How Confident Can We Be in CGE-Based Assessments of Free Trade Agreements?

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1. Introduction

With the proliferation of Free Trade Agreements (FTAs) over the past decade, demand for quantitative analysis of their likely impacts has surged. The main quantitative tool for performing such analysis is Computable General Equilibrium (CGE) modeling. Yet these models have been widely criticized for performing poorly (Kehoe, 2002) and having weak econometric foundations (McKitrick, 1998; Jorgenson, 1984). FTA results have been shown to be particularly sensitive to the trade elasticities, with small trade elasticities generating large terms of trade effects and relatively modest efficiency gains, whereas large trade elasticities lead to the opposite result. Critics are understandably wary of results being determined largely by the authors' choice of trade elasticities.

Where do these trade elasticities come from? CGE modelers typically draw these elasticities from econometric work that uses time series price variation to identify an elasticity of substitution between domestic goods and composite imports (Alaouze, 1977; Alaouze, et al., 1977; Stern et al., 1976; Gallaway, McDaniel and Rivera, 2003). This approach has three problems: the use of point estimates as "truth", the magnitude of the point estimates, and estimating the relevant elasticity. First, modelers take point estimates drawn from the econometric literature, while ignoring the precision of these estimates. As we will make clear below, the confidence one has in various CGE conclusions depends critically on the size of the confidence interval around parameter estimates. Standard "robustness checks" such as systematically raising or lowering the substitution parameters does not properly address this problem because it ignores information about which parameters we know with some precision and which we do not.

A second problem with most existing studies derives from the use of import price series to identify home vs. foreign substitution, for example, tends to systematically understate the true elasticity. This is because these estimates take price variation as exogenous when estimating the import demand functions, and ignore quality variation. When quality is high, import demand and prices will be jointly high. This biases estimated elasticities toward zero. A related point is that the fixed-weight import price series used by most authors are theoretically inappropriate for estimating the elasticities of interest. CGE modelers generally examine a nested utility structure, with domestic production substitution for a CES composite import bundle. The appropriate price series is then the corresponding CES price index among foreign varieties. Constructing such an index requires knowledge of the elasticity of substitution among foreign varieties (see below). By using a fixed-weight import price series, previous estimates place too much weight on high foreign prices, and too small a weight on low foreign prices. In other words, they overstate the degree of price variation that exists, relative to a CES price index. Reconciling small trade volume movements with large import price series movements requires a small elasticity of substitution. This problem, and that of unmeasured quality variation, helps explain why typical estimated elasticities are very small.

The third problem with the existing literature is that estimates taken from other researchers' studies typically employ different levels of aggregation, and exploit different sources of price variation, from what policy modelers have in mind. Employment of elasticities in experiments ill-matched to their original estimation can be problematic. For example, estimates may be calculated at a higher or lower level of aggregation than the level of analysis than the modeler wants to examine. Estimating substitutability across sources for paddy rice gives one a quite different answer than estimates that look at agriculture as a whole. When analyzing Free Trade Agreements, the principle policy experiment is a change in relative prices among foreign suppliers caused by lowering tariffs within the FTA. Understanding the substitution this will induce across those suppliers is critical to gauging the FTA's real effects. Using home v. foreign elasticities rather than elasticities of substitution among imports supplied from different countries may be quite misleading. Moreover, these "sourcing" elasticities are critical for constructing composite import price series to appropriate estimate home v. foreign substitutability.

In summary, the history of estimating the substitution elasticities governing trade flows in CGE models has been checkered at best. Clearly there is a need for improved econometric estimation of these trade elasticities that is well-integrated into the CGE modeling framework. This paper provides such estimation and integration, and has several significant merits. First, we choose our experiment carefully. Our CGE analysis focuses on the prospective Free Trade Agreement of the Americas (FTAA) currently under negotiation. This is one of the most important FTAs currently "in play" in international negotiations. It also fits nicely with the source data used to estimate the trade elasticities, which is largely based on imports into North and South America. Our assessment is done in a perfectly competitive, comparative static setting in order to emphasize the role of the trade elasticities in determining the conventional gains/losses from such an FTA. This type of model is still widely used by government agencies for the evaluation of such agreements. Extensions to incorporate imperfect competition are straightforward, but involve the introduction of additional parameters (markups, extent of unexploited scale economies) as well as structural assumptions (entry/no-entry, nature of inter-firm rivalry) that introduce further uncertainty.

Since our focus is on the effects of a PTA we estimate elasticities of substitution across multiple foreign supply sources. We do not use cross-exporter variation in prices or tariffs alone. Exporter price series exhibit a high degree of multicolinearity, and in any case, would be subject to unmeasured quality variation as described previously. Similarly, tariff variation by itself is typically unhelpful because by their very nature, Most Favored Nation (MFN) tariffs are non-discriminatory in nature, affecting all suppliers in the same way. Tariff preferences, where they exist, are often difficult to measure – sometimes being confounded by quantitative barriers, restrictive rules of origin, and other restrictions. Instead we employ a unique methodology and data set drawing on not only tariffs, but also bilateral transportation costs for goods traded internationally (Hummels, 1999). Transportation costs vary much more widely than do tariffs, allowing much more precise estimation of the trade elasticities that are central to CGE analysis of FTAs. We have highly disaggregated commodity trade flow data, and are therefore able to provide estimates that precisely match the commodity aggregation scheme employed in the subsequent CGE model. We follow the GTAP Version 5.0 aggregation scheme which includes 42 merchandise trade commodities covering food products, natural resources and manufactured goods. With the exception of two primary commodities that are not traded, we are able to estimate trade elasticities for all merchandise commodities that are significantly different form zero at the 95% confidence level.

Rather than producing point estimates of the resulting welfare, export and employment effects, we report confidence intervals instead. These are based on repeated solution of the model, drawing from a distribution of trade elasticity estimates constructed based on the econometrically estimated standard errors. There is now a long history of CGE studies based on SSA: Systematic Sensitivity Analysis (Harrison and Vinod, 1992; Wigle, 1991; Pagon and Shannon, 1987) However, to date, all of these studies have taken their parameter distributions "from the literature". None of these studies has been accompanied by an econometric study aimed at estimating the key parameters and their distributions at the relevant level of aggregation used in the CGE analysis.

For this paper, we use the Gaussian Quadrature (GQ) approach to SSA, which has proven to be the most efficient and unbiased approach to systematically assessing the sensitivity of model results to parametric uncertainty (DeVuyst and Preckel, 1997; Arndt, 1996). We find that many of the results are qualitatively robust to uncertainty in the trade elasticities. In those cases where our findings are not robust, we explore the source of underlying uncertainty. In this way, the paper addresses the fundamental question: How Robust are CGE Analyses of Free Trade Agreements?

2. Analytical Framework

For this study we use the GTAP model of global trade (Hertel, 1997), variants of which have been widely used for analyses of free trade agreements in recent years. In its standard form, this model assumes perfect competition and constant returns to scale in production. Global trade and transport margins are handled explicitly and bilateral trade flows are modeled using the specification of Armington (1969). Since this paper focuses its attention squarely on the estimation of the elasticities of substitution among imports from different sources, i.e. the trade elasticities, we now turn to a detailed discussion of this aspect of the model and then to the associated econometric specification.

Import Demand Functions: Expenditure on each composite commodity i in region s, E_{is}, is determined in general equilibrium by a combination of demand for the composite commodity in private consumption, public consumption, investment demand and intermediate input demand. Therefore, for purposes of partial equilibrium estimation, we treat this expenditure level as exogenous, and focus on changes in its composition. The composite commodities are modeled as being a constant elasticity of substitution (CES) function of domestic and imported goods (1), and, at the second level of this preference structure, imports from different countries are combined in a CES function (2):

$$C_{is} = \left[b_{ids} D_{is}^{\frac{j_i - 1}{j_i}} + b_{ims} M_{is}^{\frac{j_i - 1}{j_i}} \right]^{\frac{j_i}{j_i - 1}} \tag{1}$$

$$M_{is} = \left[\sum_{r=1}^{R} b_{irs} X_{irs}^{\frac{s_i - 1}{s_i}} \right]^{\frac{s_i}{s_i - 1}} \tag{2}$$

Here, the index s denotes the importing region, C_{is} is utility of consuming composite commodity i in this region, while D_{is} is utility from domestically produced i, and M_{is} is utility from composite imports (obtained from equation (2)). The parameters b_{ds} and b_{ms} represent import-specific preference weights on domestic versus imported goods, and j_i is the elasticity of substitution between domestic and imported sources of good i in region s. We assume that this elasticity is equal across regions.

In a similar fashion, the composite demand for imports (2) is a CES function of bilateral imports of *i*, sourced from different exporting regions: X_{irs} where the b_{irs} is the associate preference weight and s_i is the elasticity of substitution among imports from different exporters. Again, we assume that this elasticity is identical across regions.

Econometric Specification and Estimation of Trade Elasticities: Our econometric estimation focuses on the second level of the two-level, Armington structure. There are several reasons for doing so. Firstly, since we will be examining the impact of a proposed preferential FTA, the key parameter will be s_i, the elasticity of substitution among imports from different sources for a given commodity. A second reason is that the data set that we have available only covers imports, and therefore does not lend itself to estimation of the upper level nest anyway. Instead, we will rely on the "rule of two" which links j_s with the estimated value for s_i as follows: $s_i = 2j_s$. This rule was first proposed by Jomini et al. (1994) and was retained in the GTAP parameter file. Recently this rule was tested by Liu, Arndt and Hertel (2002) in a back-casting exercise with a simplified version of the GTAP model. While those authors reject the validity of the GTAP trade elasticities, they fail to reject the rule of two, thereby lending some additional support to this approach.

To determine aggregate demand for imports of commodity *i* into region *s*, the importing region maximizes (1), conditional on aggregate commodity expenditure for each commodity E_{is}, giving rise to the following expenditure equation:

$$I_{is} = \frac{b_{ms}^{j_{is}}}{P_{mis}^{j_{is}-1}} \frac{1}{P_{is}} E_{is} \qquad (5)$$

where the composite commodity price index is given by:

$$P_{is} = b_{dis}^{j_{is}} P_{dis}^{1-j_{is}} + b_{mis}^{j_{is}} P_{mis}^{1-j_{is}} .$$

The optimal sourcing of imports from different exporters is obtained by maximizing (2), conditional on composite import spending I_{is}, and given the bilateral trade costs t_{irs} as well as the export prices from different sources, p_{ir}:

$$X_{irs} = b_{irs}^{s_s} I_{is} \left[\frac{p_{ir} t_{irs}}{P_{mis}^{-1/s_s}} \right]^{-s_s} \qquad (6)$$

The price index over the imported commodities is $P_{mis} = \sum_{r=1}^{R} \left(p_{ir} t_{irs} \right)^{1-s_i}$; the power of the trade cost for an imported commodity, t_{irs} , equals one plus the *ad valorem* rates for freight, insurance and tariff t_{irs}, which are all commodity- and route-specific: $t_{irs} = 1 + t_{irs}$, $t_{irs} = 1 + freight_{irs} + tariff_{irs}$.

Because it is difficult to observe demand, we multiply both sides of (6) by end-user prices $t_{irs}.p_{ir}$. We get the amount of bilateral trade T_{irs}:

$$T_{irs} = b_{irs}^{s_i} I_{irs} \left[\frac{p_{ir} t_{irs}}{P_{mis}^{1/(1-s_i)}} \right]^{1-s_i} \tag{7}$$

Which by taking the natural logarithm results in an easily estimated function (8).

$$\ln T_{irs} = \ln I_{irs} + (1-s_i)\ln p_{ir} - \ln P_{mis} + (1-s)_i \ln t_{irs} + s_i \ln b_{irs} \tag{8}$$

It is commonly observed that countries with similar languages and cultures trade more with one another than would be predicted solely on the basis of trade costs. The preference parameters b_{irs} are intended to capture these effects. To reduce the number of unobserved variables in the estimating equation, we model these preference biases explicitly, treating them as a function of physical distance: *Dist*, similarity of language: *Lang*, and adjacency of the trading countries: *Adj*. The specific functional relationship is as follows:

$$b_{irs} = Dist_{rs}^{b_{1,s}} e^{b_{2,s} Lang_{ri} + b_{3,s} Adj_{ri}}$$

Using this equation, we obtain the following:

$$\ln T_{irs} = \ln I_{irs} + (1-s_i)\ln p_{ir} - \ln P_{mis} + (1-s_i)\ln(1 + freight_{irs} + tariff_{irs}) + b_{1,i}\ln Dist_{ri} + b_{2,i} Lang_{rs} + b_{3,i} Adj_{rs} \tag{9}$$

Unfortunately, there are no data on prices and the price index and output, expenditure shares are exogenous. These variables are therefore omitted in the model and replaced with importer and exporter of commodity *i* intercepts a: $a_{ir} = 1$ if country *r* is an exporter of commodity *i*, otherwise it is 0; $a_{is} = 1$ if country *s* is an importer of commodity *i*, otherwise it is 0. The final estimating equation is (10):

$$\ln T_{irs} = a_0 + a_{is} + a_{ir} + b_i \ln(1 + freight_{sri} + tariff_{sri}) + b_{1,i}\ln Dist_{rs} + b_{2,i} Lang_{rs} + b_{3,i} Adj_{rs} + e_{irs} \tag{10}$$

where $b_i = 1 - s_i$

3. Data and Elasticity Estimates

The data used in the estimation are taken from Hummels (1999). Given the emphasis in this study on the FTAA, it is appropriate that these data are a compilation of detailed customs information on imports into six FTAA countries (Argentina, Brazil, Chile, Paraguay, USA, and Uruguay) and one non-FTAA economy (New Zealand). In order to estimate equation (10) we also require data on physical distance among the countries as well as comprehensive tariff data[1]. The final dataset contains 187,000 observations with the following variables: 5-digit SITC code of the commodity traded, *fob* and *cif* values

[1] For more information see the appendix in Hummels (1999).

for each trade flow, applied tariff rates, trade distance and two dummy variables to indicate common language or countries' adjacency. In addition, we dropped extreme observations where trade costs were either non-positive or greater than 4 times the *fob* value of the product traded.

At this point we face an interesting choice. We could either aggregate the 5-digit, SITC trade flows and trade costs according to the 42 GTAP merchandise commodity groups shown in Table 1 (the aggregation approach), or we could estimate equation (10) at the 5-digit level, constraining the elasticity of substitution among imports from different sources to be equal within each of the 42 GTAP categories (the pooling approach). The advantage of the aggregation approach is that this is the level at which the CGE modeling takes place. However, the pooling approach has considerable advantages as well. Firstly, by working with the disaggregated data, we avoid confounding aggregation bias with our parameter estimates. We also have more observations when using the pooling approach. Finally, there is greater variation in tariffs and trade costs when using the disaggregated data. Therefore, the approach adopted here is that of data pooling.

The results of Ordinary Least Squares estimation of equation (10) are presented in Table 1. Note that all of these estimates are positive and are significantly different from zero. Based on a simple t-test, each of the 40 estimated elasticities of substitution allow us to reject the hypothesis that the estimated elasticity is zero at the 95% confidence level.

Table 1 also contrasts these estimates with the original elasticities of substitution among imports from the GTAP database.[2] (Note that estimates are not available for two GTAP products which are non-traded: raw sugar and raw milk. We assign these GTAP commodities the estimated elasticity of substitution associated with trade in processed sugar and milk, respectively.) As noted previously, the GTAP parameters are widely used in the analysis of FTAs.[3] If we compute the simple average of the 40 estimates it is 7.0, which is somewhat larger than the average for the 42 GTAP parameters (5.3). Although these two averages are fairly similar, there is much greater sectoral variation in the econometrically estimated elasticities. In fact, the most striking thing about the GTAP parameters is that they show no variability within broad sectors such as food and agriculture, and metal products. This is because the source studies were not conducted at a sufficiently disaggregate level.

In contrast to the "one size fits all" assumption for food, metal products, autos and parts, etc., the estimated elasticities from this study show considerable variation within these broad sectors. For example, within the agriculture sector, the elasticities of substitution vary from a low of 2.55 for the broad grouping of "other grains products" to a high of 10.07 for the narrowly defined commodity paddy rice. The largest elasticity of substitution is for natural gas (34.44) and the lowest is for other mineral products (0.79). Yet in the GTAP parameter file, both of these products are assigned the value of 5.6, corresponding to the generic estimate for natural resource products. Clearly there is much to be gained by estimating these elasticities of substitution at a more highly disaggregated level.

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[2] The GTAP parameter file was taken from the SALTER project (Jomini et al., 1994). These trade elasticities are based on a synthesis of estimates from the literature and original econometric work for one country – New Zealand.
[3] For a sampling of these applications, visit the GTAP web: www.gtap.org).

4. Application to the FTAA

Background: The recent growth of free trade agreements in the Western Hemisphere began in the 1980s as Latin American countries initiated significant trade and economic policy reforms. It was accelerated in the 1990's with the advent of the North American Free Trade Agreement (NAFTA). Over the past two decades, more than forty regional or bilateral trade agreements have been implemented within the hemisphere. In fact, every country except Cuba has been party to at least one such agreement. With the rapid growth of free trade agreements among countries, the idea for the FTAA arose as a logical next step in the economic integration of the hemisphere. A more encompassing agreement also provides a way of simplifying the complex network of existing FTA and bilateral agreements in place (Diao and Somwaru, 2001). Two of these, the NAFTA and the Common Market of the South (MERCOSUR) are among the largest FTAs in the world, and the member countries of these agreements include the principal negotiators in the FTAA process.

The FTAA effort was initiated in December of 1994 as leaders of the thirty-four democracies in the Western Hemisphere met in Miami for the "Summit of the Americas". It was decided there to begin a negotiating process leading to a free trade agreement, to be completed by 2005. The most recent ministerial meeting of the FTAA was held in Quito, Ecuador in November 2002. This resulted in ministerial declarations that largely reaffirmed the FTAA and its commitment to be implemented on time and in a consistent manner with WTO rules (FTAA Tri-Partite Commission 2002a; 2002b).

Given the focus on merchandise trade in the Americas, and in light of the large dimensions of the GTAP data base, we begin by aggregating the sixty-six regions of the version 5.0 GTAP database to the seventeen regions presented in Table 2. Full GTAP country detail is preserved in the Western Hemisphere, while composite regions are formed for the rest of the world, including: Asia-Oceania (ASOC), the fifteen-member European Union (EU15), rest of Europe (OEUR), and Middle East and Africa (MEAF). In order to further reduce the dimension, services activities are also aggregated into four broad categories.

In order to fairly assess the changes that occur due to liberalization under the FTAA, it is important that the benchmark data account for the pre-existing applied tariff structure in the liberalizing regions. This is complicated by the fact that the benchmark data in the version 5.0 database has a base year of 1997 and reflect only the MFN tariff structure (i.e. no tariff preferences are included).[4] Given the prevalence of FTAs in this region, as well as the reductions in applied tariffs that have been observed since 1997, it is necessary to adjust the initial levels of protection before undertaking our analysis.

Recent work undertaken by the International Trade Center in Geneva, with funding from the Centre d'Etudes Prospectives et d'Information Internationales (CEPII) allows us to overcome some of these problems. These organizations have developed a tariff data base for 2001, nicknamed "MacMAPS2". It is based on the most current data on preferential applied tariffs obtained from the UNCTAD TRAINS database as well as other sources (Bouët, Fontagné, Mimouni, and von Kirchbach, 2002). Table 3 depicts the FTAs in the Americas that are treated in MacMAPS2, including member countries and agreement type. Bouët et al. (2002) find that differences between GTAP Version 5.0 and

[4] The one exception in the Americas is the simplistic treatment of NAFTA, which is assumed to have eliminated all non-agricultural tariffs between Canada, USA and Mexico.

MacMaps2 protection levels are not large for weakly protected sectors, but the two are significantly different in clothing, textile, cereals, and agri-food sectors. Another source of difference between the two data bases has to do with the weights used in the tariff aggregation process – from the tariff line to the 42 GTAP merchandise trade categories. In the case of GTAP 5.0, these are the trade flows passing over the tariff in question. In the case of MacMAPS2, these weights are based on regional imports in an attempt to avoid the aggregation bias that arises when (e.g.), a prohibitive tariff in one country causes its trade flow to be zero.

Table 4 reports a comparison of average tariffs, by broad sector, for the GTAP FTAA regions, between the GTAP 5.0 and MacMAPS2 data bases. In general, the MacMAPS2 rates are lower, reflecting presence of preferential tariffs in this data base. This is particularly striking in the case of the MERCOSUR countries. When computed on an MFN basis, average manufacturing tariffs in Argentina and Brazil are about 15%, whereas they fall to 10% when preferential tariffs are used – a drop of one-third. We incorporate these revised tariffs into the initial data base using the ALTERTAX updating procedure developed by Malcolm (1998). By taking these preferences into account prior to our FTAA analysis, we obtain a much more accurate depiction of the likely effects of such an agreement. Failure to do so would result in a significant overstatement of the welfare gains from the FTAA.

Simulation and SSA: The simulation experiment undertaken here is a stylized representation of an FTAA scenario. It involves reducing all tariffs on intra-regional trade for the forty-two merchandise trade commodities to zero. While this is not likely to be a politically feasible scenario, this represents a useful benchmark and can be viewed as an upper bound on the potential gains from liberalization (Young and Huff, 1998).

As noted in the introduction, the centerpiece of this study involves the systematic sensitivity analysis of the results with respect to the estimated trade elasticities. The most common manner in which this is done employs Monte Carlo analysis. Here, the model is solved repeatedly, each time with a random sample of substitution elasticities, drawn from the empirical distribution of estimated trade elasticities. In many cases Monte Carlo is infeasible for a large CGE model however, owing to the large dimension of a multiregional model and the large number of solutions required to approximate the distribution of the uncertain parameters (Arndt, 1996). However, DeVuyst and Preckel (1997) show that an approximate distribution can be obtained based on known lower order moments of the parameters of a model, and that from selecting from this approximate distribution for generating model solutions, sensitivity results can be generated efficiently. This technique, known as Gaussian Quadrature, is employed here for generating sensitivity results to the trade elasticities.

For convenience, and for practical reasons, we invoke several assumptions about the underlying parameter distributions. First, we assume that they are independently distributed. Secondly, we assume that they can be approximated by a symmetric triangular distribution with a mean value equal to the elasticity estimate in Table 1 and a standard deviation equal to the estimate in that same table. Finally, we assume that the distribution is such that the parameter is everywhere non-negative. The final column of Table 1 presents the lower bound for the resulting, symmetric, triangular distributions. An asterisk denotes those cases where the standard deviation was reduced in order to satisfy the non-negativity requirement. Finally, the elasticity of substitution in the domestic-import substitution nest (recall equation

1) is assumed to be tied to ESUBM via the "rule of two" so that these elasticities vary together and by the same proportion in repeated solutions of the model.

5. Results

The results of our simulation may be reported in a number of ways. First of all, since we use distributions, rather than point estimates, for the trade elasticities, our results also come in the form of distributions. Therefore, the most natural thing to look at is the mean value for each variable of interest, e.g., exports, welfare, or employment. Each variable of interest will likewise have an associated standard deviation. This information, accompanied with an assumption regarding the shape of the underlying distribution of endogenous variables (we assume normality) allows formation of confidence intervals for model results, and thus the ability to address the question at the focus of this paper: *How confident can we be in the CGE-based analyses of Free Trade Agreements?*

Tables 5 through 9 report the results of the FTAA experiment for endogenous variables relating to exports and welfare changes. In each case the result is presented with a mean value bracketed by upper and lower values that represent the bounds of a 95% confidence in interval for the endogenous variable. These confidence intervals are constructed based on the assumption that each variable is normally distributed.

The second column of Table 5 reports the mean percentage change in regional export volume as a result of the FTAA experiment. Aggregate export volume increases in all regions, including the excluded (non-FTAA) regions. Furthermore, the 95% confidence intervals (columns one and three in Table 5), constructed based on the assumption of normality, show that we can be confident in all of these increases. The largest increase is for Colombia, and our 95% confidence interval for this country does not overlap with that of Peru, which shows the next largest increase in total exports. These large increases in exports may be directly attributed to the relatively larger tariff rates for these two countries (recall Table 4). Larger tariff cuts translate into a greater import increase. In order to pay for these imports, exports must increase.[5] Hence the increases observed in Table 5. Most of the aggregate export volume observations fall between +3% and +8%, with the exception of the US and Canada, which already enjoy free trade with one another. Also Uruguay and Venezuela show very low export volume increases. This can be attributed to the relative loss of preferential access that occurs under FTAA for these two regions when FTA partners in MERCOSUR and the Andean Pact, respectively, liberalize with other regions in the Americas. In fact, both Uruguay and Venezuela both experience a relatively large decline in export volume to their pre-FTAA regional agreement partners.

One interesting question that arises in the context of our SSA is whether there is greater certainty about more aggregate variables than about disaggregate variables produced by this model. The last two columns in Table 5 address this issue in the case of exports. First we report the absolute value of the coefficient of variation (the ratio of the standard deviation divided by the mean) for the change in national exports (this is the change reported in column 2 of Table 5). When this ratio is small, we can infer a

[5] An alternative mechanism would be for capital inflows to increase. This mechanism is indeed available in the standard GTAP closure used here, in which the global bank allocates investment to equate expected rates of return across regions. However, this effect is of secondary importance in the case of the FTAA.

relatively higher level of confidence in the result. Note that it is quite small for Argentina, whereas it reaches its maximum value in the case of the Middle East and Africa. The final column in Table 5 reports the *average* coefficient of variation for the percentage change in national exports, *at the sector level*. Thus this gives an indication of the average degree of precision for the more disaggregate results. As can be see by comparing these two entries for each country, the more disaggregate results are less precise. This is perhaps intuitive in that we often expect a certain degree of offset at the aggregate level. Under a given configuration of trade elasticities, some sector exports may be higher, while others are lower, leading to less variation in national exports.

Tables 6 through 9 focus on welfare effects resulting from implementation of the FTAA scenario. The decomposition approach employed is based on the equivalent variation (EV) welfare measure and is outlined in Huff and Hertel (2001). Table 6 reports the mean allocative efficiency effect associated with the FTAA. Provided the trade creation effects of lower average tariffs dominate the trade diversion effects of shifting imports from low cost non-FTAA suppliers, to higher cost, FTAA suppliers, we expect this effect to be positive for the FTAA regions. This is the case for seven of the FTAA regions, with the other six, Chile, Venezuela, USA, Argentina, Uruguay, and XSM showing negative allocative welfare effects.. In the case of USA and Uruguay, the efficiency effect is uncertain – with the 95% confidence interval including both negative and positive values.

One of the challenges in FTAA analysis derives from the fact that, unlike most of the simple models of trade theory, there are many non-tariff distortions in these economies. Thus the possibility of second best outcomes arises. Table 7 helps to pin down these second-best effects by reporting only the portion of the allocative efficiency changes that is directly attributable to increased import volumes flowing across tariffs. Here, we see that the trade diversion effect dominates the trade creation effect for Venezuela, Chile, and XSM. Therefore, in the case of USA, Argentina and Uruguay, efficiency in the non-import markets falls due to a volume change interacting with some other type of distortion – e.g., an increase in subsidized farm production in the U.S. Therefore, the uncertainty in the aggregate efficiency effect for these three regions is the result of offsetting positive (import volume) and negative (non-import volume) efficiency effects.

We turn next to the terms of trade effects (Table 8).[6] We expect these effects to be largest (relative to export volume) in those countries where exports surge the most. Thus it is no surprise that the terms of trade deteriorate for Colombia and Peru, as these are countries with very high average tariffs. The terms of trade also deteriorate for Argentina, Canada, Mexico and the Rest of South America. Mexico and Canada may be understood by the fact that these countries currently enjoy tariff free access to the largest market in the region for many of their products. When the FTAA is introduced, other countries obtain the same benefit and they displace Mexican and Canadian imports. The same general phenomenon explains why Argentina's terms of trade effect declines and the effect on XAP is uncertain.

Another dimension of this analysis of uncertainty in the terms of trade effect can be observed in Figure 1. In this figure, we show how uncertainty in each FTAA region's average export demand elasticity translates into uncertainty in the export price component of their terms of trade (see McDougall, 1992 for details on this terms of trade decomposition). Countries that rely heavily on exports of

[6] For purposes of this table, we have expanded the terms of trade effect to include the effect of changes in the prices of the savings and investment goods in addition to the traditional changes in the prices of merchandise and services.

commodities whose substitution elasticities of trade are highly uncertain (e.g., Colombia) are exposed to a great deal of uncertainty in the size of their average export demand elasticity (horizontal axis of Figure 1) and tend to experience more uncertainty in the export price component of their terms of trade (vertical axis). Venezuela is an exception to this rule. It exhibits a high degree of uncertainty in export demand elasticities due to a heavy reliance on oil and gas exports, which are large and rather uncertain. On the other hand, the variation in the export price component of its terms of trade is relatively small.

We are now in a position to answer the question: What countries gain from the FTAA? We see from Table 9 that ten of the thirteen FTAA countries gain from this free trade agreement based on the 95% confidence interval. On the other hand, Argentina and XSM are shown to lose from the FTAA. In the case of Argentina, this is entirely driven by the dominant adverse terms of trade effect that is large enough to counter the uncertainty we saw in the allocative efficiency welfare component for Argentina. For XSM, both the terms of trade and allocative effects were negative, including the observation that we are confident in a trade diversion effect driving the allocative efficiency decline.

The welfare impacts on the final country: Colombia is uncertain. This is an interesting case, since the component parts of their aggregate welfare impacts are "certain" in the sense that the 95% confidence intervals do not include zero. However, the positive allocative efficiency component is offset by an equally large negative terms of trade effect. So while the components of the welfare change are certain, the sign of their summation – the aggregate welfare gain – is *uncertain*. This type of uncertainty is not inherited from uncertainty about the model parameters governing substitution in trade. Rather, it relates to the presence of competing effects due to different economic forces at work on national welfare.

There are many other variables that one could report – particularly at the sector level. Here we focus our attention on employment, as the displacement of unskilled workers is often one of the most sensitive topics surrounding any free trade agreement. Table 10 summarizes the directional changes in unskilled employment, by sectors for each region. The first column reports the total number of sectors in which employment of unskilled labor rises and the second column reports the number in which employment falls. Since total employment remains unchanged, by assumption, the relative size of these two numbers is not very meaningful. However, it is interesting to ask how many of these changes are significantly different from zero at the 95% level. This is reported in the next column of Table 11. Here we see that the changes in employment are generally quite robust to the estimated variation in trade elasticities. We able to sign the change in employment for a given sector at the 95% confidence level for a given region in over 80% of the cases for all FTAA regions except Mexico.

Table 1 reports the same employment data as Table 10, with the focus shifted to employment by sectors across all of the model regions. This allows us to evaluate how the uncertainty in sectoral trade elasticities translates into uncertainty about the employment effects for a given sector. Here we see that for all but five of the forty-two sectors, we are confident in the direction of change in employment for a given sector in seventy percent or more of the regions. The exceptions here are four primary commodities: paddy rice, vegetables and fruits, other grains, and coal, as well as processed rice. Not surprisingly, Table 1 shows that these sectors have some of the largest standard deviations relative to the size of the estimated elasticity.

5. Summary and Conclusions

Computable General Equilibrium analysis is often criticized for its lack of econometric foundations (McKitrick, 1998). The goal of this paper is to show that it is indeed possible to provide substantial statistical underpinning to policy analyses conducted in the CGE context. We focus our attention on analysis of Free Trade Agreements – specifically, the Free Trade Agreement of the Americas – for which the key behavioral parameter is the elasticity of substitution among imports from different countries. This governs the extent to which non-FTAA regions will be displaced by the preferential reduction in tariffs on imports from FTAA countries.

Historically, estimation of the import substitution elasticity has been difficult, due to insufficient observed variation in relative prices. In this paper, we capitalize on a unique data set and approach developed by Hummels (1999), in which variation in bilateral transport costs is combined with bilateral tariff variation in order to enhance the observed variability of relative prices for imports from different sources in six FTAA countries and one non-FTAA country. Elasticities are estimated at the GTAP commodity level to facilitate subsequent incorporation into our CGE model. The resulting estimates of the elasticity of substitution among imports are all significant at the 95% level. These estimates, together with their standard errors, are used in the subsequent policy simulations.

The FTAA analysis takes explicit account of the fact that we do not know the true trade elasticities with certainty. Rather, we sample from a distribution of parameter values, constructed based on our econometric results. The product of this systematic sensitivity analysis is a distribution of model results, from which we can construct confidence intervals with which to answer the basic question posed in the title of this paper. We find that exports increase in all regions of the world as a result of the FTAA, and this outcome is robust to variation in the trade elasticities. Ten of the thirteen FTAA regions experience a welfare gain in which we are more than 95% confident. Two regions, Argentina and "rest of South America" experience welfare losses as they are displaced from existing markets in which they currently enjoy preferential access. Finally, the impact on Colombia is uncertain. We also examine the robustness of our employment effects. With the exception of several primary products, where the trade elasticity is relatively uncertain, we can be confident in the sign of the sectoral employment effects in the majority of regions.

In summary, we are conclude that there is great potential for combining econometric work with CGE-based policy analysis in order to produce a richer set of results that are likely to prove more satisfying to the sophisticated consumer of model results. In the end, the key question is always: How robust are the policy findings? In this paper we have found that some of the FTAA conclusions are robust, while others are not. This is important information for policy makers seeking to make key political decisions based in part on results from this type of economic model.

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Figure 1. Uncertainty Comparison: Trade Elasticity and TOT Export Price Effect

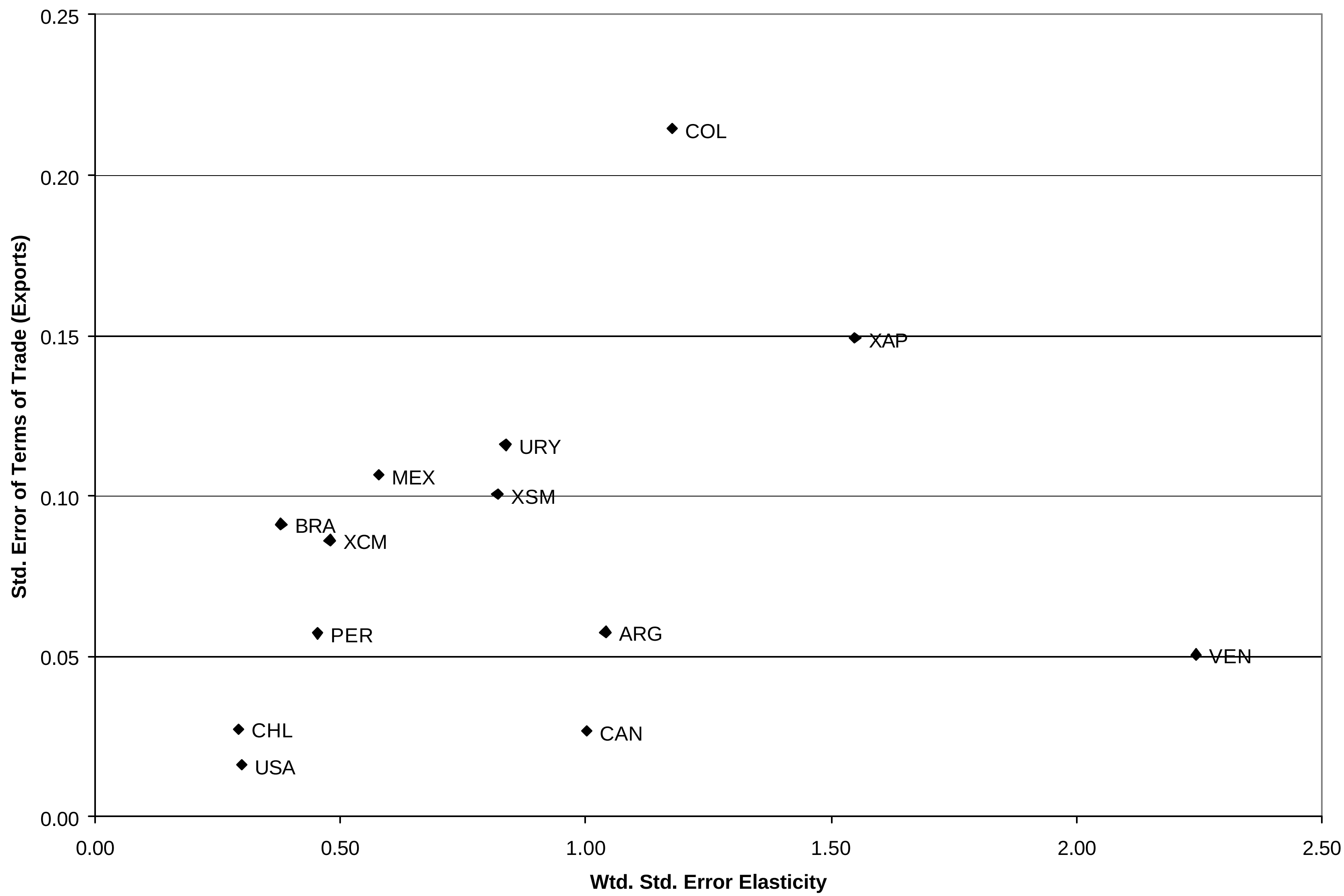

Table 1. Elasticities of Substitution among Imports from Different Sources

	Code	Description	Original Elasticity	Estimated Elasticity	SD	Num Obs	Lower Bound	Upper Bound
1	**PDR**	Paddy rice	4.4	10.1*	4.0	26	0.30	19.90
2	**WHT**	Wheat	4.4	8.9*	4.2	32	0.01**	17.79
3	**GRO**	Cereal grains nec	4.4	2.6*	1.1	131	0.01**	5.19
4	**V_F**	Vegetables, fruit, nuts	4.4	3.7*	0.4	1,199	2.72	4.68
5	**OSD**	Oil seeds	4.4	4.9*	0.8	239	2.94	6.86
6	**C_B**	Sugar cane, sugar beet	4.4	N/A	N/A	3	N/A	N/A
7	**PFB**	Plant-based fibers	4.4	5.0*	2.4	71	0.01**	9.99
8	**OCR**	Crops nec	4.4	6.5*	0.4	1,796	5.52	7.48
9	**CTL**	Bovine cattle, sheep and goats, horses	5.6	4.0*	0.7	156	2.29	5.71
10	**OAP**	Animal products nec	5.6	2.6*	0.3	813	1.87	3.33
11	**RMK**	Raw milk	4.4	N/A	N/A	-	N/A	N/A
12	**WOL**	Wool, silk-worm cocoons	4.4	12.9*	2.7	76	6.29	19.51
13	**FOR**	Forestry	5.6	5.0*	0.7	529	3.29	6.71
14	**FSH**	Fishing	5.6	2.5*	0.6	527	1.03	3.97
15	**COL**	Coal	5.6	6.1*	2.4	71	0.22	11.98
16	**OIL**	Oil	5.6	10.4*	3.8	56	1.09	19.71
17	**GAS**	Gas	5.6	34.4*	14.3	8	0.01**	68.79
18	**OMN**	Minerals nec	5.6	1.8*	0.3	1,584	1.07	2.53
19	**CMT**	Bovine meat products	4.4	7.7*	1.9	211	3.05	12.35
20	**OMT**	Meat products nec	4.4	8.8*	0.9	411	6.60	11.00
21	**VOL**	Vegetable oils and fats	4.4	6.6*	0.7	717	4.89	8.31
22	**MIL**	Dairy products	4.4	7.3*	0.8	547	5.34	9.26
23	**PCR**	Processed rice	4.4	5.2*	2.6	62	0.01**	10.39
24	**SGR**	Sugar	4.4	5.4*	2.0	156	0.50	10.30
25	**OFD**	Food products nec	4.4	4.0*	0.1	6,917	3.76	4.24
26	**B_T**	Beverages and tobacco products	6.2	2.3*	0.3	998	1.57	3.03
27	**TEX**	Textiles	4.4	7.5*	0.1	14,375	7.26	7.74
28	**WAP**	Wearing apparel	8.8	7.4*	0.2	9,090	6.91	7.89
29	**LEA**	Leather products	8.8	8.1*	0.3	3,457	7.37	8.83
30	**LUM**	Wood products	5.6	6.8*	0.2	4,120	6.31	7.29
31	**PPP**	Paper products, publishing	3.6	5.9*	0.2	6,597	5.41	6.39
32	**P_C**	Petroleum, coal products	3.8	4.2*	1.1	344	1.51	6.89
33	**CRP**	Chemical, rubber, plastic products	3.8	6.6*	0.1	61,603	6.36	6.84
34	**NMM**	Mineral products nec	5.6	5.8*	0.2	6,240	5.31	6.29
35	**I_S**	Ferrous metals	5.6	5.9*	0.3	5,524	5.17	6.63
36	**NFM**	Metals nec	5.6	8.4*	0.4	3,194	7.42	9.38
37	**FMP**	Metal products	5.6	7.5*	0.2	9,926	7.01	7.99
38	**MVH**	Motor vehicles and parts	10.4	5.6*	0.3	2,238	4.87	6.33
39	**OTN**	Transport equipment nec	10.4	8.6*	0.4	1,843	7.62	9.58
40	**ELE**	Electronic equipment	5.6	8.8*	0.2	8,916	8.31	9.29
41	**OME**	Machinery and equipment nec	5.6	8.1*	0.1	44,386	7.86	8.34
42	**OMF**	Manufactures nec	5.6	7.5*	0.2	7,586	7.01	7.99

*Estimate Significant at 95% Confidence Level for H0: (Two-Sided) Parameter not equal to zero or (One-Sided) Parameter greater than zero
**Lower Bound of Triangular Distribution Truncated

Table 2. Regional Aggregation for the Simulation

Simulation Region	Name	GTAP Region
ASOC	Asia and Oceania	Australia, New Zealand, China, Hong Kong, Japan, Korea, Taiwan, Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam, Bangladesh, India, Sri Lanka, Rest of South Asia, Rest of World
can	Canada	Canada
usa	United States	United States
mex	Mexico	Mexico
xcm	Central America and Caribbean	Central America and Caribbean
col	Colombia	Colombia
per	Peru	Peru
ven	Venezuela	Venezuela
xap	Rest of Andean Pact	Rest of Andean Pact
arg	Argentina	Argentina
bra	Brazil	Brazil
chl	Chile	Chile
ury	Uruguay	Uruguay
xsm	Rest of South America	Rest of South America
EU15	European Union	Austria, Belgium, Denmark, Finland, France, Germany, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden
OEUR	Other Europe	Switzerland, Rest of EFTA, Hungary, Poland, Rest of Central European Associates, Former Soviet Union, Turkey
MEAF	Middle East and Africa	Rest of Middle East, Morocco, Rest of North Africa, Botswana, Rest of South African Customs Union, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe, Other Southern Africa, Uganda, Rest of Sub Saharan Africa

Table 3. Regional Trade Agreements in the Americas

Agreement	Member Countries	Type	Activity
NAFTA	Canada, Mexico, USA	Free Trade Area	• 1993, preceded by Canada-US FTA in 1989 • Largely implemented
MERCOSUR	Argentina, Brazil, Paraguay, Uruguay	Common Market	• 1 January 1995 • Expansion to Associate Members (non-CET), Chile and Bolivia • Third Party Agreements with EU15, Andean Pact, Mexico
Andean Pact	Bolivia, Colombia, Ecuador, Peru, Venezuela	Customs Union	• 1969, most implementation post-1990 • CET escalation for processed products
CACM	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua,	Common Market	• 1960, most implementation post-1990 • CET escalation for processed products • Recent efforts to fully harmonize and lower CET for processed consumer goods
CARICOM	Caribbean, Small Central and South American nations	Common Market	• 1973 onward
Chile's Agreements	Chile, numerous	Bilateral Agreements	• 1988 onward

Table 4. Comparison of Tariff Rates: MacMaps2 and GTAP 5

Importing Region	Bulk Ag.		Proc. Ag.		Mnfcs.	
	MacMaps2	GTAP	MacMaps2	GTAP	MacMaps2	GTAP
can	0.90	1.21	23.25	28.94	0.84	1.30
usa	1.63	2.33	8.68	11.13	2.17	2.65
mex	16.44	15.42	35.71	31.57	6.34	2.68
xcm	5.65	6.30	16.29	17.85	9.36	11.58
col	97.72	11.43	77.71	18.18	8.41	11.37
per	12.27	13.08	14.98	15.22	11.17	12.27
ven	10.43	10.78	16.14	17.98	9.96	13.88
xap	8.48	9.09	11.75	17.84	7.53	9.92
arg	3.31	5.11	10.06	15.88	9.85	14.43
bra	1.76	5.64	7.85	16.64	10.63	15.70
chl	8.00	11.08	8.00	11.05	8.00	10.95
ury	1.16	4.21	7.71	18.36	7.48	11.40
xsm	5.70	4.44	16.04	16.09	9.25	11.62

Table 5. Change in Aggregate Exports Due to FTAAMean

	Bracketed by 95% Confidence Interval			Coefficient of variation	
Regions	Lower	Mean	Upper	Total Exports	Sector Average
can	1.35	1.67	2.00	0.10	0.33
usa	1.58	1.67	1.76	0.03	0.63
mex	5.88	7.04	8.20	0.08	0.55
xcm	6.83	7.36	7.88	0.04	0.36
col	12.82	14.91	17.01	0.07	0.27
per	8.41	9.28	10.15	0.05	0.48
ven	0.64	0.74	0.85	0.07	0.40
xap	3.43	3.82	4.22	0.05	0.62
arg	3.84	3.93	4.01	0.01	0.20
bra	6.00	6.23	6.45	0.02	0.29
chl	3.60	3.76	3.92	0.02	0.70
ury	0.79	1.03	1.26	0.12	0.82
xsm	4.40	4.73	5.07	0.04	0.30
ASOC	0.11	0.12	0.12	0.02	0.39
EU15	0.06	0.06	0.06	0.02	0.37
OEUR	0.06	0.06	0.07	0.04	0.37
MEAF	0.03	0.05	0.07	0.18	0.40

Table 6. Allocative Efficiency Effects Due to the FTAA

Region	Lower	Mean	Upper
can	576.22	781.36	986.50
usa	-146.11	-10.91	124.29
mex	984.89	1437.87	1890.85
xcm	539.12	589.92	640.73
col	527.48	656.55	785.62
per	134.49	145.70	156.91
ven	-41.06	-36.07	-31.08
xap	32.65	40.23	47.80
arg	-19.56	-11.47	-3.37
bra	1197.64	1278.19	1358.74
chl	-30.11	-25.53	-20.95
ury	-2.66	2.86	8.38
xsm	-9.96	-7.11	-4.27
ASOC	-557.44	-482.30	-407.17
EU15	-820.44	-718.73	-617.01
OEUR	-102.71	-91.27	-79.84
MEAF	-176.02	-149.20	-122.37

Table 7: Allocative Efficiency Effects Due to Import Changes

Region	Lower	Mean	Upper
can	535.66	715.91	896.16
usa	498.72	563.93	629.14
mex	790.41	1140.88	1491.35
xcm	296.20	327.30	358.41
col	484.04	599.98	715.92
per	11.22	15.28	19.34
ven	-44.31	-39.38	-34.45
xap	6.18	12.93	19.67
arg	16.14	21.42	26.69
bra	67.69	82.57	97.45
chl	-63.07	-57.94	-52.82
ury	1.83	2.93	4.03
xsm	-11.96	-10.58	-9.20
ASOC	-388.75	-328.98	-269.21
EU15	-287.39	-238.03	-188.67
OEUR	-39.39	-32.02	-24.65
MEAF	-141.52	-117.96	-94.40

Table 8. Terms of Trade Effects Due to the FTAA

Region	Lower	Mean	Upper
can	-770.97	-624.07	-477.17
usa	6328.50	6878.05	7427.60
mex	-1453.70	-1188.72	-923.74
xcm	748.30	832.34	916.38
col	-698.93	-607.33	-515.72
per	-106.07	-95.25	-84.43
ven	83.30	102.54	121.78
xap	-12.82	11.80	36.42
arg	-123.84	-90.22	-56.59
bra	403.01	538.68	674.35
chl	153.38	164.48	175.57
ury	3.28	13.55	23.82
xsm	-92.78	-82.05	-71.31
ASOC	-3022.72	-2940.59	-2858.46
EU15	-2540.80	-2493.97	-2447.14
OEUR	-290.95	-268.53	-246.11
MEAF	-267.42	-200.71	-134.00

Table 9. Regional EV Change Due to FTAA

Region	Lower	Mean	Upper
can	54.43	157.29	260.15
usa	6374.71	6867.15	7359.59
mex	51.67	249.16	446.64
xcm	1311.65	1422.27	1532.89
col	-9.49	49.22	107.93
per	34.49	50.45	66.41
ven	46.29	66.47	86.65
xap	20.29	52.03	83.76
arg	-142.43	-101.68	-60.94
bra	1602.85	1816.86	2030.87
chl	126.48	138.94	151.41
ury	2.31	16.41	30.52
xsm	-102.33	-89.16	-75.99
ASOC	-3521.33	-3422.88	-3324.43
EU15	-3331.16	-3212.70	-3094.24
OEUR	-382.61	-359.80	-337.00
MEAF	-429.29	-349.91	-270.52

Table 10. Regional Employment Effects Due to FTAA

	Number of Sectors with:		
Region	Employment Increase	Employment Decrease	Pct Results with 95% Confidence
can	30	12	81%
usa	30	12	90%
mex	29	13	79%
xcm	9	33	93%
col	21	21	86%
per	19	23	88%
Ven	23	19	83%
Xap	19	23	81%
Arg	21	21	90%
Bra	23	19	86%
Chl	21	21	86%
Ury	14	28	86%
Xsm	17	25	81%
ASOC	20	22	79%
EU15	16	26	76%
OEUR	18	24	81%
MEAF	16	26	83%

Table 11. Sectoral Employment Effects Due to FTAA

	Number of Regions with		
Sector	Employment Increase	Employment Decrease	Pct Results with 95% Confidence
PDR	12	5	53%
WHT	5	12	76%
GRO	7	10	65%
V_F	6	11	65%
OSD	10	7	82%
C_B	9	8	71%
PFB	5	12	71%
OCR	7	10	76%
CTL	12	5	71%
OAP	9	8	100%
RMK	8	9	94%
WOL	8	9	88%
FOR	8	9	94%
FSH	9	8	94%
COL	5	12	59%
OIL	8	9	82%
GAS	5	12	82%
OMN	13	4	76%
CMT	13	4	82%
OMT	7	10	94%
VOL	12	5	88%
MIL	6	11	100%
PCR	9	8	29%
SGR	10	7	76%
OFD	8	9	88%
B_T	11	6	76%
TEX	7	10	94%
WAP	9	8	88%
LEA	11	6	94%
LUM	7	10	88%
PPP	8	9	94%
P_C	8	9	76%
CRP	6	11	100%
NMM	9	8	88%
I_S	5	12	94%
NFM	9	8	94%
FMP	7	10	100%
MVH	5	12	100%
OTN	12	5	94%
ELE	7	10	94%
OME	6	11	94%
OMF	8	9	100%