No. 97-06-A

OFFICE OF ECONOMICS WORKING PAPER

U.S. International Trade Commission

INTEGRATION AND COMPETITIVENESS IN THE AMERICAS: A GENERAL EQUILIBRIUM MODEL FOR ANALYSIS

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June 30, 1997

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Summary: This working paper introduces the USITC's Latin American Regional, computable general equilibrium model, which combines flexible functional form modeling with dynamic analysis. It describes the rationale for experimenting with income elasticities of demand and substitution elasticities in the context of Western Hemisphere trade, and presents some results from experiments with U.S.-Chile trade liberalization. Free trade between Chile and NAFTA will have an appreciable impact on Chile-NAFTA trade. Welfare gains will accrue primarily to Chile, leaving the welfare of MERCOSUR's two largest economies unaffected. The paper describes the methodology of identifying the dynamic gains that should accrue from the elimination of trade barriers in the Americas. Trade externalities, which boost Latin American productivity, will be especially advantageous to Argentina.

Introduction

Within a few decades, economic integration will significantly improve living standards in the Americas, owing, to a great extent, to increased competition among the producers of the Western Hemisphere. Computable general equilibrium (CGE) modeling of regional integration has helped demonstrate the collective welfare gains of trade liberalization (Hinojosa-Ojeda, et. al., 1995), while also providing a more detailed and comprehensive analysis of sectoral prospects under regional trade agreements. Thus in addition to their analytical advantages, empirical trade models can also engender solidarity among the trading partners by showing the net gains that can arise from their agreements. Nevertheless, the more detailed results can give rise to questions about the distribution of the benefits of integration that need not descend into narrow concerns of economic nationalism; rather they can help inform the agenda on which issues are the most important to consider.

An important example of such agenda-setting is the insistence on the part of Latin Americans that the framework for talks to improve trade relations with the EU include agriculture. This derives from a wish to enhance the gains from trade for Latin America, and from an understanding of the relative competitiveness of EU manufactures in Latin American markets, and of the relative competitiveness of Latin American primary goods in the EU. Thus, the degree of competitiveness in different sectors relates closely to distributional concerns and can help identify the issues important for collective decisions on regional integration.

At the heart of economic integration in the Americas is a number of complex manufacturing economies. As has already been demonstrated within NAFTA and MERCOSUR, these circumstances lead to much intra-industry trade in differentiated products — not only in manufactures but also in primary goods and services. Competitiveness among differentiated products can be represented in a modeling framework by different degrees of substitutability among products from different country sources. The type of CGE model presented in this paper thus allows for exploring the limits of foreign competitiveness and the possibilities of increasing domestic competitiveness.

This model is used to explore outcomes for market share and growth in experiments, testing the impact of trade liberalization.

The primary purposes of this paper are (1) to describe the Latin American Regional (LAR) CGE model of the United States International Trade Commission (USITC), (2) to give some examples of its application to issues relevant to hemispheric integration and competitiveness, and (3) to highlight the derived information that is relevant to policymakers in Latin America.

The Latin American Regional Model

The USITC Latin American (LAR) CGE model is an extension of the Western Hemisphere Free Trade Area (WHFTA) regional CGE model, developed by Sherman Robinson.[1] The LAR model currently includes the three NAFTA countries, and Argentina, Brazil, Chile, and the rest of the world (ROW) as a unit. The six economies and the ROW are linked through trade, and, with the exception of the ROW, all of them are represented by general equilibrium equations.

As in the WHFTA model, LAR can specify either CES or AIDS import demand systems. While CES allows the specification of one degree of substitutability between imports from all sources and domestic goods, the AIDS function distinguishes the degree of substitutability between different country sources of imported goods and domestic goods. This enhances the role of different degrees of competitiveness among suppliers. The LAR model extends the WHFTA model by further disaggregating the manufacturing sectors, creating product categories where competitiveness among different Western Hemisphere suppliers can become an important determinant of the level and distribution of gains from trade liberalization proposals. The AIDS function also allows the income elasticity of imports by commodity groups and suppliers, as well as the income elasticity of total trade, to be other than one, as assumed in CES specifications.

The LAR model includes the following 22 sectors: agriculture, mining, petroleum, processed food, beverages and tobacco, textiles, apparel, leather, paper, chemicals, rubber, nonmetallic minerals, iron and steel, nonferrous metal, wood and metal products, industrial machinery, office machines, household appliances, transportation equipment, auto parts, other manufactured goods, and services. The Social Accounting Matrix (SAM) for each country includes production, employment, income, enterprises, government, and capital account. The model calculates the demand for imports from various sources based on the presumption of constant elasticity of substitution (CES), i.e., based on the assumption that elasticity is constant between each pair of suppliers in a given commodity group, or based on the assumptions of an ”Almost Ideal Demand System” (AIDS); or based on a combination of the CES and AIDS approaches.[2]

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[1] For descriptions of the Robinson models and some model simulations relevant to trade liberalization in the Americas, see (Robinson and Thierfelder, 1996) and (Robinson, Soule, and Weyerbrock, 1992).

[2] For a description of AIDS, see (Deaton and Muellbauer, 1980). For a detailed description of the CES and AIDS approaches, see USITC Working Paper, 96-05-A.

Under the AIDS, a flexible functional from approach, the model endogenously calculates country market shares as functions of the inflation-adjusted expenditures on the product category in question, on the prevailing price ratios, and on two exogenous parameters; the income elasticity of demand in the product group, and the substitution elasticities between suppliers. Endogenous change in the market share occurs if real expenditures or relative prices change. The possibility of experimenting with exogenously determined parameters is a form of sensitivity analysis (comparative statics). It represents a significant improvement in the analytic apparatus of CGE-based policy research.

The Rationale for Experimenting with Income Elasticities of Demand

The exogenous change in income elasticities of demand allows for the analysis of income effects by sector and supplier. There are three main reasons for such experimentation:

To explore the consequences of economic integration.--Increased integration between two countries call for the use of relatively higher income elasticities of demand vis-a-vis each others' products. Experiments in which integration leads to increased market shares among the integrating partners, higher income elasticities may compensate for a possible decline in cross-country substitution elasticities, a consequence of less intense competition in the wake of integration.

To deal with asymmetry in the ability to import owing to the level of development. In general, developed countries import more as their per capita incomes grow than developing countries. Consequently, the income effect of trade liberalization may not be the same in two countries at different levels of development.

To account for significant, incalculable changes in the subsectors.- Even the most skillfully estimated sectoral income elasticity of demand is only an average of perhaps hundreds of uncalculated elasticities. Opening a range around the point estimate may keep the results more relevant in case preference in the wake of integration change in an important subcategory of the sector under consideration. This reason for experimenting with income elasticities is partially subsumed into the previous two reasons. A full range of elasticities under varying levels of integration and assumptions of asymmetry evidently cover effects originating at the subsectoral level. However, this third reason is considered independently when an interval is calculated around the point estimate without an actual cause to presume change at the sectoral level; or, when the calculation of the range is determined to be superfluous.

The Rationale for Experimenting with Substitution Elasticities

The exogenous change in substitution elasticities allows for the exploration of relative price effects.[3] Experimentation with substitution elasticities in connection with AIDS-based CGE policy simulations turns the point estimate of a substitution elasticity into an interval estimate. There are three main reasons for such experimentation:

To consider likely increases or decreases in the level of competition.--Increased competition in a sector following trade liberalization is tantamount to having relatively higher substitution elasticities between each pair of suppliers. However, a trade liberalization agreement may catalyze integration among the partners, increasing the preference for each other's goods. This is equivalent to reduced competition with suppliers who are not parties to the agreement, calling for the application of relatively lower substitution elasticities. (As mentioned before, higher income elasticities are expected to overcompensate for the market-share decreasing effects of lower substitution elasticities in integration scenarios showing increased market shares in the partner states.)

To deal with asymmetry in the ability of substitution owing to the level of development.--In general, developed countries are more able than developing countries to substitute between imports and domestic products and among various sources of imports. Consequently, the price effect of trade liberalization may not be the same in two countries at different levels of development.

To account for significant, incalculable changes in the subsectors.--This line of argument here is similar to the one advanced under income elasticities.

Preliminary Runs on NAFTA-Chile Trade Liberalization[4]

Preliminary results from the LAR model analyzing NAFTA-Chile trade liberalization show no significant effects on the overall U.S. economy or volume of trade. However, U.S.-Chile trade is affected markedly. The static impact could be a 15-percent increase in bilateral merchandise trade. Upon implementation of the FTA, U.S. exports to Chile would clearly tend to increase more than U.S. imports from Chile. Model results indicate that Chile would expand its imports of manufactures from the United States, while increasing its exports of metals, agriculture and light manufactures to a variety of trade partners. The sectors posting the greatest increases of U.S. exports to Chile are industrial machinery and chemicals, followed by transport equipment, other manufactures,[5] and office machinery.

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[3] The elasticity of substitution shows the effect of a change in relative prices on the relative market shares. For example, in the LAR model, the substitution elasticity in Chile between U.S. and ROW industrial machinery is 0.586. This means that a 1-percent increase in the price of these products from the ROW relative to the price of the U.S. products would increase the U.S. share compared to the share of the ROW by 0.586 percent. (See formula on next page.)

[4] Chile has concluded a bilateral trade agreements with Canada, and it may conclude similar agreements with Mexico and the United States.

[5] Professional, scientific and controlling equipment and apparatus (SITC sec. 8, div. 87) represent the largest commodity group among U.S. exports of "other manufactures" to Chile.

The impact on the Chilean economy is more discernible. In terms of static gains, the FTA would raise Chile's real GDP by roughly 0.2 percent.[6] Changes in its trade with NAFTA partners Mexico and Canada would basically pattern changes in its trade with the United States. One difference is that exports of transport equipment from Mexico to Chile rise as much as that from the United States, while such exports from Canada to Chile hardly change, starting from a much smaller base.

Experiments to Explore the Effects of Trade Liberalization on Shares in Chile's Industrial Machinery Sector

In the LAR model, the industrial machinery sector includes SITC categories 7111-7121 and 7141-7499. This sector seems particularly interesting in Chile's dynamic, quickly industrializing economy. Trade shares in Chile's industrial machinery sector are also closely tied with shares of foreign direct investment in the country.[7] The policy shock consists of eliminating trade barriers between Chile and the NAFTA countries, and among the MERCOSUR countries included in the model. This shock is combined first with various integration scenarios (income elasticity experiments), then with various levels of competitiveness (substitution elasticity experiments).[8]

Income elasticity experiments.--These experiments involve changes in the absolute and relative levels of Chile's income elasticities of demand, while keeping substitution elasticities constant at a uniform 0.586 level. The ratio of income elasticity vis-a-vis a foreign supplier in Chile to the income elasticity vis-a-vis the domestic industry is used as the proxy for Chilean preference in the purchase of industrial machinery. The higher the ratio the greater the preference. For example, in scenario A, the ratio is 2.22 (2:0.9) for both the United States and the ROW (Table 1). In scenario B, the ratio remains 2.22 for the United States, but it is reduced to 1 (0.9:0.9) for the ROW. Naturally, preference is constrained by the economic and technological status quo of Chile's domestic industry. The following scenarios were considered under a hypothetical free trade agreement between the NAFTA and Chile:

Scenario A: The model parameters prevail.
Scenario B: Chile shifts its industrial machinery acquisitions from the ROW to the developed countries of NAFTA, that is, the United States and Canada.
Scenario C: Chile develops an extreme preference for U.S. products.
Scenario D: By virtue of its integration into MERCOSUR, Chile develops a greater preference for Brazilian industrial machinery.

As Table 1 shows, the elimination of Chile-NAFTA tariff barriers may cause an expansion of the U.S. share in Chile's industrial machines market between 3.2 (scenarios A and D) and 11.3 percent

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[6] In comparison, other CGE-based studies showed that the greatest winners from the Uruguay Round trade liberalization may expect benefits worth about 1 percent of their respective GDP levels.

[7] For a summary of the literature on the effects of U.S.-Chile trade liberalization, see USITC Working Paper, 96-06-A.

[8] See Appendix for a description of LAR model specificities in income and substitution elasticity experiments.

(scenario C). Thus, given the average U.S. share of 23.7 percent for 1990-1995, the elimination of trade barriers between the two countries is expected to raise this average in the years following the agreement to 24.5 -26.4 percent. The inclusion of Chile in the NAFTA does not portend a significant loss in Chile's domestic market share.

Substitution elasticity experiments.--These experiments were based on the assumption of increased competition among developed countries in Chile's industrial machinery market. Seven experiments with increased substitution elasticities were performed (Table 2). The original model parameter was 0.586, and income elasticity of demand for all imported goods was fixed at one.

As Table 2 indicates the use of original model parameters in the tariff shock indicated did not show any change in the 24.7 percent U.S. market share. Under the tariff shock, at and above the terminal value of the substitution elasticity, the U.S. market share is 30.3 percent. This means that the maximum increase in U.S. industrial machinery exports, which may result from gaining market share with price competition under the prevailing economic and technological conditions, is 22.7 percent. If the annual level of U.S. industrial machinery exports to Chile is $900 million (1996 partial-year estimate), the maximum level of U.S. exports to Chile in this product category that may be reached under the specified conditions is $1,104.3 million.

Chile captures about four-fifths and the NAFTA countries about one-fifth of the modest welfare gains generated by the inclusion of Chile in NAFTA. The welfare of the two MERCOSUR giants in the model remained unchanged. As testimony to the accurate fit of the original model parameters--which are expected to reflect optimizing behavior in the economies depicted by the model--extreme changes in them actually diminish the model's welfare indicators. Increasing the substitution elasticity between U.S. and ROW industrial machinery to the terminal value actually diminished the U.S. share of the combined welfare gain.

Trade Externalities

Much discussion has arisen over the potential importance of "trade externalities," i.e., the extent to which increasing trade volumes are correlated with rising economic productivity. While various mechanisms for connecting trade and productivity have been hypothesized, some of the most compelling empirical evidence indicates that the main value of rising exports from developing countries is that it generates the capacity to import more capital goods.[9] An externality of this form has been included in the LAR model and tested in multi-period simulations of various trade liberalization shocks.

Latin American countries receive a boost to the productivity of their capital stocks when they increase their imports of capital goods. Multiperiod simulations demonstrate that in only a few years, modest allowance for such capital trade externality can raise welfare gains from hemispheric trade

[9] Econometric evidence indicates that after the impact of the level of country's exports on its imports of capital has been taken into account, the level of total exports has no further impact on the country's economic growth (Devarajan and Heng-fu Zou, 1996; Jong-Wha Lee, 1996; Baldwin and Seghazza, 1996; and Esfahani, 1991).

liberalization shocks from 0.2 to 1.0 percent of the GDP over the case where no such externality is in operation. Preliminary simulations indicate that Argentina would be the greatest beneficiary of such an effect under the hemispheric trade liberalization scenarios tested.

Conclusions from Model Simulations

1. Trade liberalization between Chile and the NAFTA countries will have an appreciable impact on Chile-NAFTA trade flows; welfare gains accrue primarily to Chile, leaving the welfare of MERCOSUR's two largest economies unaffected.

2. The effects of manipulation (i.e., increase or decrease) of income and substitution elasticities upon market shares are constrained. Chile's share in its domestic industrial machinery market is resilient, even under the assumptions of strong preference for foreign goods and strong competition from U.S. suppliers. Single elasticity experiments exert small, but revealing impacts on welfare measures

3. In the short run, trade externalities, treating imports of capital goods as a boost to productivity, will be especially advantageous for Argentina.

Table 1
The effects of Chilean sourcing preferences on shares in Chile's industrial machinery market

	Chile	United States	Canada	Mexico	Argentina	Brazil	ROW	Total
1994 share (%)	33.0	24.7	1.3	0.2	1.5	5.4	33.9	100.0
Scenario A: Model parameters prevail								
income elasticity	0.9	2.0	0.9	0.9	0.9	0.9	2.0	
Share (%)	32.7	25.5	1.4	0.2	1.5	5.3	33.4	100.0
Change (%)	-1.0	3.2	7.7	0.0	0.0	-2.0	-1.5	
Scenario B: Strongest preference for U.S. and Canadian goods								
income elasticity	0.9	2.0	2.0	0.9	0.9	0.9	0.9	
Share (%)	32.5	26.1	1.4	0.2	1.5	5.3	33.0	100.0
Change	-1.5	5.7	7.7	0.0	0.0	-2.0	- 2.7	
Scenario C: Extreme preference for U.S. goods								
income elasticity	0.1	4.0	0.1	0.1	0.1	0.1	0.1	
Share (%)	31.8	27.5	1.4	0.2	1.4	5.2	32.5	100.0
Change (%)	-3.6	11.3	7.7	0.0	0.0	-3.7	- 4.1	
Scenario D: Strongest preference for Brazilian goods								
income elasticity	0.9	2.0	2.0	0.9	0.9	4.0	0.9	
Share (%)	32.7	25.5	1.4	0.2	1.5	5.5	33.2	100.0
Change (%)	-1.0	3.2	7.7	0.0	0.0	1.9	- 2.7	

Table 2
The effects of varying substitution elasticities between U.S. and ROW products on shares in Chile's industrial machinery market

	Chile	United States	Canada	Mexico	Argentina	Brazil	ROW	Total
1994 share (%)	33.0	24.7	1.3	0.2	1.5	5.4	33.9	100.0
Substitution elasticity entered = 0.586								
subst. elasticity imputed	2.386	-4.703	4.057	3.457	2.386	3.457	0.263	
share (%)	32.7	24.7	1.2	0.2	1.5	5.3	34.4	100.0
change (%)	-1.0	0.0	-7.7	0.0	0.0	-2.0	1.5	
Substitution elasticity entered= 1								
subst. elasticity imputed	2.386	-5.272	4.057	3.457	2.386	3.457	0.677	
share (%)	32.3	25.4	1.4	0.2	1.5	5.2	34.0	100.0
change (%)	-2.1	2.8	7.7	0.0	0.0	-3.7	0.3	
Substitution elasticity entered = 2								
subst. elasticity imputed	2.386	-6.648	4.057	3.457	2.386	3.457	1.677	
share (%)	32.5	25.8	1.4	0.2	1.4	5.2	33.5	100.0
change (%)	-1.5	4.5	7.7	0.0	0.0	-3.7	-1.0	
Substitution elasticity entered = 3								
subst. elasticity imputed	2.386	-8.023	4.057	3.457	2.386	3.457	2.677	
share (%)	32.4	26.1	1.4	0.2	1.5	5.3	33.1	100.0
change (%)	-1.8	5.7	7.7	0.0	0.0	-1.9	- 2.4	

Table 2 continued

	Chile	United States	Canada	Mexico	Argentina	Brazil	ROW	Total
Substitution elasticity entered = 4								
subst. elasticity imputed	2.386	-9.398	4.057	3.457	2.386	3.457	3.677	
share (%)	32.5	26.4	1.4	0.2	1.5	5.3	32.7	100.0
change (%)	-1.5	6.9	7.7	0.0	0.0	-1.9	-3.5	
Substitution elasticity entered = 10								
subst. elasticity imputed	2.386	-17.651	4.057	3.457	2.386	3.457	9.677	
share (%)	32.7	27.6	1.4	0.2	1.5	5.3	31.3	100.0
change	-1.0	11.7	7.7	0.0	0.0	-1.9	- 7.7	
Substitution elasticity entered = 1,000								
subst. elasticity imputed	2.386	-1.379	4.057	3.457	2.386	3.457	999.7	
share (%)	33.0	29.8	1.4	0.2	1.5	5.4	28.7	100.0
change (%)	0.0	20.6	7.7	0.0	0.0	0.0	-15.3	
Substitution elasticity entered = 5,000 (terminal value)								
subst. elasticity imputed	2.386	-6.881	4.057	3.457	2.386	3.457	4.999	
share (%)	33.0	30.3	1.4	0.2	1.5	5.4	28.2	100.0
change (%)	0.0	22.7	7.7	0.0	0.0	0.0	-16.8	

Appendix

LAR Model Specificities in Income Elasticity Experiments

Income elasticities in the LAR model vary between 0.9 and 3.0, with an average value close to 2.0. The developed countries have higher income elasticities than the developing ones. For example, the LAR model contains the following income elasticities regarding industrial machinery purchases in Chile: Chile (domestic products), 0.9; United States, 2.0; Canada, 0.9; Mexico, 0.9; Argentina, 0.9; Brazil, 0.9; and ROW, 2.0. For example, the 2.0 in the case of the United States means that a 1 percent increase in Chile's total income (GDP) would increase Chile's industrial machinery imports from the United States by 2.0 percent.

Compliance with the rules of optimization requires that the market-shared weighed income elasticities add up to 1. (This requirement is also knows as the Engel aggregation.) Therefore, elasticities imputed by the model will differ from the ones entered.

The increase in income elasticity cannot increase any given market share to 1. Ratios among the quantities produced and supplied must remain in balance, precluding the possibility of the quantity supplied from any source (non-zero in the model data) becoming zero. (Even a single zero would create mathematical insolvability, because ratios between products supplied must be a positive number.)

LAR Model Specificities in Substitution Elasticity Experiments

Although any substitution elasticity may be entered into the LAR model, it will be rescaled to safeguard the model's conformity with the requirements of the maintained hypotheses of demand theory. The recalculation is different according to whether the Stone or the translog price index is used to compute real expenditures. The recalculation is the same if income elasticities are set to one.

Substitution elasticities are symmetrical. If the substitution elasticity in Chile's industrial machinery sector is 0.586 between the U.S. and the ROW products--used to determine the U.S. market share--its value is the same between the ROW and the U.S. products--used to determine the ROW's market share. However, this does not preempt the possibility of experimenting with market shares through the manipulation of substitution elasticities Consider the following two symmetrical substitution elasticities (denoted with sigmas) between sources "1" and "2";

$$\sigma_{1,2} = \frac{\dfrac{\partial(q_1/q_2)}{q_1/q_2}}{\dfrac{\partial(p_2/p_1)}{p_2/p_1}} \; ; \qquad \sigma_{2,1} = \frac{\dfrac{\partial(q_2/q_1)}{q_2/q_1}}{\dfrac{\partial(p_1/p_2)}{p_1/p_2}}$$

where the q's stand for quantities and the p's stand for the prices, their subscripts indicating the import source, i.e., whether it is country 1 or country 2. An increase in $\sigma_{1,2}$ raises the p_2 / p_1 ratio, which, in turn, raises the demand for source 1 at the expense of source 2. The equivalence between $\sigma_{1,2}$ and $\sigma_{2,1}$ does not undo this new price relation. In the second expression, the price ratio is the reciprocal of the one shown in the first expression. The increase in $\sigma_{1,2}$ is a terms of trade shock in favor of source 1. If initially $\sigma_{2,1}$ is raised, source 2 would benefit from a similar terms of trade shock against source 1. The solver's algorithm recognizes where the change occurred, thus ensuring that the alteration will be carried out as intended. Nonetheless, the symmetry of substitution elasticities in case of further changes in the price ratio is of significance. An increase in the price from source 1 compared to source 2 would provoke the same strong substitution effect as vice versa. After the initial price shock, the symmetrical increase becomes equivalent to greater competition between the two sources.

The AIDS market shares represent the first, and the substitution elasticities represent the second derivatives of the cost curve. As it is well known to economists, the demand curves themselves are obtained by Shepard's lemma through the differentiation of the total cost curve with regard to prices. The presentation of the demand curves in a market share does not alter its first derivative characteristics. The second derivatives of the cost curves are usually presented in Slutsky's analytical framework, i.e., as the differentiation of the optimal demand curves with regard to prices.

This intimate relationship between market shares and substitution elasticities limits the range of experimentation with substitution elasticities. Increasing a substitution elasticity is equivalent to sliding backwards on the concave cost curve that depicts total spending on sectoral output as a function of prices. Moving further backwards as a result of additional increases in the substitution elasticity will eventually run into a limit set by microbalances in the model. These require equilibrium between a minimum level of production and matching consumption in each sector.[10] This limitation is inherent in the economic and technological conditions the model captures.

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