Input–Output Technologies and the Effects of Tariff Reductions

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Using input–output (IO) tables from several developed countries (United States, EEC, and Japan) and one developing country (Brazil), we calculate the effects of tariff removal using various combinations of these tables to represent technologies for the countries included in the Michigan Computational Model of World Production and Trade. Among the IO tables, Brazil's reflected unusually high shares of value added, low labor shares, and small supply elasticities. Supply elasticities for the developed countries were somewhat lower than for the United States. Using the Michigan model, our calculated effects of tariff reductions are overstated using the U.S. IO table to represent technologies for other developed countries. Further, for developing countries that use import licensing, the model shows considerable sensitivity to IO table specification. It is especially important, therefore, for computational purposes to obtain the most accurate information possible about IO structures of developing countries.

1. INTRODUCTION

The Michigan Model of World Production and Trade, like most other computable models of national microeconomic activity, makes essential use of input–output (IO) tables in its characterization of technology. Unlike models of single countries, however, the Michigan Model incorporates behavior from a large number of countries—34 in the current version—and should in principle use input–output data from all of them. In practice, we have been unable to obtain and process this many data, and have made do with a smaller number of IO tables, applying those from some countries to characterize technology in others.

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While we still do not have tables for all 34 countries, we do have enough now to begin to examine the role that they play in the model. This paper, then, examines within the context of the Michigan Model the errors that are introduced in a computable model when incorrect IO tables are used to characterize technology.

Naturally, one could not answer this question in the abstract, since IO tables could in principle differ from one another almost without limit. Nor can one perform conventional sensitivity analysis, since the data at issue here are not parameters, such as elasticities, that can be scaled to indicate their effects. Instead, an IO table is a complete matrix of data, the importance of which depends on relationships among the elements rather than on their overall size. How much these relationships can differ across countries is an empirical matter. Thus it seems only appropriate to analyze the roles of IO tables themselves by comparing actual national tables as they have been tabulated, rather than performing hypothetical variations on the data such as would be appropriate in other contexts.

Thus our first task, in Section 2, is to examine the IO tables themselves, and see how they differ. We currently have IO tables for 11 countries. It is somewhat difficult to know how best to compare them, but we report several such comparisons in Section 2. Since in our earliest applications of the Michigan Model we relied solely on the U.S. table, we focus mainly on how the tables for another 10 countries differ from the U.S.

In Section 3 we describe the Michigan Model itself. Since it has been amply described elsewhere, especially in Deardorff and Stern (1981), this description can be brief. However, we try to elaborate a bit more than previously on the ways that IO tables enter the model.

In Section 4, then, we examine how results of multilateral tariff reductions in the major industrialized countries depend on which IO tables are used to characterize technology. Having observed in Section 2 that our Brazilian table differs noticeably from the others, we compare the results of the model in two steps. The tariff-cutting experiment is run three times, first using the U.S. table only, in all 34 countries, then again replacing it with the Brazilian table in all of the 16 developing countries, and finally using the remaining nine tables in their respective countries. Comparison of the first two runs focuses on the importance of just the Brazilian table. Comparing the second and third runs focuses collectively on the remaining tables that we have collected, which happen to be all from other industrialized countries.

In Section 5 we summarize our results and discuss their significance for the modeling efforts of ourselves and others.

2. DIRECT COMPARISON OF THE INPUT-OUTPUT TABLES

The Michigan Model currently includes 34 countries. These are listed in Table 1, together with other information that will be discussed later. The table indicates the 11 countries for which we have IO tables—the U.S., Japan, Brazil, and members of the European Community—as well as the tables used to characterize technology in the other countries. All of these tables refer to approximately 1970.[1]

There are 29 industries in the model, based roughly on the International Standard Industrial Classification (ISIC) at the one- and three-digit levels, and these are listed in Table 2.

The first step in using any national IO table in the model is to concord it to our particular industry classification scheme. This has been done for all of the 11 tables, and we will therefore focus here on the concorded tables, rather than on the original sources. Our intermediate transactions matrices are therefore 29 by 29. In addition, we have concorded primary input transactions to distinguish only two primary inputs, labor and all others, and have aggregated sales to final users into a single column. Space does not permit us to report the actual IO data, but only several summary measures that allow comparisons.

In considering which measures to use, we sampled the sizable literature on international comparison of IO tables. Some of this literature—for example, Brody and Carter (1972)—concerns conceptual and national accounting issues in standardizing IO tables. Another part of the literature—see Chenery and Watanabe (1958), Watanabe (1964), Simpson and Tsukui (1965), Augustinovics (1970), and Robinson and Markandya (1973)—seeks regularities in structure within and between countries. Finally, there have been numerous efforts—see, for example, Schultz (1972)—to analyze international economic interdependence and the effects of national policies and plans using national tables. From this literature, it was evident that there were many different ways to compare IO tables. Those we selected are reported in Table 3.

The first four rows of Table 3 report various shares, each averaged across the 29 industries, weighted by 1976 value of production. 1976 is the base year used for all calculations, and is the year for which we have data on production, trade, and employment.[2] The IO tables are of course not available on a yearly basis, and we have used the most recent available in 1980 in constructing the Michigan Model.

[1]Because we use the tables only for fractional shares, not levels of transactions, we have not updated the tables to reflect inflation.

[2]We chose 1976 since this was the reference year used in evaluating the Tokyo Round negotiations.

Table 1: The Countries of the Model, Their Assumed Exchange Regimes, and the Source and Levels of Input–Output, Tariff, and NTB Data for Each

Country name	Country abbreviation	Flexible (F), pegged (P), or licensed (L), and country pegged to: F	P	L	Pegged to:	Input–output table	Post-Tokyo-Round average tariff level[a] (percent)	Assumed average coverage by NTBs[a] (percent)
Industrialized countries:								
Australia	ALA		×		basket	USA 1972	14.8	12.2
Austria	ATA	×				USA 1972	11.3	6.7
Canada	CND	×				USA 1972	4.6	11.7
European Community:								
Belgium–Luxembourg	BLX	×				BEL 1970	5.4	4.8
Denmark	DEN	×				DEN 1970	6.4	3.0
France	FR	×				FR 1970	4.9	30.1
Germany	GFR	×				GFR 1970	5.7	17.1
Ireland	IRE	×				IRE 1969	6.6	5.7
Italy	IT	×				IT 1970	4.4	13.3
Netherlands	NL	×				NL 1970	5.7	6.0
United Kingdom	UK	×				UK 1970	4.9	5.3
Finland	FIN		×		basket	USA 1972	6.2	4.0
Japan	JPN	×				JPN 1970	6.2	56.9

New Zealand	NZ			×	basket	USA 1972	13.8	13.6
Norway	NOR		×		basket	USA 1972	4.5	7.4
Sweden	SWD		×		basket	USA 1972	3.9	3.8
Switzerland	SWZ		×		GFR	USA 1972	3.5	13.2
United States	US	×				USA 1972	3.3	22.3
Developing countries:								
Argentina	ARG			×	basket	BRZ 1970	—	—
Brazil	BRZ			×	basket	BRZ 1970	—	—
Chile	CHL			×	basket	BRZ 1970	—	—
Columbia	COL			×	basket	BRZ 1970	—	—
Greece	GRC			×	basket	BRZ 1970	—	—
Hong Kong	HK	×				BRZ 1970	—	—
India	IND			×	basket	BRZ 1970	—	—
Israel	ISR	×				BRZ 1970	—	—
South Korea	SK			×	basket	BRZ 1970	—	—
Mexico	MEX	×				BRZ 1970	—	—
Portugal	POR			×	basket	BRZ 1970	—	—
Singapore	SNG		×		basket	BRZ 1970	—	—
Spain	SP			×	basket	BRZ 1970	—	—
Taiwan	TWN			×	basket	BRZ 1970	—	—
Turkey	TRK			×	basket	BRZ 1970	—	—
Yugoslavia	YUG	×				BRZ 1970	—	—

[a]Available only for industrialized countries.

Table 2: The Industries of the Model, Their Assumed Elasticities of Substitution and Demand, and Tariff and NTB Data for Each

Industry name	ISIC code	Elasticity of capital–labor substitution	Elasticity of import–home-good substitution	U.S. import demand elasticity	Post-Tokyo-Round average tariff level[a] (percent)	Assumed average coverage by NTBs[a] (percent)
Traded goods:						
Agriculture, forestry, and fishing	1	0.787	1.139	1.130	6.9	18.4
Food, beverages, and tobacco	310	1.746	1.133	1.130	11.0	23.4
Textiles	321	0.963	1.147	1.140	8.5	29.1
Wearing apparel	322	1.191	4.269	3.920	17.5	46.5
Leather products	323	1.230	1.810	1.580	3.0	1.1
Footware	324	1.436	2.825	2.390	12.0	37.1
Wood products	331	0.852	1.757	1.690	1.9	0.0
Furniture and fixtures	332	1.122	3.096	3.000	6.9	0.0
Paper and paper products	341	1.626	1.585	1.550	4.3	0.6
Printing and publishing	342	0.810	3.013	3.000	1.5	10.4
Chemicals	35A	1.098	2.612	2.530	6.4	4.1
Petroleum and related products	35B	10.011	2.[illegible]59	1.960	1.4	47.8
Rubber products	355	1.647	[illegible].707	5.260	4.1	3.1
Nonmetal mineral products	36A	1.246	2.784	2.700	4.0	8.4

Glass and glass products	362	1.267	1.628	1.600	8.0	0.0
Iron and steel	371	1.382	1.445	1.420	4.3	8.2
Nonferrous metals	372	1.350	1.430	1.380	1.7	6.9
Metal products	381	0.943	3.674	3.590	6.2	2.5
Nonelectric machinery	382	0.677	1.022	1.020	4.7	1.9
Electric machinery	383	0.521	2.110	2.000	7.1	7.1
Transport equipment	384	0.344	3.585	3.280	5.9	10.4
Miscellaneous manufacturing	38A	1.272	1.984	1.780	4.8	2.7
Nontraded[a] goods:						
Mining and quarrying	2	1.541	—	—	—	—
Electric, gas, and water	4	2.266	—	—	—	—
Construction	5	1.105	—	—	—	—
Wholesale and retail trade	6	2.266	—	—	—	—
Transportation, storage, and communications	7	1.457	—	—	—	—
Finance, insurance, and real estate	8	1.657	—	—	—	—
Commercial, social, and personal services	9	1.087	—	—	—	—

[a]Available only for industrialized countries.

Table 3: Comparison of Input–Output Tables for Eleven Countries: Selected Shares, Elasticities, and Correlations

	US	BLX	BRZ	DEN	FR	GFR	IRE	IT	JPN	NL	UK
1. Average[a] value-added share (%)	59.49	61.22	67.07	58.48	58.24	55.16	57.88	58.10	51.22	55.47	60.66
2. Average[a] labor share in value added (%)	62.16	55.47	35.55	54.80	61.47	54.94	55.12	51.36	48.30	57.52	63.70
3. Average[a] intraindustry input coefficient (%)	10.43	9.74	7.51	8.79	10.18	11.54	11.58	11.23	11.48	10.66	6.49
4. Average[a] tradable input share (%)	20.24	25.69	23.30	25.73	24.34	28.89	27.92	26.27	34.56	27.28	23.32
5. Average[a] supply elasticity (exc. ISIC 35B)	6.19	3.68	1.26	3.60	5.65	3.29	4.62	3.36	2.90	4.73	6.48
6. Average correlation of columns with U.S.	—	0.74	0.54	0.78	0.81	0.81	0.63	0.77	0.68	0.68	0.77
7. Minimum correlation of columns with U.S. (industry)	—	0.32 (2)	0.04 (2)	0.31 (2)	0.33 (2)	0.32 (2)	0.23 (6)	0.32 (2)	0.10 (2)	0.32 (2)	0.25 (6)

[a]Weighted by the value of production.

The first share in Table 3 is the average share of value added in production, defined for each industry as total payments to primary factors divided by value of output. One minus this share indicates the importance of interindustry interactions. These shares do not differ markedly among the 11 countries.[3]

The second share in Table 3 is the share of labor in value added, and here the results differ more widely. Brazil is the greatest outlier, with an average labor share of only 36 percent compared to shares ranging from 48 percent to 64 percent in the U.S., Japan, and Europe.

The significance of these two shares—value added and labor—can be considerable in our model because of their role in calculating supply elasticities. As we will show in Section 3, supply elasticities depend positively on labor shares and negatively on value-added shares. Because supply elasticities play an important role in the model, we report their average values also in line five of Table 3.[4]

The third row of Table 3 reports the average "intraindustry" input coefficient. This is the average of the IO coefficients on the diagonal of the IO matrix, and represents the extent to which industries rely on inputs purchased from their own industry. It should be sensitive to the level of aggregation, but since that is the same for all tables, it can be compared across countries. These averages are quite similar, however—all in the neighborhood of 10 percent.

Finally, row four of Table 3 has average tradable input shares. These are calculated by adding up input coefficients across the 22 industries listed as producing "traded goods" in Table 2. These shares reflect the extent to which industries rely for inputs on industries that compete directly with imports and are therefore likely to be vulnerable to changes in import prices. The shares range from 20.2 percent for the U.S. to 34.6 percent for Japan. The U.S. table may therefore understate the importance of international linkages that affect industries in other countries.

It is difficult, with averages alone, to capture all differences among IO tables. Within the intermediate transactions part of a table, what matters is *where* the numbers appear (that is, between which industries the transactions take place), and not their size. For such a comparison, we

[3]There are two outliers here: Brazil's value-added share is unusually high, at 67%, and Japan's is unusually low, at 51%. These differences could reflect differences at the industry level or differences in weights. It appears from the disaggregated tables that these differences are representative of the shares at the disaggregated level.

[4]These averages exclude industry ISIC 35B, Petroleum and Related Products, because its unusually high elasticity in some of the countries would otherwise lead to a misleading impression.

have calculated correlations that compare the U.S. table with each of the other ten.[5]

For each column of intermediate transactions in a country's IO table we calculated the simple correlation between it and the corresponding column of the U.S. table. Unweighted averages of these correlations are reported in the sixth row of Table 3. Also, in row seven, we report the smallest of the individual column correlations in each case and the industry code where it occurs.

Clearly, considerable differences exist among the IO tables in comparison with the U.S. None of these average correlations exceeds 0.81. Thus the issue of the importance of such differences is not trivial.[6]

The conclusions from this comparison of IO tables are neither strong nor startling, but they bear repeating nonetheless. Differences among IO tables do exist and seem greatest where the differences in countries are greatest. Thus, among countries, Brazil's table differs more from those of the developed countries than the latter do among themselves. This difference shows up most clearly in labor and value-added shares, which contribute to unusually small supply elasticities in Brazil. But even within interindustry transactions, the Brazilian table differs more from the U.S. table than do any of the other countries. Finally, among industries the smallest correlations between the U.S. table and others are in two nontraded industries, ISIC 2 and 6.

All of this gives some clue as to how interchanging IO tables might affect the calculations with our model. But without looking at results, we cannot conclude, just from the IO tables, whether the differences among them are important.

3. THE MICHIGAN MODEL

The Michigan Model is basically a collection of supply and demand equations. These are differentiated in logarithmic form and solved to yield comparative static expressions for proportional changes in various

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[5]In an earlier version of this paper we also reported an alternative measure of the similarity of IO tables, based upon the distances that numbers within them would have to be moved to make them alike. These calculations told us less than we had hoped, and we omit them here.

[6]Once again, the Brazilian table is the outlier, and because the correlations involve only intermediate transactions, the difference is independent of that already noted for labor and value-added shares. Some of these column correlations are much smaller when one looks at individual columns rather than averages. However, none falls below zero, and except in Brazil all are above 0.20.

prices and quantities with respect to a wide variety of exogenous variables. The markets that are modeled include world markets for the 22 tradable industries listed in Table 2, plus domestic markets in the 34 countries of Table 1 for these and another 7 nontradable industries. The model also includes markets for foreign exchange and labor, though in the runs reported here, money wages are held fixed. Since details of the model are discussed in Deardorff and Stern (1981), we only look here at certain features that are relevant for the roles of input–output tables in the model.

3A. The Input–Output Structure of the Model

Production in each industry is modeled as using inputs from all other industries plus two primary inputs, labor and capital. Production functions require that intermediate inputs be used in fixed proportions to one another and in fixed proportions also to an aggregate—called value added—of the primary inputs. Value added in turn is modeled as a constant-elasticity-of-substitution (CES) function of labor and capital. Also, inputs from industries are both domestically produced and imported, and these too are aggregated using CES functions.

Supply of each good arises from perfectly competitive profit maximization by firms, and thus depends on the price of output and the prices of all inputs. The latter include the wage of labor and the prices of all other goods, both imported and domestic. In particular, the response of supplies to prices will be greater, the greater is the need for intermediate inputs of tradable goods and the greater is the share of imports in tradable industries.[7]

The IO structure also plays a role that is familiar from the literature on effective protection. Import prices affect both what industries can charge for their outputs and what they must pay for their inputs. These two effects have traditionally been incorporated into the formula for the effective rate of protection, as demonstrated by Corden (1966) and others. We have argued elsewhere, as in Deardorff and Stern (1982a), that this formula is too simple to capture the multiple interindustry

[7]There is one feature of the IO structure of an actual economy that is not captured in our model. Our IO tables do not distinguish imported and domestically produced goods (even though this information was sometimes available). Instead we treat all demanders of goods from a given industry as demanding home-produced and imported goods in the same proportions. This is a disadvantage of our model, since it neglects behavior about which some information is available. But since we use some IO tables to characterize countries other than their own, it is desirable that we not build in such country specific information.

quantities. In some situations this makes the prices of these imported goods more volatile than prices of other traded goods. The quantitative importance of NTBs in the model is suggested in both Tables 1 and 2, which show the average coverage by NTBs for each (industrialized) country and industry, respectively.

4. COMPARISON OF THE TARIFF RUNS

We turn now to our experiment designed to gauge the importance of differences in IO tables. The experiment focuses on a typical analysis of tariffs: the effects of removing all post-Tokyo-Round tariffs in the industrialized countries.[9] This is an exercise that we reported before in Deardorff and Stern (1983a). Here, however, we have performed the experiment three times, each with different IO tables.[10]

In our first run, following the procedure that we used when we first built the model, we use the U.S. IO table to represent technology in all countries. In our second run we add the IO table of Brazil, and use it for all developing countries. This "2 IO" experiment was done to isolate the role of the Brazilian IO table, which we noted earlier to be unusual.[11] Finally, our third run, labeled "11 IO," makes use of all the IO tables that we currently have available.

Table 4 reports aggregate results of tariff removal for the countries of the model, as calculated in the three runs. These results are the easiest to compare and most comprehensive, but they do not reflect the disaggregated behavior that our model is primarily intended to capture and that would also be most sensitive to variations within the body of the IO table. Thus we also describe disaggregated results for employment changes for selected countries. A more general comparison of disaggregated results for additional variables and countries is then reported in Table 5 using rank correlations across industries. We now look at our results in more detail.

4A. Aggregate Results

Table 4 reports aggregate effects of tariff removal on trade, employment, welfare, exchange rates, and prices for each country. For each variable, results of each of the three experiments are reported side by

[9] We assume throughout that the existing NTB coverage remains intact.

[10] In an earlier version of this paper, we also reported the results of 1% devaluations of each country's currency relative to all others. These results, which are available on request, parallel those to be reported below for the most part. For further analysis of the effects of exchange-rate changes in the Michigan Model, see Deardorff and Stern (1982b).

[11] Also, some of our early work with the model used just these two tables

Table 4: Countrywide Effects of Industrialized Country Tariff Removal: Comparison of Results with One, Two, and Eleven Input–Output Tables[a]

	Change in exports (million dollars)			Change in imports (million dollars)			Gross change in employment[b] (thousands of workers)		
	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO
Industrialized countries:									
Australia	1193	1166	1322	1971	1964	1946	43	42	47
Austria	1313	1311	1322	1284	1280	1292	83	83	86
Canada	1749	1738	1736	1752	1744	1731	49	49	51
European Community:									
*Belgium-Luxembourg	1470	1461	1329	1463	1453	1302	79	79	64
*Denmark	658	653	532	654	650	538	38	38	36
*France	3274	3253	2957	3335	3317	3032	154	154	139
*Germany	4920	4890	4399	5071	5040	4430	225	224	231
*Ireland	234	231	168	236	233	173	15	15	12
*Italy	1716	1710	1573	1689	1683	1571	132	132	118
*Netherlands	1921	1906	1659	1993	1982	1718	61	61	58
*United Kingdom	2781	2765	2717	2719	2699	2635	139	137	133
Total EC	16973	16869	15332	17159	17056	15399	843	841	792
Finland	654	648	861	389	387	364	37	37	49
*Japan	1648	1635	1474	1805	1794	1565	182	188	130
New Zealand	−41	−61	88	−47	−68	86	4	4	9
Norway	342	339	433	374	371	346	14	14	17
Sweden	822	816	1092	668	663	616	34	34	45
Switzerland	271	265	544	466	462	412	12	12	21
*United States	4278	4288	3398	4007	3953	4248	143	145	131
Total industrialized:	29203	29013	27600	29828	29607	28006	1443	1450	1377

(continued)

Table 4: Continued

	Change in exports (million dollars)			Change in imports (million dollars)			Gross change in employment[b] (thousands of workers)		
	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO
Developing countries:									
Argentina	−20	12	34	26	60	90	36	19	25
*Brazil	38	40	108	90	96	190	147	48	61
Chile	34	−209	−188	25	−218	−198	15	143	130
Columbia	24	9	13	47	33	41	40	19	23
Greece	−189	−26	−0	−213	−50	−13	24	7	6
Hong Kong	−53	1	−2	−87	−34	−6	12	5	6
India	−47	1	28	−51	−3	28	483	113	142
Israel	−5	−0	−2	−13	−8	−6	3	2	2
South Korea	1043	33	124	1043	34	149	218	24	49
Mexico	−54	−31	−34	−46	−22	−18	59	26	28
Portugal	−100	−16	1	−129	−45	−21	29	6	7
Singapore	45	3	8	−30	−27	−35	5	2	3
Spain	−87	−38	35	−124	−74	21	28	11	16
Taiwan	−547	50	109	−546	51	129	117	18	20
Turkey	−129	−21	−3	139	−30	0	45	11	11
Yugoslavia	−31	−8	−9	41	−18	−7	12	5	6
Total LDCs:	−80	−197	222	−189	−256	345	1276	460	544
All countries:	29123	28816	27823	29640	29351	28351	2720	1910	1921

	Change in welfare (million dollars)			Percent change in effective exchange rate[c]			Percent change in prices[d]		
	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO
Industrialized countries:									
Australia	777	787	647	0.00	0.00	0.00	−0.98	−0.98	−0.95
Austria	−448	−447	−502	0.24	0.23	0.65	−2.84	−2.84	−2.91
Canada	305	307	262	0.61	0.61	0.51	−0.70	−0.70	−0.70
European Community:									
*Belgium-Luxembourg	−551	−553	−13	2.12	2.11	1.60	−3.10	−3.09	−2.75
*Denmark	−329	−337	−289	0.92	0.93	0.52	−2.12	−2.11	−1.99
*France	−499	−496	−70	−0.50	−0.50	−0.59	−0.89	−0.89	−0.82
*Germany	−1052	−1054	−1530	−0.18	−0.18	−0.25	−1.36	−1.36	−1.43
*Ireland	−10	−12	9	1.56	1.58	0.88	−2.16	−2.16	−1.98
*Italy	19	21	193	−0.24	−0.23	−0.21	−0.80	−0.80	−0.75
*Netherlands	54	48	53	1.04	1.05	1.00	−2.27	−2.26	−2.16
*United Kingdom	761	772	825	−0.81	−0.83	−0.67	−0.62	−0.61	−0.62
Total EC:	−1606	−1611	−823	−0.13	−0.13	−0.20	−1.23	−1.23	−1.20
Finland	−276	−276	−523	0.00	0.00	0.00	−1.56	−1.55	−1.64
*Japan	2106	2159	317	−0.07	−0.08	−0.41	−0.32	−0.32	−0.41
New Zealand	−34	−34	−65	0.00	0.00	0.00	0.14	0.24	−0.58
Norway	−3	−4	−99	0.00	0.00	0.00	−0.86	−0.86	−0.81
Sweden	−295	−296	−598	0.00	0.00	0.00	−1.03	−1.03	−1.01
Switzerland	173	179	−244	0.13	0.13	0.00	−0.67	−0.67	−0.66
*United States	1114	1102	1720	−0.68	−0.70	−0.35	−0.10	−0.10	−0.11
Total industrialized:	1813	1865	93	−0.29	−0.30	−0.23	−0.62	−0.62	−0.63
Developing countries:									
Argentina	93	13	−30	0.00	0.00	0.00	0.01	−0.31	−0.50

(continued)

Table 4: Continued

	Change in welfare (million dollars)			Percent change in effective exchange rate[c]			Percent change in prices[d]		
	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO	1 IO	2 IO	11 IO
Developing countries (continued)									
*Brazil	−550	−44	−41	0.00	0.00	0.00	−0.19	−0.14	−0.21
Chile	−84	679	615	0.00	0.00	0.00	−6.09	151.26	138.10
Colombia	−57	7	5	0.00	0.00	0.00	−0.47	−0.42	−0.51
Greece	68	5	−12	0.00	0.00	0.00	0.60	0.21	0.00
Hong Kong	−15	−28	−31	−0.06	0.07	1.09	0.19	0.05	−0.24
India	−468	−28	−39	0.00	0.00	0.00	−0.03	−0.03	−0.11
Israel	12	9	4	0.03	0.21	0.48	0.15	0.09	0.03
South Korea	286	11	55	0.00	0.00	0.00	−3.76	−0.23	−0.78
Mexico	−249	−62	−74	0.45	0.57	0.59	−0.08	−0.07	−0.11
Portugal	64	−10	−38	0.00	0.00	0.00	0.92	0.37	0.05
Singapore	−38	−10	−24	0.00	0.00	0.00	0.13	0.18	0.17
Spain	−120	−36	−49	0.00	0.00	0.00	0.07	0.04	−0.09
Taiwan	423	30	78	0.00	0.00	0.00	4.21	−0.46	−1.03
Turkey	191	−3	−5	0.00	0.00	0.00	0.33	0.03	−0.05
Yugoslavia	39	26	22	−0.26	−0.09	0.30	0.13	0.06	0.01
Total LDCs:	−405	557	436	0.04	0.07	0.11	−0.10	1.82	1.53
All countries:	1408	2423	529	−0.25	−0.25	−0.18	−0.55	−0.28	−0.33

[a] The eleven input–output tables are indicated by an asterisk above. Runs with one IO table use U.S. only; runs with two IO tables use U.S. and Brazil.

[b] Refers to sum of changes in home and export sectors within industries.

[c] Positive = appreciation.

[d] Index of import and home prices.

side. Results of the three runs are quite similar, though individual differences do show up and some of these need to be explained. We will discuss each variable in turn, examining where possible the reasons for the more dramatic differences.

TRADE. The changes in exports and imports show a consistent and largely very similar pattern of increases for almost all of the developed countries which removed tariffs. Differences among runs do not seem very large and are concentrated, as one would expect, in the developing countries moving from "1 IO" to "2 IO" and in the industrialized countries moving from "2 IO" to "11 IO." In the industrialized countries with new IO tables, there is a damping of the effects on trade, which results from the reduced supply elasticities that the new IO tables tend to imply.

Aside from this overall damping of the effects on trade, the two most notable differences here concern New Zealand and South Korea. In New Zealand trade contracts in both of the first two runs, even though tariffs in New Zealand are eliminated, and trade expands only in the third, "11 IO," run. The reason for the contraction is that New Zealand, alone among industrialized countries, is modeled as using import licensing to manage its balance of payments.[12]

The other notable difference in the trade results is in South Korea. Here trade expands astonishingly in the first run, but behaves more like other LDCs once the Brazilian IO table is used to describe its technology. This seems to be a case of near instability in the import licensing arrangement, as mentioned briefly above. That is, as South Korean exports begin to rise owing to rising world prices, restrictions on imports are relaxed and their prices fall. This in turn reduces prices of competing home-produced goods and together these price reductions lower costs of producing for export. Exports therefore expand still further and the process continues. In the end the process is evidently stable, since a new equilibrium is reached with a rise in exports. But because it is close to the borderline of instability, the necessary adjustment is very large.

What does this have to do with the IO table? As noted in Table 3, the average share of value added in the Brazilian table is markedly larger

[12] While it may not be obvious from our earlier description of import licensing, this scheme essentially *replaces* nominal tariffs with endogenously determined tariff equivalents that ration imports. Thus actual tariffs play no role, and the effects for such countries, when tariffs are removed, arise entirely from the changes in world markets due to changes in other countries. Trade may contract in New Zealand, therefore, for the same reason that it may contract in developing countries where tariffs are not reduced.

than in the U.S. table. This means that interindustry interactions are more important in the U.S. table, increasing the strength of this feedback process. Furthermore, in South Korea the greatest exports are in textiles and wearing apparel, where differences in the two IO tables are largest. Thus the textile industry is less susceptible to feedback effects with the Brazilian table than with the U.S. table. Also, since textiles provide a large input into wearing apparel, the difference applies to it as well. Together they show up in the results for South Korea because of its reliance on exports in these particular industries.

EMPLOYMENT. The next column of Table 4 reports results for what we call the "gross change in employment." As mentioned earlier, in these runs we make aggregate expenditure endogenous so as to keep aggregate employment constant in each country. This is done to neutralize macroeconomic effects of tariff changes and means that changes in aggregate employment are zero. We focus instead on the labor-market adjustment that policy changes entail for workers that must move between sectors and industries. Thus we have added up only those disaggregated employment changes that are positive, and we report them as the "gross change in employment."

These results in Table 4 again suggest only moderate effects of changing the IO tables. Orders of magnitude are unaffected, and in the industrialized countries the numbers themselves are very similar, with again some evidence of damping for the same reason noted above for trade. Somewhat larger differences appear in LDCs, where the adjustments seem smaller with the Brazilian table. Again this is probably the result of the reduced interindustry interaction in the Brazilian table. The one exception is Chile, which has special problems that we will note below.

WELFARE. Changes in welfare are based on an ad hoc calculation of the usual consumer- and producer-surplus triangles and tariff revenues, and are not really central to our model. The calculation implicitly takes account of terms of trade effects, which can lead to negative welfare changes in some countries as world prices adjust. In addition, welfare also depends on the level of endogenously determined aggregate expenditure.

There are some fairly large differences in these results—most notably in Japan, where very large positive welfare effects in the first two runs are reduced by almost a factor of 10 when Japan's own IO table is used. This seems to be a consequence of our using aggregate expenditure to stabilize employment. In most tariff-reducing countries, expenditure falls slightly to stabilize employment, but when Japan is modeled using the U.S. IO table, Japanese expenditure actually rises, and this permits an unusual increase in demand and therefore welfare.

The reason for this rise in expenditure seems to be Japan's high tariffs in agriculture. When these are removed, even given extensive NTBs, there is substantial drift of resources out of agriculture and into other sectors. However, because of the high labor intensity of agriculture in Japan, this movement would have reduced aggregate employment unless spending were allowed to grow. Finally, this effect is considerably stronger when the U.S. IO table is used, since the value-added share in agriculture is much smaller there (only 38 percent) than in Japan (64 percent), implying a greater response to price changes using the U.S. table. This is one place, then, where a clear error was present in our earlier analyses, which relied solely on the U.S. table, since there was an inconsistency between the low value-added share in the IO table and the large amount of labor actually employed in Japanese agriculture.

EXCHANGE RATES. Changes in effective exchange rates are trade-weighted averages of changes in bilateral rates, and are meaningful only for countries that do not peg to a trade-weighted basket of currencies. Results here are therefore sparse, and are difficult to interpret due to the variety of exchange regimes.

Most interesting, perhaps, is the reduced depreciation of the U.S. dollar that results from tariff elimination once other industrialized countries are modeled with their own IO tables. The difference is only about a third of a percentage point, but it is fairly uniform: all currencies appreciate less against the dollar in the "11 IO" run than in the others, and most do so by a fraction of a percent.

Unfortunately, we have been unable to find a good explanation for this result. We only note again that average supply elasticities implied by the U.S. IO table are larger than those implied by the others. This evidently gives the U.S. an advantage in increasing exports in response to a multilateral tariff reduction, and prevents the dollar from falling as much as it otherwise would if supply elasticities were everywhere the same.

PRICES. The price changes in Table 4 are indices of home and import prices. In the industrialized countries these appear insensitive to the inclusion of IO tables. Also, with one notable exception, results in the developing countries do not change much, though they may appear more variable just because they are closer to zero.

Chile is the exception, displaying peculiar behavior as it has consistently since we began using the Brazilian IO table to describe its technology. Chile is the one country where instability due to import licensing actually seems to arise in the model. In much of our work, we have found and reported unusually large and wrong-signed results for Chile, a sure indication of an unstable system.

Thus in these results for prices, with the U.S. IO table used for Chile, prices fall substantially due to tariff removal. Evidently, rising *world* prices expand Chile's exports, reduce the premium on foreign exchange, and thus reduce prices of both imports and competing home goods. The large size of the price decline suggests that Chile is near the threshold of instability, that falling input prices have further stimulated exports in a manner that could have been unstable. If Brazil's IO table is used instead, this threshold is evidently crossed, since prices rise instead of fall, by well over 100 percent. What has happened is also indicated by the reversal of the trade results earlier in the table. An increase in exports, were it to occur, would now stimulate through falling input prices an even greater increase in exports, and the process does not converge. Instead the equations of the model find an equilibrium in the other direction, with rising prices and falling trade.

Earlier we noted that near instability in South Korea was improved when we replaced the U.S. table with Brazil's, presumably because the latter was more appropriate to a developing country. We may ask now why it would be that the Brazilian table is *less* appropriate for describing Chile. The answer seems to lie in Chile's unusually large exports of copper, part of ISIC 372, where it happens that differences in value-added and labor shares between the U.S. and Brazil are particularly strong.[13] Exactly how these differences generate instability is not immediately clear, and we suspect that an additional inaccuracy in our data may also contribute to the problem.[14]

4B. Disaggregated Employment Effects

We also calculated the disaggregated employment effects of tariff removal. Our model has always been intended to focus on disaggregated effects, and it is here, therefore, that sensitivity to the IO tables would be most serious.

Space does not permit presentation of the detailed results, but we will describe the main conclusions. Considering first Brazil, tariff removal

[13]The supply elasticity for nonferrous metals is estimated at 15.6 from the U.S. table and only 1.4 from the Brazilian table.

[14]Our data on production and trade, which came from two different sources, show Chile's net exports from this industry to be greater than its production.

caused a general reallocation of labor into agriculture and out of most other sectors, especially those producing nontraded goods. This pattern held in all three runs, and was not sensitive to whether Brazil was modeled with its own IO table or that of the United States. However, the *extent* of this reallocation was considerably reduced using the Brazilian table. This is an obvious result of the much lower supply elasticities already noted as implied by the Brazilian table. On the whole, considering the rather large differences that seemed to separate the Brazilian table from the others in Table 3, the uniformity of these results was a bit surprising.

In the remaining countries, the differences in runs were even less dramatic. Japan was rather a mirror image of Brazil in this respect—with tariff removal reallocating labor out of agriculture and into most other sectors—and again the reallocation was much less when the Japanese IO table, with its smaller elasticity of supply, was used. Otherwise the sign patterns, and even the approximate sizes of the results, were remarkably consistent across the runs.

4C. Correlations Among Other Disaggregated Effects

To give some indication of how IO tables have affected other disaggregated variables, we have calculated rank correlations for several variables between different pairs of runs. These appear in Table 5 for the industrialized countries and Brazil.

We consider first changes in employment. Under this heading, the first column shows correlations between the "1 IO" and "2 IO" runs, and thus indicates the effect of introducing the Brazilian IO table alone. Here the correlations are all very close to unity. The lowest, as one would expect, is for Brazil itself, but even it is a highly significant 0.87. Thus, the orderings that are implied among industries, in terms of the labor market adjustment that tariff elimination will entail, are very similar.

The second column in Table 5 reports correlations for employment changes between the "2 IO" and "11 IO" runs of the model, and thus reflects the effect of adding the remaining IO tables. These correlations are somewhat smaller than in the first column, as one might expect from changing even more IO tables. Nonetheless, all but two are still highly significant.[15]

Most interesting, perhaps, are the two countries for which this correlation is not significantly positive: New Zealand and Switzerland. New Zealand is readily explainable in terms of import licensing, and we

[15]Even in Japan, where the correlation is only 0.50, this correlation is significantly different from zero at the 99 percent confidence level.

Table 5: Rank Correlations of Disaggregated Effects of Industrialized Country Tariff Removal Between Runs with One, Two, and Eleven Input–Output Tables,[a] for Developed Countries and Brazil

	Percent change in employment			Change in exports			Change in imports			Percent change in per-unit value added		
	IO 1:2	IO 2:11	IO 1:11	IO 1:2	IO 2:11	IO 1:11	IO 1:2	IO 2:11	IO 1:11	IO 1:2	IO 2:11	IO 1:11
Australia	1.00	0.96	0.96	1.00	0.94	0.94	1.00	1.00	1.00	1.00	0.99	0.99
Austria	1.00	0.99	0.99	1.00	0.98	0.98	1.00	1.00	1.00	1.00	0.99	0.99
*Belgium–Luxembourg	0.97	0.84	0.78	1.00	0.69	0.69	1.00	0.91	0.90	0.99	0.77	0.76
Canada	1.00	0.87	0.90	0.99	0.94	0.95	1.00	1.00	1.00	0.99	0.90	0.89
*Denmark	1.00	0.83	0.85	1.00	0.71	0.69	1.00	0.95	0.94	1.00	0.83	0.83
Finland	1.00	0.96	0.96	1.00	0.96	0.96	1.00	0.98	0.98	1.00	0.97	0.98
*France	1.00	0.87	0.86	0.99	0.93	0.93	1.00	0.99	0.99	1.00	0.93	0.93
*Germany	1.00	0.78	0.77	0.99	0.88	0.87	1.00	0.96	0.96	0.99	0.72	0.73
*Ireland	0.99	0.76	0.75	0.99	0.72	0.71	1.00	0.93	0.93	0.99	0.74	0.75
*Italy	1.00	0.87	0.86	0.98	0.91	0.90	1.00	0.93	0.94	0.99	0.90	0.89
*Japan	0.96	0.50	0.61	0.99	0.72	0.75	1.00	0.99	0.99	0.99	0.60	0.65
*Netherlands	1.00	0.85	0.85	0.99	0.84	0.82	1.00	0.96	0.96	1.00	0.86	0.86
New Zealand	0.99	0.20	0.25	1.00	0.17	0.18	1.00	−1.00	−1.00	0.98	−0.23	−0.11
Norway	1.00	0.91	0.91	0.99	0.91	0.92	1.00	0.97	0.98	1.00	0.93	0.93
Sweden	1.00	0.92	0.94	1.00	0.92	0.93	1.00	0.98	0.98	1.00	0.94	0.94
Switzerland	0.99	0.28	0.28	0.92	0.75	0.85	1.00	0.90	0.90	0.98	0.52	0.55
*United Kingdom	1.00	0.56	0.57	1.00	0.75	0.74	1.00	0.98	0.97	0.99	0.73	0.69
*United States	0.91	0.85	0.74	0.97	0.92	0.89	1.00	0.99	0.99	0.94	0.74	0.67
*Brazil	0.87	0.89	0.69	0.99	0.90	0.88	1.00	1.00	1.00	0.67	0.90	0.64
Average	0.98	0.77	0.76	0.99	0.82	0.82	1.00	0.86	0.86	0.97	0.78	0.77

[a]The eleven input–output tables are indicated by an asterisk above. Runs with one IO table use U.S. only; runs with two IO tables use U.S. and Brazil.

will discuss it in a moment when we examine trade. Switzerland's correlation of only 0.28, however, is harder to interpret since its IO table has not been changed. It is difficult to find the cause of this result, but after some attempts to do so, we are inclined to attribute it to Switzerland's high degree of specialization. The consequent low levels of employment in many industries make our rank correlations unduly sensitive to differences that ought to be insignificant.[16]

The middle two columns of Table 5 report correlations for exports and imports. Introduction of the Brazilian IO table had practically no effect on the rankings of industries by changes in trade, and this is largely true of the other IO tables as well. Only in New Zealand is there a dramatic shift.[17] Even in Switzerland, though its correlations tend to be lower than in other countries, all are now easily large enough to be significant.

The last variable we report is the "change in per-unit value added" (CPVA). This is a general equilibrium analog to the effective rate of protection, and we have devoted considerable attention to it elsewhere.[18] In these runs of post-Tokyo-Round tariff removal it measures the protective effects of post-Tokyo-Round tariffs, and the correlations among runs provide one indication of the sensitivity of this measure to the particular IO table employed. These correlations are similar to those for employment and are significantly positive at the 99 percent confidence level for all countries except New Zealand, for reasons already indicated.[19]

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[16]For example, moving to 11 IO tables caused the employment change in the Swiss leather products industry (ISIC 323) to change from −6.7 percent to +0.1 percent. Yet this industry accounts for only about one tenth of one percent of total employment in Switzerland.

[17]The behavior of New Zealand is sufficiently odd to deserve special mention, though again the reason lies in import licensing. As already noted, total trade of New Zealand declines in these runs except with the full 11 IO tables. With import licensing all imports are scaled up or down together, maintaining fixed ratios to their initial values. Thus it is inevitable that when total trade moves in different directions in two runs, disaggregated imports will be perfectly negatively correlated. Changes in exports are also substantially altered by this change in direction because of differences in input prices when import licensing is relaxed rather than tightened.

[18]See for example Deardorff and Stern (1982a).

[19]We are uneasy, however, about using correlations as our only measure of what is happening here. In Deardorff and Stern (1983b) we used a visual technique for comparing rankings of CPVA in a different context, and we found that large correlations can mask some very important differences in disaggregated results. That visual technique is too cumbersome to use here, but it suggests that some better numerical measure may be needed.

5. CONCLUSION

Our objective has been to evaluate the importance of various national input–output tables in a multicountry model of world trade and production. Using IO tables from 10 developed countries and one less developed country, Brazil, we calculated the effects of tariff removal using various combinations of these tables to represent technologies. Our analysis has focused on differences in the tables themselves, and on differences in results of the model that the tables imply.

In the IO tables themselves, we found the greatest differences comparing the Brazilian table with those of the developed countries. Brazil's industries appear to have unusually high shares of value added and low shares of labor within value added, both of which contribute to unusually small supply elasticities as we calculate them. Among the IO tables of the developed countries the pattern is less clear, but except for the U.K., supply elasticities again appear somewhat lower in all of these countries than in the United States.

These differences in supply elasticities, it turns out, account for the bulk of the differences that we find in results of the model. The effects of tariff removal on trade, for example, tend to be damped when the U.S. IO table is replaced by the more appropriate national ones. Thus one conclusion from this analysis is that the results we calculated with our model before non-U.S. IO tables were available tended to overstate the effects involved. Since a major conclusion of this earlier work was that tariff changes, for example, would have relatively small effects on the world's economies, correcting this apparent bias only strengthens the conclusion.

The other major finding of this analysis concerns those countries, mostly LDCs, that we have modeled as using import licensing. We find that the behavior of such a scheme is very sensitive to the particular specification of the IO table, even to the point of determining whether the scheme is stable or unstable. This suggests that more work is needed, first to refine the modeling of such arrangements in LDCs, and then to collect the most accurate information possible about their input–output structures. The current state of our own model in this regard may be seriously deficient.

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