.742	–0.999
25 Fin, Ins, and RE	–9.782	–19.056	–1.811	–2.272	–1.847	–0.558	–0.438	–2.783	–1.167	–1.423
26 Other Services	–68.819	–54.452	–11.349	–21.578	–32.545	–0.388	–0.268	–2.616	–0.998	–1.254
Total/Wgt average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 5. Canada: Employment Changes by Sector and Occupation (Experiment 5)

	Thousands of annual FTE workers					*Percent of base employment*				
	Prof & Mngr	*Sales & Cler*	*Agriculture*	*Crafts*	*OperLab*	*Prof & Mngr*	*Sales & Cler*	*Agriculture*	*Crafts*	*OperLab*
1 Agriculture	–13.749	–4.258	–6.017	–2.647	–1.583	–8.840	–8.605	–1.289	–12.483	–11.196
2 Mining	–0.100	0.033	0.043	–2.578	–0.471	–0.148	0.110	8.123	–4.138	–2.728
3 Petroleum	0.924	0.422	0.012	0.565	0.185	13.504	13.797	22.905	8.968	10.571
4 Food Processing	1.499	1.544	0.164	–1.754	–0.108	2.269	2.533	10.740	–1.818	–0.374
5 Beverages	0.261	0.261	0.022	–0.104	0.020	3.244	3.510	11.795	–0.882	0.576
6 Tobacco	0.082	0.080	0.005	0.024	0.017	5.269	5.541	13.988	1.062	2.548
7 Textiles	–0.272	–0.207	0.029	–1.475	–0.328	–1.452	–1.198	6.710	–5.390	–3.999
8 Apparel	1.102	1.102	0.094	–0.473	0.079	3.187	3.454	11.734	–0.936	0.520
9 Leather	0.254	0.248	0.017	0.038	0.047	4.655	4.925	13.323	0.473	1.950
10 Paper	–0.777	–0.515	0.145	–6.102	–1.304	–0.906	–0.650	7.301	–4.866	–3.467
11 Chemicals	0.281	0.333	0.066	–1.413	–0.231	0.907	1.167	9.265	–3.125	–1.701
12 Rubber	2.088	1.993	0.101	1.426	0.600	8.111	8.389	17.065	3.790	5.316
13 NonMetal Minerals	0.107	0.142	0.037	–0.913	–0.160	0.589	0.848	8.920	–3.431	–2.011
14 Iron and Steel	2.067	1.957	0.087	1.822	0.674	11.198	11.485	20.408	6.754	8.324
15 NonFerrous Metals	0.540	0.531	0.039	–0.017	0.080	4.073	4.342	12.693	–0.086	1.384
16 Wood & Metal Prod	3.325	3.349	0.301	–2.002	0.126	2.913	3.178	11.436	–1.200	0.253
17 NonElec Machinery	0.535	0.563	0.068	–0.904	–0.093	1.888	2.151	10.327	–2.184	–0.745
18 Electric Machinery	1.982	1.947	0.140	0.017	0.310	4.189	4.457	12.818	0.025	1.496
19 Transport Equip	43.478	40.418	1.232	56.571	17.710	57.267	57.673	70.293	50.983	53.203
20 Other Manufactures	0.680	0.689	0.065	–0.519	0.005	2.696	2.961	11.202	–1.408	0.042
21 Construction	2.412	2.223	2.011	–17.760	–0.777	1.142	1.403	9.519	–2.900	–1.472
22 Electricity	0.043	0.170	0.021	–0.540	–0.928	0.136	0.395	8.430	–3.866	–2.452
23 Commerce	–9.188	–25.643	0.363	–14.011	–5.612	–1.645	–1.392	6.501	–5.576	–4.187
24 Transport & Comm	–0.284	0.250	0.118	–3.311	–5.922	–0.157	0.101	8.113	–4.147	–2.737
25 Fin, Ins, and RE	–3.601	–6.742	0.060	–0.279	–0.103	–1.369	–1.114	6.801	–5.310	–3.918
26 Other Services	–33.690	–20.892	0.777	–3.659	–2.233	–1.920	–1.667	6.203	–5.840	–4.455
Total/Wgt average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6. Mexico: Employment Changes by Sector and Occupation (Experiment 5)

	Thousands of annual FTE workers					Percent of base employment				
	Prof & Mngr	*Sales & Cler*	*Agriculture*	*Crafts*	*OperLab*	*Prof & Mngr*	*Sales & Cler*	*Agriculture*	*Crafts*	*OperLab*
1 Agriculture	–4.494	–8.869	–11.723	–9.757	–4.182	–7.963	–7.857	–0.467	–9.879	–9.879
2 Mining	1.091	1.713	0.043	3.498	1.499	7.512	7.636	16.268	5.273	5.273
3 Petroleum	0.931	1.402	0.000	3.524	1.510	40.835	40.997	0.000	37.902	37.902
4 Food Processing	0.165	0.788	0.638	–0.126	–0.054	2.007	2.125	10.316	–0.117	–0.117
5 Beverages	0.059	0.275	0.184	0.140	0.060	2.614	2.732	10.972	0.477	0.477
6 Tobacco	0.010	0.018	0.005	0.000	0.000	2.133	2.251	10.452	0.007	0.007
7 Textiles	0.500	2.018	0.000	8.350	3.578	15.155	15.287	0.000	12.757	12.757
8 Apparel	0.020	0.135	0.000	0.226	0.097	3.465	3.584	0.000	1.311	1.311
9 Leather	0.050	0.263	0.008	0.063	0.027	2.280	2.398	10.611	0.150	0.150
10 Paper	–0.015	–0.030	0.021	–0.631	–0.271	–0.255	–0.141	7.869	–2.332	–2.332
11 Chemicals	0.650	1.093	0.138	0.633	0.271	3.535	3.654	11.968	1.379	1.379
12 Rubber	0.070	0.204	0.000	0.287	0.123	3.355	3.474	0.000	1.203	1.203
13 NonMetal Minerals	0.223	0.637	0.000	1.589	0.681	5.948	6.070	0.000	3.742	3.742
14 Iron and Steel	0.118	0.289	0.000	0.899	0.385	6.396	6.518	0.000	4.180	4.180
15 NonFerrous Metals	0.029	0.071	0.000	0.206	0.088	5.755	5.876	0.000	3.553	3.553
16 Wood & Metal Prod	0.389	1.116	1.243	2.352	1.008	5.156	5.277	13.721	2.966	2.966
17 NonElec Machinery	0.624	0.910	0.000	1.285	0.551	5.865	5.987	0.000	3.661	3.661
18 Electric Machinery	0.748	0.990	0.000	2.188	0.938	10.269	10.396	0.000	7.973	7.973
19 Transport Equip	2.199	2.372	0.000	6.837	2.930	20.137	20.275	0.000	17.635	17.635
20 Other Manufactures	0.339	0.515	0.000	0.687	0.295	10.086	10.213	0.000	7.794	7.794
21 Construction	0.527	1.318	0.317	–9.014	–3.863	0.744	0.860	8.950	–1.353	–1.353
22 Electricity	0.356	1.002	0.046	0.671	0.287	5.397	5.518	13.981	3.202	3.202
23 Commerce	0.007	1.615	1.348	–3.599	–1.543	0.009	0.124	8.154	–2.074	–2.074
24 Transport & Comm	0.398	2.178	0.097	–2.273	–0.974	0.939	1.056	9.161	–1.162	–1.162
25 Fin, Ins, and RE	–0.408	–2.082	0.499	–0.222	–0.095	–1.198	–1.085	6.849	–3.256	–3.256
26 Other Services	–4.586	–9.942	7.136	–7.812	–3.348	–0.626	–0.512	7.468	–2.695	–2.695
Total/Wgt average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

prominence. Indirect taxes, input–output relationships, interindustry wage differentials, and increased *intra*-industry trade work against the traditional Stolper–Samuelson effects of the Heckscher–Ohlin model.

Sectoral Results

Aggregate welfare rarely plays a decisive role in the formulation of trade policy. It is individual sectors who seek protection, and for this reason, EV measures of welfare have little to say about the real forces influencing trade policy. For this reason, we next evaluate some of the detailed sectoral effects of regional trade liberalization in North America. We do so using Experiment 5 as an example since this is the experiment for which sectoral adjustments are largest.[17]

Tables 4–6 present sectoral results on levels and percentage changes in employment. In Experiment 5, total occupational employment is fixed in each country, and service-sector occupation employment often contracts as a result of regional trade liberalization. For two reasons, these contractionary effects are most likely to be overstatements. First, real wage elasticities of labor supply are probably not zero. Second, owing to data limitations, the service sectors in our model are nontraded within the North American region. Despite the lack of data on trade in services within North America, such trade does exist and would provide at least some opportunities for the service sectors not captured here.

Agricultural adjustments are significant in all three countries. Generally, we see net import penetration by US producers, which leads to contractions in employment in Canada and Mexico. The contraction in employment of agricultural workers in the agricultural sector of Mexico is particularly large and contributes to the declines in the wage of agricultural workers in this country reported in Table 3. The transportation equipment sector shows large positive employment gains across all relevant occupational categories in each country. Because we are using coverage ratios to model NTBs, we cannot defend the actual *magnitudes* of these employment gains. However, the *qualitative* pattern of expanded *intra*-industry trade in the transportation equipment sector within the region is striking and, we would argue, robust. Its contrast to popular predictions of the effect of North American trade liberalization on the automobile sector is notable.

Tables 4–6 show that labor substitution between occupational groups can reduce and increase employment in the same sector simultaneously. For example, in the US paper sector under Experiment 5, white-collar employment grows while blue collar employment is reduced. The main reason for this is not a depression in blue-collar labor demand in this sector, but sharply rising demand for this occupational category *elsewhere* in the economy which pushes up their average wages and forces paper firms to make do with fewer blue-collar workers. Economy-wide labor supply elasticities place limits on overall job growth in each occupational group and thus require a certain amount of this type of substitution.

To summarize the sectoral results, Canada has the largest and most even sectoral gains, while Mexico is the most uneven owing to agricultural market displacement and a sharp expansion of manufacturing export opportunities. If there is a silver lining in the Mexican results it is that the shedding of labor in the Mexican agricultural sector is something that must take place over the long run. Managing this transition should be high on the agenda of Mexican policymakers.

5. Conclusions and Caveats

The Canada–US Free Trade Agreement and NAFTA are now a fact of life. As these agreements take effect, increased North–South trade will be one important consequence. Worldwide, increased North–South trade will ensue from the WTO trade liberalization process. The ultimate effects of these changes will take years to be fully discernable. However, the wage and employment effects of the increased North–South trade are controversial *now*. We concur with Richardson (1995) that general equilibrium analysis has a crucial role to play in the sorting out of these controversies. Within the general equilibrium framework, Leamer (1996) notes that analysts can make two important mistakes: "(1) taking the theory too seriously, and (2) not taking the theory seriously enough" (p. 8). We avoid the second mistake by formulating a completely specified and closed AGE model. We avoid the first mistake by recognizing that the failure of AGE simulations of North–South trade to generate HO results is not an anomaly to be brushed aside. We acknowledge that these AGE simulations embody model structures that capture salient features of the modeled economies which can suppress Heckscher–Ohlin results with regard to trade and wages. The theoretical considerations and empirical simulations for the case of North America we presented bear out this possibility. It appears that it is not necessarily the case that Stolper–Samuelson results follow from all examples of increased North–South trade.

It would be foolish for us to claim generality based on our results. Our model addresses only a particular region, and our treatment of NTBs and labor markets is incomplete. However, we have achieved a consistent and complete general equilibrium treatment of North American production, consumption, and intraindustry trade with a significant amount of sectoral and occupational detail. Furthermore, the model is based on recent data for the construction of the three-country social accounting matrix (see the Appendix) as well as on econometrically estimated Armington elasticities. In these respects, it provides results that can inform future debate.

Appendix

This appendix provides a brief description of the construction of the 1991 social accounting matrix (SAM) of North America used to calibrate the AGE model described in section 3. 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, 1993b), US macroeconomic data were taken from US 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 US 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 interindustry 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 of America, we used 1987 US Department of Labor input–output accounts. In the case of Mexico, we used 1989 Secretary of Commerce and Industrial Development (SECOFI) input–output accounts. 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 US 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, US 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 of America, 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.[18] 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.

Employment for Canada in 1991 was disaggregated across five occupational groups. The last year for which Statistics Canada published an industry–occupation employment matrix was for 1981 (Statistics Canada, 1984). More recent data were (to say the least) prohibitively expensive. Therefore, we updated the 1981 data to 1991 using the RAS procedure and 1991 occupational employment totals from Statistics Canada (1991). We were unable to locate information on earnings by occupational group for Canada. To remedy this, we used employment data, combined with information on US occupational earnings from Murphy and Topel (1987) to disaggregate labor value-added across occupational groups. In 1991 employment for the United States of America was disaggregated across occupational groups using the US Department of Labor industry–occupation employment matrix for 1990. These employment data and occupational earnings information form Murphy and Topel (1987) were used to disaggregate labor added across occupational groups. None of the *many* academics and Mexican government officials we contacted was able (or willing) to supply us with a Mexican industry–occupation matrix. Therefore, an initial estimate of such a matrix was made with US data. This matrix was then re-estimated using occupational control totals from Wilke (1993). To translate this employment matrix into an earnings matrix, we used information from Centro de Investigaciones Económicas (1981).

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Notes

1. The recent review articles by Burtless (1995), Freeman (1995), and Richardson (1995) contain the relevant citations.
2. See, for example, the chapters of Francois and Shiells (1994).
3. For a set of related theoretical investigations, see Francois (1996). The importance of product differentiation by country of origin is encountered in Leamer (1996) who, despite adherence to a HO, perfect-substitutes framework, needs to consider "product upgrading" on the part of the United States of America to explain patterns of trade and wages. He states: "through product upgrading, US apparel products by 1980 no longer were in competition with low-wage Asian sources of supply. T-shirts and jeans were imported; women's high-fashion clothing was made locally" (p. 16). It is precisely this phenomenon that is captured by product differentiation by country of origin.
4. On product differentiation by country of origin specifications, see de Melo and Robinson (1989).
5. See Mussa (1979).
6. Again, we assume a value of l allowing for both goods to be produced at B.

7. It can be shown that, with world prices constant, the relationship is

$$\hat{p}_3 = \frac{\sigma}{(\sigma+\tau)}\frac{dt}{(1+t)},$$

where $\hat{x} = dx/x$; σ is the elasticity of substitution between goods 2 and 3; τ is the elasticity of transformation between goods 1 and 3; and t is the *ad valorem* tariff.

8. It can be shown that, with the tariff constant, the relationship is

$$\hat{p}_3 = \frac{(\sigma-1)}{(\sigma+\tau)}\hat{\pi}_2,$$

where $\hat{x}$, σ, and τ are defined as in footnote 7.

9. See Bell and Freeman (1991), Gaston and Trefler (1994), and Haveman (1996). Bernard and Jensen (1995) find that US export plants pay higher wages to production and nonproduction workers, and that this differential is higher for *production* workers. We therefore might expect positive differentials in US sectors with significant export orientation and that the expansion of exports in the USA as a result of regional liberalization in North America would tend to put upward pressure on average wages.

10. Most AGE modelers include only one or two of the North American countries in their model. An exception to this is Brown et al. (1992a).

11. In contrast to the approach taken here, Brown et al. (1992a) use a firm-level product differentiation approach. One advantage of the country-level product differentiation approach used in our model is that it allows for econometric estimation of trade substitution elasticities (see Winters, 1990). Indeed, we make use of the estimates of Shiells and Reinert (1993) in our model calibration of import aggregation. That said, we have no quarrel with the firm-level differentiation specification. Both approaches have strengths and weaknesses.

12. In assuming that capital is immobile among the North American countries, we ignore the impacts of changes in direct foreign investment (e.g., Markusen et al., 1995). Feenstra and Hanson (1996a,b) skillfully investigate the role of outsourcing in generating wage inequality. In a crude way, the outsourcing process is present in our model at the sectoral level. Intermediate inputs are part of total sectoral imports in our specification, and these intermediate imports increase along with total imports. What we do not caputure is the increased *share* of intermediate imports in total imports.

13. Cross-wage elasticities of labor supply undoubtedly are nonzero. To our knowledge, however, no data sources are available to parameterize these off-diagonal elements. The information on the diagonal elements is in itself sketchy. Our reading of Killingsworth (1983), for example, leads us to conclude that the diagonal elements are positive. How positive, however, is not clear. We use a number of estimates, but focus on the range between 0 and 1. Leamer (1996) alerts us to the fact that there can be a wide variety of skill levels (and hence wages) within an occupational group. Without a doubt, this is the case. We have at least gone a step further than the production workers/nonproduction workers dichotomy used in a number of empirical investigations (e.g., Lawrence and Slaughter, 1993).

14. These NTB measures are described in Roland-Holst et al. (1994).

15. Losses in aggregate welfare can arise from trade diversion, other second-best effects, and terms-of-trade effects, all of which are present in our simulations.

16. In most cases, econometric estimates of the real wage elasticities of labor supply fall within this range. See Killingsworth (1983).

17. Sectoral results for Experiment 3, included in the original version of this paper, are available from the authors upon request.

18. On the RAS procedure, see Schneider and Zenios (1990).