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Abstract

Computable General Equilibrium models, widely used for the analysis of Free Trade Agreements (FTAs) are often criticized for having poor econometric foundations. This paper improves the linkage between econometric estimates of key parameters and their usage in CGE analysis in order to better evaluate the likely outcome of a Free Trade Area of the Americas. Our econometric work focuses on estimation of a particular parameter, the elasticity of substitution among imports from different countries, which is especially critical for evaluating the positive and normative outcomes of FTAs. We match the data in the econometric exercise to the policy experiment at hand, and employ both point estimates and standard errors from the estimates.

The FTAA analysis then takes explicit account of the degree of uncertainty in the underlying parameters. We sample from a distribution of parameter values given by our econometric estimates in order to generate a distribution of model results, from which we can construct confidence intervals. We find that imports 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. We 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 policy maker.

JEL classifications: C15; C68; F11; F15

Keywords: Trade elasticities; general equilibrium; systematic sensitivity analysis; free trade agreements

"The econometric cat was set among the pigeons when a second government-commissioned modelling study on the FTA was finally released… The second reason for the contradictory results is differing assumptions about an arcane economic relationship known as Armington elasticity." (Financial Times, 2003)

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 assumptions on the price elasticity of export demand (henceforth, the trade elasticity). As will be demonstrated in Section 2, small trade elasticities generate large terms of trade effects by reducing the responsiveness of export demand. On the other hand, small trade elasticities reduce the likelihood of trade diversion, as import sourcing becomes less sensitive to relative prices. Of course, large trade elasticities lead to the opposite results. Critics are understandably wary of results being determined largely by the authors' choice of trade elasticities. Indeed, the sensitivity of welfare results to the choice of trade elasticities has even surfaced in the popular press as witnessed in the opening quotation to this paper.[1]

Where do these trade elasticities come from? CGE modelers typically draw the 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, Marsden, and Zeitsch, 1977; Stern et al., 1976; Gallaway, McDaniel and Rivera, 2003). This approach has three problems: the use of point estimates as "truth", downward bias in the magnitude of the point estimates created by problems in the estimation technique, and a mis-match between the data sample and source of variation in the econometric exercise and the policy experiment explored in the CGE exercise.

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[1] In this article, two studies of the Australia-USA FTA are discussed, one which reports a gain, and one which reports a loss. Differing assumptions about the benefits of services liberalization was the first reason identified, while the second difference for the contradictory results was identified as the assumptions about the Armington elasticities.

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 fail to properly address this problem because they ignore 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. This approach tends to systematically understate the true elasticity 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 substituting 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. In addition, 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 vs. 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 vs. foreign substitutability.

In summary, the history of estimating the substitution elasticities governing trade flows in CGE models has been checkered at best. Yet they are central to the welfare results of such studies. 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 world-wide 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. As highlighted by the quotation at the start of this paper, this type of model is still widely used by government agencies for the evaluation of such agreements. In fact, the GTAP model (Hertel 1997) which we employ in this paper is actively used in dozens of public research institutions around the world. 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 *preferential* FTA 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, affecting all suppliers in the same way. Tariff preferences, where they exist, are often difficult to measure – sometimes being confounded by quantitative barriers, rules of origin, and other restrictions. Instead we employ a unique 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 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 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 in which the key parameters and their distributions are estimated using data samples and variation that closely match the policy experiment considered 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. Explaining Welfare Changes: The Role of Trade Elasticities

Due to the centrality of the trade elasticities to our argument, we begin by specifying the nested CES import demands. 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):

$$QC_{is} = \left[\beta_{Dis} QD_{is}^{\frac{\varphi_i - 1}{\varphi_i}} + \beta_{Mis} QM_{is}^{\frac{\varphi_i - 1}{\varphi_i}} \right]^{\frac{\varphi_i}{\varphi_i - 1}} \tag{1}$$

$$QM_{is} = \left[\sum_{r=1}^{R} b_{irs} QMS_{irs}^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}} \tag{2}$$

Here, the index s denotes the importing region, QC_{is} is utility of consuming composite commodity i in this region, while QD_{is} is utility from domestically produced i, and QM_{is} is utility from composite imports (obtained from equation (2)). The parameters β_{Dis} and β_{Mis} represent import-specific preference weights on domestic versus imported goods, and φ_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 r: QMS_{irs} where the b_{irs} is the associated preference weight and σ_i is the elasticity of substitution among imports from different exporters. Again, we assume that this elasticity is identical across regions.

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 import expenditure equation:

$$I_{is} = \frac{\beta_{Mis}^{\varphi_{is}}}{P_{Mis}^{\varphi_{is}-1}} \frac{1}{P_{is}} E_{is} \tag{3}$$

where the composite commodity price index is given by:

$$P_{is} = \beta_{Dis}^{\varphi_{is}} PD_{is}^{1-\varphi_{is}} + \beta_{Mis}^{\varphi_{is}} PM_{is}^{1-\varphi_{is}} \ . \tag{4}$$

The optimal sourcing of imports from different exporters is obtained by maximizing (2), conditional on composite import spending I_{is}, given the import prices from different sources, PMS_{irs}:

$$QMS_{irs} = b_{irs}^{\sigma_i} I_{is} PM_{is}^{-1} \left[\frac{PMS_{irs}}{PM_{is}} \right]^{-\sigma_i} \tag{5}$$

The price index over the imported commodities is given by:

$$PM_{is} = \left[\sum_{r=1}^{R} b_{irs}^{\sigma_i} \left(PMS_{irs} \right)^{1-\sigma_i} \right]^{1/1-\sigma_i} \tag{6}$$

Changes in welfare in response to an FTA may be decomposed using the method of Huff and Hertel (1996), who provide an analytical decomposition of the Equivalent Variation (EV) for the representative household in region s.[2] It is similar in spirit to that of Baldwin and Venables (1995), however, unlike the latter decomposition, it allows for non-homothetic preferences, domestic taxes and subsidies, and, most importantly, it assumes products are differentiated by origin (the Armington assumption). This decomposition is also implemented numerically to decompose non-local welfare changes. For the sake of brevity, we focus on the case where there are no export taxes, and domestic taxes are applied only to consumption and production. (This assumption will be relaxed in the empirical analysis.) As we will show, the elasticity of substitution is a key parameter determining both positive responses to the FTAA as well as their normative implications.

The EV decomposition is given by the following equation:

$$EV_s = (\psi_s) \left\{ \begin{array}{l} \sum_{i=1}^{N} \sum_{r=1}^{R} \left(\tau_{Mirs} PCIF_{irs} dQMS_{irs} \right) \\ + \sum_{i=1}^{N} \left(\tau_{CDis} PD_{is} dQD_{is} \right) \\ + \sum_{i=1}^{N} \left(\tau_{CMis} PM_{is} dQM_{is} \right) \\ + \sum_{i=1}^{N} \left(\tau_{Ois} PD_{is} dQO_{is} \right) \\ + \sum_{i=1}^{N} \sum_{r=1}^{R} \left(QMS_{irs} dPFOB_{irs} \right) \\ - \sum_{i=1}^{N} \sum_{r=1}^{R} \left(QMS_{irs} dPCIF_{irs} \right) \end{array} \right\} \qquad (7)$$

where the subscript i is indexed over the traded commodities, r denotes source region and s refers to the importing region. ψ_s is a scaling factor which is normalized to one initially, but changes as a

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[2] The Huff-Hertel EV decomposition is obtained by starting with the equation for regional income as a function of endowment income, plus taxes less subsidies. Into this equation, they substitute the general equilibrium conditions for zero profits, price linkages, and market clearing for tradeables and non-tradeables. They deflate income by deducting the appropriate price index from both sides of the equation, thereby obtaining equation (3)

function of the marginal cost of utility in the presence of non-homothetic preferences (McDougall, 2002).

The first four summations on the right-hand side (RHS) of (7) measure the changes in efficiency of resource utilization in region *s*. These involve the interaction of tax/subsidy distortions with the change in associated quantities. Consider what happens when we eliminate the bilateral tariff on imports of commodity *i* from one of the FTAA partner countries. The relevant term appears in the first summation:

$$WQMS_{irs} = \left(\tau_{Mirs} PCIF_{irs} dQMS_{irs}\right) \tag{8}$$

Here, ($\tau_{Mirs} PCIF_{irs}$) is the per unit tariff revenue on imports of good *i* from *r* into *s,* associated with the *ad valorem* tariff rate τ_{Mirs}. This is multiplied by the change in the volume of imports of *i* from *r* into *s*: $dQMS_{irs}$. The "Harberger triangle" that we are measuring with this term may be seen in Figure 1. In order to evaluate the area of this triangle as the tariff is eliminated, we must consider both the "base" ($\tau_{Mirs} PCIF_{irs}$) and the "height" ($dQMS_{irs}$). By continually reevaluating the base of this triangle as we solve the CGE model, we track the diminishing gap between *PCIF* and *PMS*. In this way, we are able to accurately measure its area, which is then added to the aggregate welfare measure.

In order to properly perform the numerical integration depicted in Figure 1, equation (7) must be solved in conjunction with the CGE model, using appropriate solution procedures. We use version 8 of the GEMPACK software suite (Harrison and Pearson, 1996; 2002) which is ideally suited to this problem, as it solves the non-linear CGE model using a linearized version of the behavioral equations, coupled with updated equations that link the change (e.g., $dQMS_{irs}$) and levels (e.g., QMS_{irs})

variables. Standard extrapolation techniques can be used to obtain arbitrarily accepted solutions to any well-posed problem (Harrison and Pearson, 1996; 2002).[3]

Note from equation (7) we see that, in addition to tariffs, we consider volume interactions with consumption taxes on household purchases of both domestic goods (τ_{CDis}) and imported goods (τ_{CMis}). Taxes (or subsidies) on output also play a role. If $\tau_{Ois} < 0$, then the production of commodity *i* in region *s* is subsidized and an expansion of output ($qo_{is} > 0$) will contribute negatively to efficiency and hence to EV. The absence of terms associated with intermediate input taxes, as well as primary factor taxes, mean that we are assuming these taxes are zero in this stylized example. (In the empirical section below, this assumption will be relaxed.)

The final two terms on the RHS of (7) refer to the terms of trade (TOT) effects for region *s*. These determine how the global efficiency gains are shared amongst regions. If region *s*'s export-weighted FOB prices rise, relative to her import -weighted CIF prices, then the TOT will improve. Since one region's export prices are another region's import prices, the improved TOT for region *s* translates into a TOT deterioration in the rest of the world (taken as a group).

In summary, each region's welfare gains can be decomposed into a terms of trade and an allocative efficiency component. The essence of the FTAA experiment involves eliminating the trade taxes within the block, i.e., $\tau_{Mik\ell} = 0, \forall i$ and $\forall k, \ell \in FTAA$. This, in turn, induces a shift in the sourcing of imports, away from exporters outside the block and towards exporters within the block. As seen from (5), the extent of this shifting depends on the Armington elasticity of substitution, σ_i. Log differentiating (5) and (6), and converting to percent changes (lower case denotes the percentage change in the associated upper case levels variables), we obtain the following two equations describing import sourcing in region *s*:

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[3] For purposes of this paper, we require that 95% of the variables and levels variables are accurate to four digits. Another useful check is to compare EVs computed from equation (3) with that computed directly from the utility function. These match, to machine accuracy.

$$qms_{irs} = qm_{is} - \sigma_i \left[pms_{irs} - pm_{is} \right] \tag{9}$$

$$pm_{is} = \sum_{r=i}^{R} \Theta_{irs} pms_{irs} \tag{10}$$

where $pms_{irs} = (tm_{irs} + pcif_{irs})$, and tm_{irs} is the percentage change in $(1 + \tau_{Mirs})$. The coefficient and Θ_{irs} is the expenditure share of total imports of *i* into *s* that is sourced from region *r*.

Now, if we assume, for the sake of exposition, that *there are no domestic taxes whatsoever*, then we can convert the simple changes in equation (7) into percentage changes, thereupon substituting in equations (9) – (10) to obtain the following decomposition of the local change in welfare of region *s*:

$$EV_s = (\psi_s / 100) \left\{ \begin{array}{l} \sum_{i=1}^{N} \sum_{r=1}^{R} (TR_{irs})(qms_{irs} - \sigma_i [(tm_{irs} + pcif_{irs}) - pm_{is}]) \\ + \sum_{i=1}^{N} \sum_{r=1}^{R} (PFOB_{isr} QMS_{isr}) pfob_{isr} \\ - \sum_{i=1}^{N} \sum_{r=1}^{R} (PCIF_{irs} QMS_{irs}) pcif_{irs} \end{array} \right\} \tag{11}$$

where $TR_{irs} = (\tau_{Mirs} PCIF_{irs} QMS_{irs})$ = tariff revenue on commodity *i* imported from *r* into *s*. Provided region *s* is small, relative to supplier markets, it will have little impact on import prices ($pcif_{irs} \cong 0$). However, even a small country can have a substantial impact on its own export prices in this differentiated product framework, so $pfob_{isr} \neq 0$. The size of the export price changes will be determined by the export demand elasticity, which approaches $-\sigma_i$ for a country that is small in its export markets $(\Theta_{isr} \cong 0)$ (recall equations 9 and 10).

This decomposition makes clear why, in our econometric exercise, we focus so intently on $\sigma_{i\,,}$ the elasticity of substitution among imports. The welfare consequences of a single, small economy's FTA measures will depend first and foremost on the value of $\sigma_{i\,,\,.}$ Large values of σ_i will cause the elements of the first term in (11) to become larger in absolute value, as the shift in import sourcing becomes more pronounced. On the other hand, large values for σ_i serve to increase the export demand elasticity facing region *s*, thereby dampening the change in export price.[4]

It is the first term in equation (11) which determines whether or not trade diversion or trade creation takes place in this FTA. If, for example, $\sigma_i = 0$, then the pattern of import sourcing will remain unchanged and the sole effect of lower tariffs will be to lower the cost of composite imports (equation (10)), thereby leading to an increased demand for imports $\left(qms_{irs} = qm_{is} > 0\right)$, by equation (9), and the efficiency gain collapses to: $\psi_s qm_{is} \sum_{i=1}^{N} \sum_{r=1}^{R} \left(\tau_{Mirs} PCIF_{irs} QMS_{irs}\right)$. This is the case of pure trade creation.

In practice, we expect the value of σ_i to be quite large—a point confirmed by the econometric work reported below. This means that the second part of equation (9) will be dominant in the determination of qms_{irs} . In this situation, the key issue is how the changes in bilateral imports, qms_{irs} , correlate with bilateral tariff revenues. Clearly, if the preferential FTA eliminates tariffs on flows that are already lightly taxed (lower average tariff revenue), then there will be potential for trade diversion, as the bilateral import changes will be negatively correlated with tariff revenue (i.e., $qms_{irs} >$ when $TR_{irs} \cong 0$ and $qms_{irs} < 0$ for $TR_{irs} >> 0$). In the ensuing empirical analysis of the FTAA, we will examine this trade creation/diversion effect in all participating countries. We will also explore its sensitivity to the econometrically estimated uncertainty in $\sigma_{i,}$ a topic to which we now turn.

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[4] Since in the FTAA one country's exports represent another country's imports, and the terms of trade for any specific country will be determined by the complex interaction between the specific pattern of bilateral tariff cuts and the existing pattern of bilateral trade flaws.

3. Econometric Specification and Estimation of Trade Elasticities

Our econometric estimation focuses on the second level of the two-level, Armington structure, since we will be examining the impact of a proposed preferential FTA, and the key parameter is σ_i, the elasticity of substitution among imports from different sources for a given commodity.[5] We begin by introducing the power of the trade cost for an imported commodity, T_{irs}, which equals one plus the *ad valorem* rates for freight, insurance and tariff, which are all commodity- and route-specific: $T_{irs} = (1 + \tau_{Firs} + \tau_{Mirs}) = 1 + freight_{irs} + tariff_{irs}$, so the domestic cost of imports is given by $PMS_{irs} = T_{irs} PFOB_{irs}$. Because it is difficult to observe the quantity of demand, we multiply both sides of (5) by end-user prices $T_{irs}PFOB_{ir}$ to get the amount of bilateral trade in value terms, V_{irs}:

$$V_{irs} = b_{irs}^{\sigma_i} I_{irs} \left[\frac{PFOB_{ir} T_{irs}}{PM_{is}} \right]^{1-\sigma_i} \qquad (12)$$

which by taking natural logarithm results in an easily estimated equation (13).

$$\ln V_{irs} = \ln I_{irs} + (1-\sigma_i)\ln PFOB_{ir} - (1-\sigma_i)\ln PM_{is} + (1-\sigma)_i \ln T_{irs} + \sigma_i \ln b_{irs} \qquad (13)$$

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:

$$b_{irs} = Dist_{rs}^{\beta_{1,s}} e^{\beta_{2,s} Lang_{ri} + \beta_{3,s} Adj_{ri}} \qquad (14)$$

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[5] It is also the case that the data set that we have available only covers imports, and therefore does not lend itself to estimation of the upper level nest.

Substituting (14) into (13), we obtain the following:

$$\begin{aligned} \ln V_{irs} &= \ln I_{irs} + (1-\sigma_i)\ln PFOB_{ir} - (1-\sigma_i)\ln PM_{is} \\ &+ (1-\sigma_i)\ln(1 + freight_{irs} + tariff_{irs}) + \beta_{1,i}\ln Dist_{ri} + \beta_{2,i} Lang_{rs} + \beta_{3,i} Adj_{rs} \end{aligned} \tag{15}$$

Data on prices, the price index, output, and expenditure shares are difficult to obtain, and in any case, endogenous. All of 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 (16):

$$\ln V_{irs} = a_0 + a_{is} + a_{ir} + \beta_i \ln(1 + freight_{sri} + tariff_{sri}) + \beta_{1,i}\ln Dist_{rs} + \beta_{2,i} Lang_{rs} + \beta_{3,i} Adj_{rs} + \varepsilon_{irs}$$

(16)

where $\beta_i = 1 - \sigma_i$.

4. Data and Elasticity Estimates

The data used in 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 (16) we also require data on physical distance among the countries as well as comprehensive tariff data[6]. The final dataset contains 187,000 observations with the following variables: 5-digit SITC code of the commodity traded, *fob* and *cif* values 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.

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

At this point we face an interesting choice. We could aggregate the 5-digit, SITC trade flows and trade costs according to the 42 GTAP merchandise commodity groups used in our CGE model (Table 1). The advantage of this aggregation approach is that it exactly matches the data variation contained in the CGE exercise (i.e. a single value of trade for each bilateral pair in each of the 42 commodity groups). An alternative approach retains the variation across bilateral pairs and 5-digit level commodities within each of the 42 GTAP categories, constraining the elasticity of substitution to be equal within each broad sector. The main advantage of the pooling approach is that it provides greater within-sector variation in tariffs and transport costs which is critical for identifying the relevant substitution elasticities. We employ the pooling technique in order to yield more precise estimates. [7]

The results of Ordinary Least Squares estimation of equation (14) 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.[8] (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.[9] 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

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[7] In the results section, we also discuss the results obtained from using the aggregation approach.

[8] 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

[9] For a sampling of these applications, visit the GTAP web: www.gtap.org).

metal products. This is because the source studies were not conducted at a sufficiently disaggregate level.[10]

5. 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.

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". After a four year preparatory process, negotiations were launched in April 1998 in Santiago Chile, with the goal of achieving substantial progress by 2000 and completing the negotiations by 2005. The most recent ministerial meeting of the FTAA was held in Miami in November 2003, and the deadline of September 30, 2004 was established for conclusion of the negotiations over market access. 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 2002; 2003).

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[10] It is also striking to observe that the largest elasticity of substitution is for natural gas (34.4) and the lowest is for other mineral products (1.8), yet for the GTAP model, both of these products are assigned the value of 5.6, corresponding to the generic estimate for natural resource products.

Given the focus on merchandise trade in the Americas, and in light of the large dimensions of the GTAP data base, which we use as the empirical basis for our simulations, we begin by aggregating the sixty-six regions of the version 5.0 GTAP database to seventeen regions. (See Appendix Table A.1). 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 dimensions of this model, services activities are also aggregated into four broad categories. A fair assessment of the changes that occur due to liberalization under the FTAA requires updating the GTAP 5.0 database benchmark data to account for the pre-existing applied tariff structure in the liberalizing regions – in particular taking account of preferential trade agreements in the Western Hemisphere (see Appendix Table A2).

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 serves as a useful benchmark that represents 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. This is most commonly done via Monte Carlo analysis, where, the model is solved many times using a random sample of substitution elasticities, drawn from the empirical distribution of estimated trade elasticities. In many cases Monte Carlo is impractical for a large CGE model 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). The recently developed Gaussian Quadrature approach of DeVuyst and Preckel (1997) provides an attractive alternative. These authors show that an approximate distribution can be obtained based on known lower order moments of the parameters of a model, and that selectively solving the model based on the moments of this approximate distribution generates sensitivity results consistent with those of the Monte Carlo approach, with much more efficient use of computing time. The Gaussian Quadrature technique is employed here for generating sensitivity results to the trade elasticities.

We must now invoke some assumptions about the underlying parameter distributions. First, we assume that they are independently and normally distributed. Secondly, the elasticity of substitution in the domestic-import substitution nest (recall φ_i in equation 1) is assumed to be tied to σ_i via the "rule of two" so that these elasticities vary together and by the same proportion in repeated solutions of the model.[11]

6. 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, along with the associated standard deviation, or the coefficient of variation (standard deviation/mean). This information, accompanied with an assumption regarding the shape of the underlying distribution of endogenous variables (we assume normality as with the parameters) allows formation of confidence intervals for welfare changes as well as other 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?*

Our approach to analyzing the results in this paper will be to investigate the elements of equation (7) individually, thereafter examining their combined impact on welfare. We begin with the

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[11] The "rule of two" links φ_s with the estimated value for σ_i as follows: $\sigma_i = 2\varphi_i$. 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 additional support to this approach.

tariff-related efficiency effect. Since this is driven by changes in import volume, let us first consider what happens to imports. Table 2 reports the mean percentage change in regional import volume as a result of the FTAA experiment. Aggregate import volume increases in all FTAA regions, while falling in the non-FTAA regions. Furthermore, 95% confidence intervals, constructed based on the assumption of normality, show that we can be confident in all of these increases. The largest increases are for Colombia and the Other Central America. Our 95% confidence intervals for these two countries do not overlap with that of Peru, which shows the third largest increase in total imports. These large increases in imports may be directly attributed to the relatively larger tariff rates for these countries. Most of the aggregate import volume changes are between +4% and +9%, with some exceptions. The US and Canada, which already enjoy free trade with one another, show a smaller increase in imports. Also, there is a very low import volume increase for Uruguay. This can be attributed to the relative loss of preferential access that occurs under FTAA when partners in MERCOSUR liberalize with other regions in the Americas.

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 2 address this issue in the case of import volumes. First we report the coefficient of variation (the ratio of the standard deviation divided by the mean) for the change in national imports (this is the change reported in column 4 of Table 2). When this ratio is small, we can infer a relatively higher level of confidence in the result. Note that it is quite small for Chile, whereas it reaches its maximum value in the case of the rest of the Andean Pact (XAP). The final column in Table 2 reports the *average* coefficient of variation for the percentage change in national imports, *at the sector level*. This gives an indication of the average degree of precision for the more disaggregate results. As can be seen by comparing these two entries for each country, the more disaggregate results are less precise. This is intuitive in that we often expect a certain degree of offset at the aggregate level (when one sector's imports are low, another's may be high).

Next, turn to the allocative efficiency effects associated with the import volume changes. These are reported in the first column of Table 3, which gives both the mean and the coefficient of variation (CV) associated with the tariff-related allocative efficiency component of equation (3). Recall that this is the (welfare-scaled) summation of the tariff revenue-weighted import quantity changes. From the mean values of this variable, we see that there *is* net "trade creation" for 10 of the 13 FTAA partners. In the cases of Venezuela, Chile and the Other South America, this import efficiency term is negative, despite the fact that aggregate import volume rises (recall Table 2). This is due to the fact that the *welfare* contribution of the trade volume change depends on the interaction between tariff rates and trade flows. As tariffs are eliminated on intra-FTAA flows, the associated welfare weight is eliminated. If the remaining tariffs on extra-FTAA imports are large, and if the associated FTAA-driven decline in the trade volume is also large, these negative numbers can dominate the overall welfare effect, leading to trade diversion.

Table 4 explores this trade diversion phenomenon in detail for the case of machinery and equipment imports into Chile. Chile is notable for is its uniform tariff structure (8% across all sources/products in 2001). This is efficient in that it promotes the sourcing of imports from the least cost supplies of any given product, as well as discouraging substitution across import categories in response to differential tariffs by product. Of course, there remains the distortion of import/domestic choices, as with any tariff regime. We focus the discussion here on other machinery and equipment imports because this contributes the largest share of the aggregate efficiency loss in column one of Table 3 (one-third of the total).

The individual columns in Table 4 correspond to different parts of equation (4). The first entry reports the non-linear solution value for EV_s (τ_{Mirs}) for $i = ome$, s = Chile and r = all regions.[12]

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[12] Note that the non-linear solution to equation (9) requires that we incorporate it individually into the model's solution (as apposed to it being a part of equation (3)). This permits us to capture the interaction between changes in the levels of τM_{irs} and $PCIF_{irs}$ on the one hand, and the volume changes, $dQMS_{irs}$, on the other.

The driving force behind each of these entries is the underlying change in bilateral import volume, $dQMS_{irs}$ reported in column two of the table. This is measured in $US 1997, where one unit of the good is the amount that could be purchased in the source country for $1.00 in the initial (i.e., pre-FTAA) equilibrium. Since these goods are differentiated products, the sum of these trade volumes is not particularly meaningful. But if we did perform this summation, we would find that this crude estimate of import volume showed an *increase* of $214 million, with the rises in intra-FTAA imports of machinery and equipment into Chile more than offsetting the declines in extra-FTAA imports. This naïve estimate of increased import volume stands in sharp contrast to the negative welfare outcome share in the first column total.

The difference between the simple volume summation and the welfare change derives from the bilateral weights applied to these volume changes: $\tau_{Mirs} PCIF_{irs.}$ In this regard, it is instructive to consider both the initial (0) and ending (1) values for the tariff rate and import price. These are also reported in Table 4. Note that the proportional $PCIF_{irs}$ changes (typically less than 10%) are an order of magnitude smaller than the changes in intra-regional tariffs (-100%), so we focus our attention on the latter. While the initial reductions in the tariff on intra-FTAA imports bring fairly large welfare gains, (recall Figure 1), the final reductions bring almost nothing. Yet, the final reduction in τ_{Mirs} continues to lead to substantial displacement of extra-FTAA imports (recall equation (5)). Given the absence of reductions on the extra-FTAA tariffs, these volume reductions come to dominate the welfare story. This is why the welfare loss due to reduced imports of machinery and equipment from the EU is nearly twice as large as the gain due to increased imports from USA, even though the absolute value of the trade volume change with respect to USA is nearly twice that of the EU.

Recall from our earlier analysis (e.g., equation 11) that the elasticity of substitution among imports, by source, is a critical determinant of the allocative efficiency effect associated with tariff changes. Yet these elasticities are uncertain, and we have characterized this uncertainty in our systematic sensitivity analysis. So it is of some interest to explore the relationship between uncertainty in the trade elasticities and uncertainty in these welfare contribution terms themselves. We examine this issue statistically for the welfare changes associated with FTAA flows in the model. Consider the welfare term in equation (8), $WQMS_{irs}$. In a typical CGE analysis, there is but one value of this term for each commodity i, exporter r, and importer s. However, in our approach, we have a value for this term for each solution of the model, every time with a different set of trade elasticities. To better understand the standard error in $WQMS_{irs}$ across model solutions, we regress the standard error in this variable on the depth of the associated bilateral tariff cut, τ_{irs}, which is the same across model solutions), and an interaction between the depth of the tariff cut and $SE_{\sigma i}$, the standard error of the substitution elasticity among imports by source, for commodity *i*. We include the depth of the tariff cut as an explanatory variable to control for differences in relative dispersion in the welfare contribution variable, because larger tariff cuts will increase variability of the welfare variable for a constant standard error for the elasticity. Estimates are reported in equation (17)[13], along with the associated T-statistics (in parentheses):

$$SE_{WQIMirs} = \underset{(6.464)}{0.020}\,\tau_{irs} + \underset{(6.936)}{0.023}\,\tau_{irs} SE_{\sigma i} \tag{17}$$

The OLS coefficients in (17) are significant and positive indicating that both the depth of the tariff reduction and the interaction of the tariff with the variability of the elasticity are important in explaining variability in the allocative welfare effects. The positive relationship is as we would expect, since we hypothesize that uncertainty in the model parameter should be carried over to the allocative welfare component as demonstrated in section 2.

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[13] The regression is based on 5,337 non-zero bilateral trade flows in the FTAA region. The R^2 for the regression is 0.040, indicating fairly low explanatory power as we would expect given the large number of omitted variables (in the regression model) that affect the welfare term in the GE model. Since our primary concern is to characterize the relationship between uncertainty in the welfare term and the trade elasticity we feel the regression model is serviceable as it controls for the dominant effect of size of the tariff cut, and shows the significant positive relationship between the two measures of uncertainty.

The coefficient levels indicate that we predict a change of 0.043 in the standard error of the welfare variable when the tariff cut is increased by one percent and the standard error of the substitution elasticity is increased by one. The mean standard error for the allocative welfare effect is 0.163, so this predicted change represents about twenty-five percent of the mean for the dependent variable.

We now return to Table 3 to discuss the remaining elements of the efficiency story. For Chile, the next most important efficiency change relates to the consumption taxes,[14] which apply equally to consumption of imports and domestic goods. Thus, the increased consumption of imported goods boosts overall consumption and results in positive contributions to aggregate welfare in all of the FTAA regions where good consumption taxation data are available.[15] Production taxes (subsidies) also play a big role in the welfare decomposition in some regions. In USA, the strong expansion of subsidized grains output leads to a negative welfare contribution, whereas in Mexico, the expansion of taxed manufacturing activity at the expense of untaxed fuel and agriculture improves efficiency in that country.

The final column in Table 4 reports the combined efficiency impacts of intermediate import taxes, primary factor taxes (subsidies), and export taxes (subsidies). (These were suppressed in equation (7) for the sake of brevity.) The negative efficiency contribution in the US derives from land and capital subsidies for program crops and dairy export subsidies, whereas agricultural export taxes in Brazil play a key role in the positive welfare contribution in that country.

Next, turn to Table 5, which reports the aggregate welfare effects, by country, decomposed into their efficiency and terms of trade components. The aggregate efficiency effect is simply the summation of the results reported in Table 3. This permits us to explain the efficiency loss in the USA

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[14] This includes the Chilean value-added taxes which are most naturally modeled as a consumption tax.

[15] The negative number for Argentina results from the apparent exemption of imported oil products from consumption taxation. This appears to be an error in the original data base for that country.

and Venezuela. In Venezuela, this is caused by net trade diversion, whereas in the USA it is due to expansion of the subsidized agriculture sector.

We turn next to the terms of trade effects (the second pair of columns in Table 5).[16] *Ceteris paribus,* 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 that must export more to affect the large increase in import volume. The terms of trade also deteriorate for Canada, Mexico, Argentina and Other South America. The TOT deterioration for 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 decline. Of course, one region's TOT loss is another's gain, and Other Central America is one of the regions showing a strong TOT gain. In this case, it is the strong increase in exports that is driving the import growth reported in Table 2.

Another dimension of this analysis of uncertainty in the terms of trade effect can be observed in Figure 2. 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 the terms of trade decomposition). Countries that rely heavily on exports of 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 2) 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

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[16] 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.

large and rather uncertain (recall Table 1). On the other hand, the variation in the export price component of its terms of trade is relatively small, due perhaps to the relative homogeneity of this product and the generally low tariffs on oil.

We are now in a position to answer the question: Which countries gain from the FTAA? We see from the final two pairs of columns in Table 5 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 Other South America are shown to lose from the FTAA. In the case of Argentina, this is driven by a dominant, adverse terms of trade effect. For Other South America, both the terms of trade and allocative effects are negative.

The welfare impact of the FTAA 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 economic forces at work in the determination of the change in national welfare.

There are many other variables in addition to the change in aggregate welfare that we could examine, particularly at the sector level. Here we focus our attention on employment, since the displacement of unskilled workers is often one of the most sensitive topics surrounding any free trade agreement. Table 6 summarizes the directional changes in unskilled employment, by sector, 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 5. Here we see that the changes in employment are generally robust to the estimated variation in trade elasticities. We able to sign the change in sectoral employment at the 95% confidence level for every region in over 75% of the sectors.

Table 7 reports the same employment results as Table 6, 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, wheat, other grains, and coal, as well as for processed rice. Not surprisingly, these sectors have some of the largest standard deviations relative to the size of the estimated elasticity (recall Table 1).

7. 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 using the CGE framework. 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 outcome 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 imports 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 welfare impact of the FTAA on

Colombia is uncertain due to offsetting efficiency and terms of trade effects. 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.

Of course all of these findings are conditional on the underlying model structure, as well as the other parameters employed in the CGE analysis. Variations in that structure will change both the econometric procedures as well as the CGE model itself. Given the uncertainty surrounding the appropriate structure for international trade modeling, and the diversity of outcomes that such changes in structure can engender, we must view the confidence intervals in this paper as being on the conservative side. Future work should focus on discriminating among these alternative model structures for purposes of establishing a firmer foundation for CGE analysis of trade policies (e.g., Hummels and Klenow, 2002).

In summary, we 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 policy maker. In the end, decision makers and their advisors increasingly ask: 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 those seeking to make key political decisions based in part on results from quantitative economic models.

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Figure 1. Allocative Efficiency Gains from Tariff Elimination

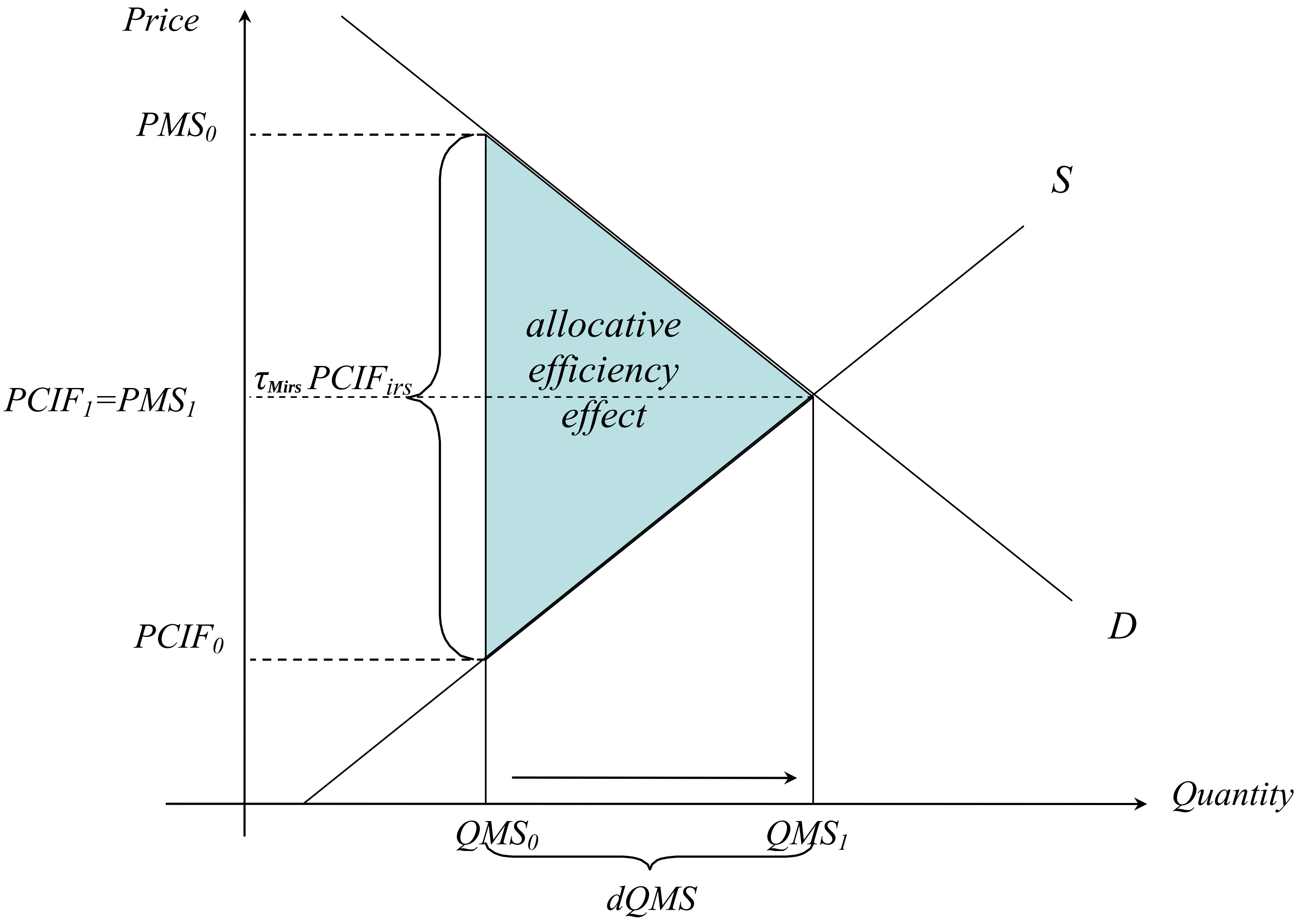

Figure 2. Uncertainty Comparison: Trade Elasticity and TOT Export Price Effect

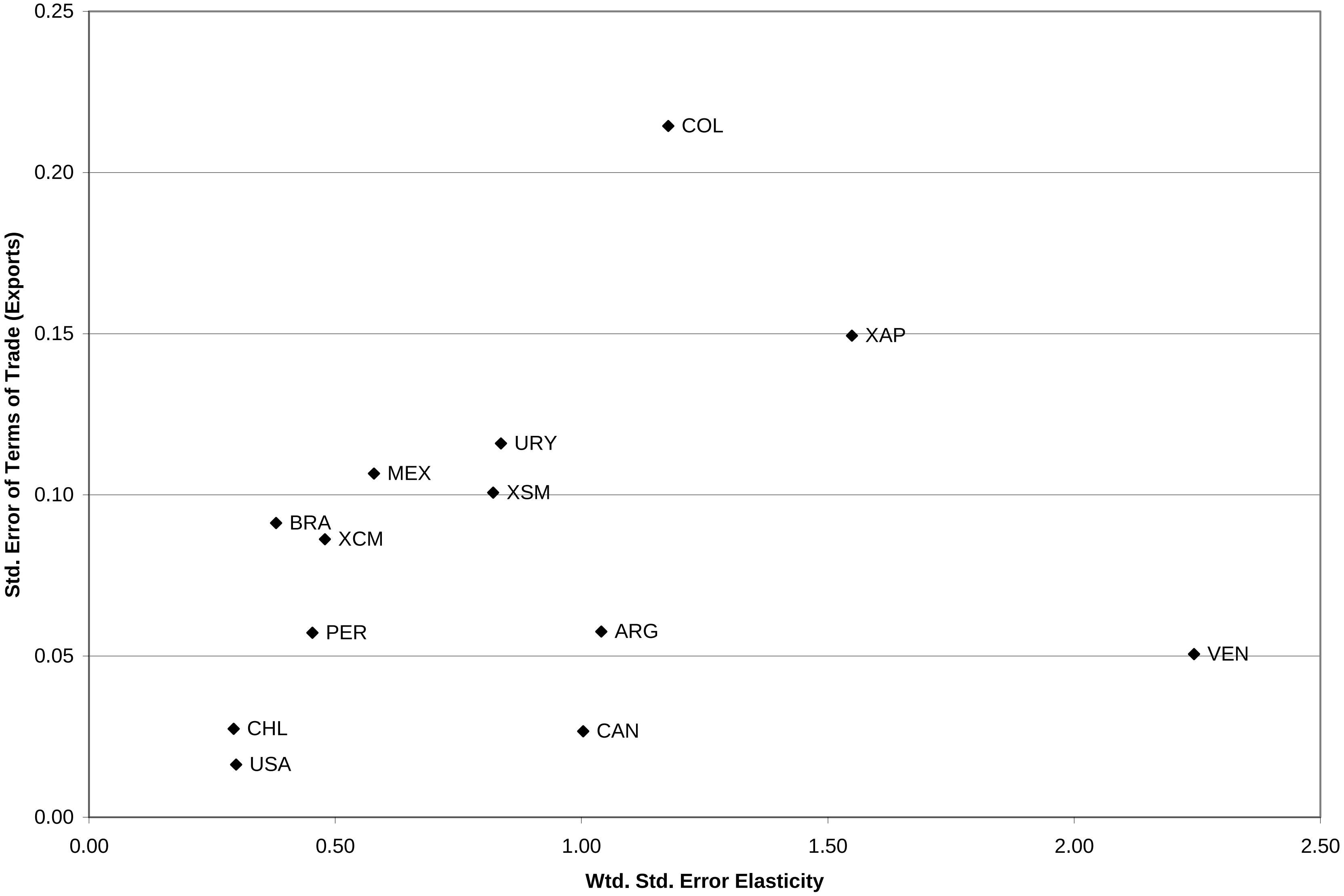

Table 1. Elasticities of Substitution among Imports from Different Sources

Code	Description	Original Elasticity	Estimated Elasticity	SD	Num Obs
PDR	Paddy rice	4.4	10.1*	4.0	26
WHT	Wheat	4.4	8.9*	4.2	32
GRO	Cereal grains nec	4.4	2.6*	1.1	131
V_F	Vegetables, fruit, nuts	4.4	3.7*	0.4	1,199
OSD	Oil seeds	4.4	4.9*	0.8	239
C_B	Sugar cane, sugar beet	4.4	N/A	N/A	3
PFB	Plant-based fibers	4.4	5.0*	2.4	71
OCR	Crops nec	4.4	6.5*	0.4	1,796
CTL	Bovine cattle, sheep and goats, horses	5.6	4.0*	0.7	156
OAP	Animal products nec	5.6	2.6*	0.3	813
RMK	Raw milk	4.4	N/A	N/A	-
WOL	Wool, silk-worm cocoons	4.4	12.9*	2.7	76
FOR	Forestry	5.6	5.0*	0.7	529
FSH	Fishing	5.6	2.5*	0.6	527
COL	Coal	5.6	6.1*	2.4	71
OIL	Oil	5.6	10.4*	3.8	56
GAS	Gas	5.6	34.4*	14.3	8
OMN	Minerals nec	5.6	1.8*	0.3	1,584
CMT	Bovine meat products	4.4	7.7*	1.9	211
OMT	Meat products nec	4.4	8.8*	0.9	411
VOL	Vegetable oils and fats	4.4	6.6*	0.7	717
MIL	Dairy products	4.4	7.3*	0.8	547
PCR	Processed rice	4.4	5.2*	2.6	62
SGR	Sugar	4.4	5.4*	2.0	156
OFD	Food products nec	4.4	4.0*	0.1	6,917
B_T	Beverages and tobacco products	6.2	2.3*	0.3	998
TEX	Textiles	4.4	7.5*	0.1	14,375
WAP	Wearing apparel	8.8	7.4*	0.2	9,090
LEA	Leather products	8.8	8.1*	0.3	3,457
LUM	Wood products	5.6	6.8*	0.2	4,120
PPP	Paper products, publishing	3.6	5.9*	0.2	6,597
P_C	Petroleum, coal products	3.8	4.2*	1.1	344
CRP	Chemical, rubber, plastic products	3.8	6.6*	0.1	61,603
NMM	Mineral products nec	5.6	5.8*	0.2	6,240
I_S	Ferrous metals	5.6	5.9*	0.3	5,524
NFM	Metals nec	5.6	8.4*	0.4	3,194
FMP	Metal products	5.6	7.5*	0.2	9,926
MVH	Motor vehicles and parts	10.4	5.6*	0.3	2,238
OTN	Transport equipment nec	10.4	8.6*	0.4	1,843
ELE	Electronic equipment	5.6	8.8*	0.2	8,916
OME	Machinery and equipment nec	5.6	8.1*	0.1	44,386
OMF	Manufactures nec	5.6	7.5*	0.2	7,586

*Estimate Significant at 95% Confidence Level.

Table 2. Percentage Change in Aggregate Imports: Mean, 95 % Confidence Interval, and Coefficient of Variation

Region	Confidence Interval			Coefficient of Variation	
	Lower	Mean	Upper	Total Imports	Sector Average
Canada	1.07	1.32	1.57	0.10	1.17
USA	2.07	2.19	2.31	0.03	0.10
Mexico	7.36	8.38	9.39	0.06	0.06
Central America	10.76	11.16	11.56	0.02	0.01
Colombia	9.22	10.37	11.51	0.06	0.22
Peru	7.93	8.41	8.89	0.03	0.16
Venezuela	4.69	4.81	4.93	0.01	0.18
Other Andean Pact	4.65	5.39	6.12	0.07	0.24
Argentina	4.13	4.26	4.39	0.02	0.12
Brazil	8.07	8.33	8.58	0.02	0.18
Chile	5.39	5.51	5.64	0.01	0.17
Uruguay	2.04	2.24	2.45	0.05	0.80
Other South America	5.68	5.98	6.27	0.03	0.01
Asia-Ocenia	-0.32	-0.31	-0.31	-0.01	-0.11
European Union	-0.23	-0.23	-0.23	-0.01	2.01
Other Europe	-0.15	-0.15	-0.15	-0.01	-0.10
Mid-East and Africa	-0.29	-0.27	-0.25	-0.04	-0.10

Table 3. Components of Allocative Efficiency Effects Due to FTAA ($US million): Mean and Coefficient of Variation (CV)

	Imports		Consumption		Production		Other
Region	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**
Canada	760.60	0.12	246.40	0.11	40.78	0.21	-212.06
USA	545.25	0.06	-0.01	-0.23	-74.44	-0.09	-495.42
Mexico	975.35	0.19	2.50	0.29	174.80	0.23	103.37
Central America	322.05	0.05	217.79	0.05	-10.58	-0.15	-8.56
Colombia	508.55	0.10	15.38	0.08	4.22	0.23	98.54
Peru	9.35	0.15	23.68	0.08	-2.69	-0.38	123.03
Venezuela	-10.50	-0.09	2.83	0.08	0.00	-0.13	1.44
Other Andean Pact	17.26	0.17	11.48	0.13	-5.12	-0.39	22.83
Argentina	32.61	0.08	*-0.19*	*-0.80*	-0.23	-0.02	-29.45
Brazil	148.88	0.04	431.82	0.02	-10.62	-0.17	788.52
Chile	-15.69	-0.06	33.40	0.03	-5.46	-0.04	9.40
Uruguay	1.57	0.36	3.88	0.10	*0.22*	*0.73*	-4.16
Other South America	*-0.60*[q]	*-1.04*	7.64	0.19	-1.56	-0.03	-2.72
Asia-Ocenia	-252.95	-0.07	-34.53	-0.03	46.53	0.09	-362.48
European Union	-226.71	-0.06	-120.41	-0.05	60.52	0.03	-407.48
Other Europe	-49.62	-0.04	-15.67	-0.04	6.17	0.08	-42.99
Mid-East and Africa	-66.17	-0.07	-10.27	-0.10	1.91	0.17	-14.03

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[q] Results in italics indicate a result for which the confidence interval encompasses zero, i.e. it is not robust to direction of change under parametric uncertainty.

Table 4. Analysis of Trade Diversion in Chile: Machinery and Equipment

	Welfare Change ($US mill.) ($EV_s$)	**Volume Change ($US mill.)** ($dQMS_{irs}$)	**Initial Tariff Rate** (τ^0_{Mirs})	**Updated Tariff Rate** (τ^1_{mirs})	**Price Initial** (PMS^0_{irs})	**Price Updated** (PMS^1_{irs})
Canada	1.00	25.54	0.08	0.00	0.93	0.93
USA	18.20	450.01	0.08	0.00	0.93	0.93
Mexico	2.70	71.77	0.08	0.00	0.93	0.93
Central America	0.01	0.28	0.08	0.00	0.93	0.92
Colombia	0.30	8.12	0.08	0.00	0.99	0.96
Peru	0.04	1.19	0.08	0.00	0.81	0.97
Venezuela	0.07	1.82	0.08	0.00	0.93	0.81
Other Andean Pact	0.01	0.42	0.08	0.00	0.81	0.91
Argentina	1.28	33.31	0.08	0.00	0.93	0.81
Brazil	4.54	106.97	0.08	0.00	0.96	0.92
Chile	0.00	0.00	0.00	0.00	1.00	0.96
Uruguay	0.02	0.58	0.08	0.00	0.93	1.00
Other South America	0.00	0.11	0.08	0.00	0.94	0.93
Asia-Ocenia	-16.14	-189.46	0.08	0.08	0.94	0.93
European Union	-23.41	-284.15	0.08	0.08	0.93	0.92
Other Europe	-1.19	-14.50	0.08	0.08	0.93	0.92
Mid-East and Africa	-0.80	-9.72	0.08	0.08	0.93	0.93
Total	-13.356	202.303	n.a.	n.a.	n.a.	n.a.

Table 5. Welfare Effects of FTAA Outcome ($US million)

	Allocative EV		Terms of Trade EV		EV Total		Welfare (% Change)	
Region	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
Canada	835.71	0.13	-620.78	-0.12	167.18	0.26	0.03	0.26
USA	-24.61	-2.87	6244.82	0.04	6845.20	0.04	0.09	0.04
Mexico	1256.02	0.19	-1241.76	-0.12	*78.02*	*1.29*	*0.02*	*1.29*
Central America	520.70	0.05	855.32	0.04	1385.57	0.04	1.70	0.04
Colombia	626.70	0.09	-514.99	-0.07	*41.95*	*0.60*	*0.05*	*0.60*
Peru	153.37	0.03	-73.39	-0.06	62.72	0.11	0.11	0.11
Venezuela	-6.23	-0.18	82.92	0.16	110.38	0.11	0.15	0.11
Other Andean Pact	46.45	0.08	*22.10*	*0.57*	63.94	0.27	0.27	0.27
Argentina	*2.73*	*1.56*	-30.69	-0.51	-74.50	-0.28	-0.02	-0.28
Brazil	1358.59	0.03	548.33	0.10	1921.85	0.06	0.28	0.06
Chile	21.64	0.04	189.57	0.03	200.41	0.03	0.29	0.03
Uruguay	*1.52*	*1.80*	22.32	0.22	16.71	0.44	0.09	0.44
Other South America	2.75	0.30	-42.78	-0.06	-82.85	-0.04	-0.89	-0.04
Asia-Ocenia	-603.43	-0.04	-2625.12	-0.01	-3577.75	-0.01	-0.05	-0.01
European Union	-694.09	-0.05	-2383.01	-0.01	-3171.74	-0.02	-0.05	-0.02
Other Europe	-102.12	-0.04	-246.90	-0.05	-390.04	-0.03	-0.03	-0.03
Mid-East and Africa	-88.55	-0.07	-232.27	-0.18	-340.07	-0.14	-0.04	-0.14

Table 6. Regional Employment Effects Due to FTAA

Region	Number of Sectors with: Employment Increase	Number of Sectors with: Employment Decrease	Pct Results with 95% Confidence
Canada	29	13	83%
USA	31	11	88%
Mexico	28	14	79%
Central America	9	33	93%
Colombia	20	22	88%
Peru	18	24	88%
Venezuela	22	20	88%
Other Andean Pact	18	24	76%
Argentina	22	20	90%
Brazil	23	19	86%
Chile	21	21	88%
Uruguay	13	29	79%
Other South America	19	23	83%
Asia-Ocenia	19	23	81%
European Union	17	25	88%
Other Europe	16	26	86%
Mid-East and Africa	17	25	81%

Table 7. Sectoral Employment Effects Due to FTAA

Sector	Number of Sectors with: Employment Increase	Employment Decrease	Pct Results with 95% Confidence
Paddy rice	9	8	65%
Wheat	6	11	59%
Cereal grains	9	8	65%
Vegetables, fruit, nuts	6	11	71%
Oil seeds	10	7	76%
Sugar	9	8	82%
Plant-based fibers	4	13	71%
Other Crops	7	10	76%
Cattle	12	5	76%
Animal products	9	8	94%
Raw milk	8	9	94%
Wool	7	10	88%
Forestry	8	9	82%
Fishing	9	8	94%
Coal	4	13	59%
Oil	8	9	82%
Gas	8	9	82%
Minerals	12	5	76%
Bovine meat products	13	4	82%
Other meat products	7	10	88%
Veg. oils and fats	11	6	94%
Dairy products	6	11	100%
Processed rice	8	9	35%
Processed sugar	10	7	76%
Food products	8	9	100%
Bev. and tobacco	10	7	88%
Textiles	7	10	94%
Wearing apparel	9	8	88%
Leather products	11	6	100%
Wood products	7	10	82%
Paper products	8	9	100%
Petroleum, coal products	8	9	71%
Chemical, rubber, plastic products	6	11	100%
Mineral products	9	8	88%
Ferrous metals	5	12	100%
Metals	9	8	100%
Metal products	7	10	94%
Motor vehicles and parts	5	12	100%
Transport equipment	12	5	100%
Electronic equipment	7	10	100%
Machinery	6	11	94%