SENSITIVITY ANALYSIS IN APPLIED GENERAL EQUILIBRIUM MODELS:
AN EMPIRICAL ASSESSMENT FOR MERCOSUR FREE TRADE AREAS AGREEMENTS

by

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Sensitivity Analysis in Applied General Equilibrium Models: an Empirical Assessment for Mercosur Free Trade Areas Agreements

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ABSTRACT: In this paper, an applied general equilibrium (AGE) model is used to assess the welfare results of alternative free trade areas (FTA) for three MERCOSUR countries, Brazil, Argentina and Uruguay. The results of the sensitivity to shocks and parameters are evaluated. In such a way, the robustness of the results to different degrees of intra-blocs trade liberalization and trade elasticities will be assessed. It is shown that welfare gains for Brazil are very robust to different degrees of trade liberalization, and allocation effects drive these gains. For Argentina and Uruguay, welfare gains depend heavily on a higher degree of liberalization, as they are connected to terms of trade effects. This paper shows that trade elasticities are important parameters driving the model's results, as welfare gains for Argentina and Uruguay in both scenarios are very sensitive to these parameters. Therefore, AGE models results of alternative FTA for Mercosur countries need to consider the uncertainty about parameters and shocks.

1. Introduction

While applied general equilibrium models have been used to assess the overall effects of the Uruguay Round reform (Francois, 2000), ex-ante impacts due to NAFTA (Francois and Shiells, 1994), and other trade policy issues, they have been frequently criticized for resting on weak empirical foundations. While Hansen and Heckman (1996) argue that the flexibility of the general equilibrium paradigm is a virtue hard to reject and provides a rich apparatus for interpreting and processing data, it can be considered as being empirically irrelevant because it imposes no testable restrictions on market data. McKitrick (1998) has also criticized the parameter selection criteria used in most AGE models, arguing that the calibration approach leads to an over-reliance on non-flexible functional forms.

Although most of AGE modelers recognize that accurate parameters values are very important, it is not easy to find empirical estimates of key parameters, like substitution elasticities, in the literature. Most of the models take up estimates "found in the literature" or even "best guesstimates" (Deardorff and Stern, 1986). Thus, if there is a considerable

uncertainty surrounding the 'right' parameters, and these are key elements in the AGE results, a consistent procedure in their evaluation is imperative.

Applied general equilibrium models at regional level are tools for impact analysis, comparable to input-output and input-output econometric models, with important similarities and differences (West, 1995).   Concerns about sensitivity analysis have also garnered significant attention in the application of these models. In input-output (IO) analysis, multipliers are estimated by taking the Leontief inverse of the estimated IO coefficients. Ten Raa and Jansen (1998) argue that this procedure is biased because Leontief inverses are non-linear functions, and the function mean values differ from the value of means. They have also proposed a methodology to deal with bias and sensitivity of multipliers in IO models. More generally, the issue of uncertainty and error analysis in input-output models has occupied the attention of many analysts; Jackson (1986) has explored the role of different density functions associated with the point estimates of input coefficients while Sonis and Hewings (1992) have explored the ramifications of errors in estimates through the identification of a field of influence approach. The problem in AGE models is further compounded by the presence of a variety of parameters, some estimated with known probability distributions, others with no known distributions combined with input-output data that are provided as point estimates.

If a consistent econometric estimation for key parameters in a AGE model study is not possible, the effort should be directed to test the uncertainty surrounding these parameters in terms of their impact on the model. Robustness tests are an important step to obtain the acceptance of the model results in applied economics. The assumptions embodied in AGE models come from general equilibrium theory. However, one set of assumptions, the values of model parameters, such as elasticities, are natural candidate for sensitivity analysis. Wigle (1991) has discussed alternative approaches to evaluating model sensitivity to parameter values, while DeVuyst and Preckel (1997) have proposed a quadrature-based approach to evaluate robustness of AGE models results, and demonstrated how it could be used for an applied policy model.

The Gaussian Quadrature (GQ) approach (Arndt, 1996; DeVuyst and Preckel, 1997) was proposed to evaluate AGE model results' sensitivity to parameters and exogenous shocks. This approach views key exogenous variables (shocks or parameters) as random variables with associated distributions.   Due to the randomness in the exogenous variables, the

endogenous results are also random; the GQ approach produces estimates of the mean and standard deviations of the endogenous model results, thus providing an approximation of the true distribution associated with the results. The accuracy of the procedure depends on the model, the aggregation and the simulations employed. Simulations and tests with the Global Trade Analysis Project (GTAP) model have shown that the estimates of mean and standard deviations are quite accurate (Arndt and Hertel, 1997). In the present paper, this approach will be used to assess the sensitivity of welfare results in the GTAP model, in a set of proposed free trade area agreements involving MERCOSUR countries.

This paper is organized as follows. In section 2, a brief discussion of the new regional trading agreements involving MERCOSUR is presented. The database and modeling framework is shown in section 3, and the proposed experiments are explained. Section 4 presents the results, and section 6 analyses their sensitivity to parameters and shocks. Section 6 provides some concluding comments.

2. MERCOSUR and New Free Trade Agreements

There is a great interest in free trade areas (FTA) in South America, predominantly in the context of a proposed Free Trade Area of the Americas (FTAA). In addition, a free trade area between MERCOSUR (the customs union involving Brazil, Argentina, Uruguay and Paraguay) and the European Union has been considered. Brazilian strategies seem to be tied to MERCOSUR; Argentina is the second most important country in South America and MERCOSUR. Any negotiation involving MERCOSUR and a trade agreement would also have to meet Argentinean concerns. Therefore, it seems reasonable to assume that both countries, Brazil and Argentina, would negotiate in unison for any new free trade area, like the FTAA or other involving the European Union.

FTAA is a proposed free trade area sponsored mostly by NAFTA involving 34 countries in the Americas. Brazil formally has generally supported the idea of the creation of the FTAA, but has been less enthusiastic to accelerate the schedule for a launch than some other countries, preferring instead to strengthen its leadership role in MERCOSUR. Although the MERCOSUR trade bloc is passing through an institutional crisis, caused by Argentina's unilateral decision to cut the so-called TEC common tariff (charged on trade with non-

MERCOSUR countries), the four member states remained united and negotiated as a bloc during the FTAA talks at the Buenos Aires Summit, in early April 2001.

At the same time, Brazilian authorities have suggested that MERCOSUR could reach a major trade deal with the European Union before the FTAA's launch.   From the Brazilian viewpoint, a EU/MERCOSUR agreement would be attractive if European negotiators make a feasible offer regarding EU farm subsidies, seen as the main problem for MERCOSUR farm exports to the European Union. The negotiations between the EU and MERCOSUR began in 1995. OnMarch, 2001 the EU announced to MERCOSUR diplomats that it would make a concrete proposal to reduce import tariffs, including those on agricultural products. Meetings between Mercosur and EU authorities have been taken place on a regular basis. A final agreement is scheduled to be achieved by the end of 2004.

Among others, Haddad and Domingues (2000) have studied implications for Brazil of multilateral agreements using a national, multi-sector, AGE model.   They concluded that general trade agreements under WTO negotiations are preferable for Brazil than either the implementation of FTAA or regional agreements involving MERCOSUR and the European Union.   Haddad *et al.* (2001) have extended this analysis to the within country level, analyzing the impacts on the Brazilian states. Spatial implications of the trade policies are assessed, showing that the trade strategies that were examined were likely to increase regional inequality in the country. Diao and Somwaru (2000) have applied an inter-temporal dynamic world AGE model to study effects of different MERCOSUR trade policies. They conclude that elimination of intra-MERCOSUR trade barriers can result in growth of intercountry trade and would likely be accompanied by increases in trade between MERCOSUR and other countries[1].

The present paper uses a multi-country, multi-sector AGE model to examine welfare implications of alternative trade arrangements, and its sensitivity to the parameters and shocks. The empirical analysis will deal with the impact in three MERCOSUR countries (Brazil, Argentina and Uruguay) of two alternative free trade areas. The first will be the implementation of FTAA, and the second a free trade agreement with the European Union.

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[1] This paper employs the GTAP database version 3, which represents the world economy in 1992, therefore captures a pre-Uruguay Round Reform.

3. Database and Model

In this paper, the widely used GTAP model of global trade (Hertel, 1997) is employed [2]. GTAP is a relatively standard, multi-region, applied general equilibrium model. It uses a Constant Difference of Elasticities (CDE) consumer demand system to capture differential price and income responsiveness across countries, an explicit modeling of international transport margins and a global "bank" specified to allocate world savings and investment. Throughout this paper, the assumptions of perfect competition and constant returns to scale in production activities are maintained[3].

The Armington approach (Armington, 1969) is employed to model trade flows; therefore products are differentiated by origin. They are assumed to be imperfect substitutes for one another, and combine to form a composite import aggregate; this composite substitutes imperfectly for domestically produced goods. In this way, the model is able to generate bilateral trade flows in specific goods, an important empirical regularity in the trade flows between countries. Tests with the GTAP model (Gehlhar, 1997; Coyle *et al.,* 1998) show that it was able to project, to a reasonable degree, some of the major changes in trade patterns over the past two decades.

Trade elasticities play a crucial role in the simulations implemented in the present paper, especially as attention is directed to liberalization experiments. Gehlhar (1997) has emphasized the key role of trade elasticities in the GTAP model. He found that a better fit over the long run (one decade) period of analysis is obtained by increasing the size of trade elasticities. It became standard practice to double the size of the trade elasticities in long run projections (Hertel *et al.,* 1996; Anderson *et al.*, 1998; Hertel and Martin, 2001). However, this practice has not been formally validated, and is rather *ad hoc* (Hertel and Martin, 1999) .

The GTAP version 4 database used in this paper marks the first year of the Uruguay Round implementation, 1996. As the proposed free trade areas in the agenda are supposed to evolve over a long time (FTAA may start its implementation in 2005), it can be assumed that the Uruguay Round Reform agreement will be implemented at that time. Besides, as MERCOSUR countries have stressed, a FTAA agreement would benefit from a more integrated MERCOSUR; the same would be the case for a European Union-MERCOSUR free trade area.

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[2] The model is implemented using GEMPACK (Harrison and Pearson, 1996).
[3] Imperfect competition has also been applied in other versions of the GTAP model (Francois, 1999).

These considerations were taking into account in the database starting point by conducting a pre-simulation. The Uruguay Round reform and a 'full' MERCOSUR (elimination of import tariffs and export subsidies among MERCOSUR countries) were assumed to have been implemented. The shocks for this simulation follow the description in Yang *et al.* (1997). In order to implement this pre-simulation, and to facilitate attention on the three main MERCOSUR countries, the global economy was aggregated in 10 regions. The 10 goods aggregation (see Appendix 1) is the same as the one employed in Yang *et al.* (1997). The standard GTAP primary factors aggregation in 5 groups is also specified (Land, Unskilled labor, Skilled labor, Capital and Natural Resources).

Deeper analysis of the changes implied by these starting-point simulations is not the objective of this paper, but some indicators can be calculated to assess the changes in bilateral trade flows among MERCOSUR countries. The intraregional trade share (the share of intra-bloc trade in total trade) can be a misleading indicator due to the relative size of each bloc (Frankel, 1997). The simple intraregional trade concentration ratios correct this share by the total participation of the bloc in the world trade. Frankel (1997) reports a ratio of 12.84 for MERCOSUR; the initial database used here provides a very close figure, 11.68. The starting point database has a slightly higher value, 16.46. These results are as expected, the Uruguay Round reform and the complete elimination of trade barriers within MERCOSUR increases intercountry trade in the bloc.

The structure of protection in this synthetic starting point database (post Uruguay Round reform and MERCOSUR FTA) is an important feature for the FTA's simulations since they will comprise the shocked variables. Table 1 shows the average import tariff rates by source in MERCOSUR countries; note that Brazil appears to be the most 'protected' economy compared with Argentina and Uruguay. Uruguay has the lowest overall rate of protection in MERCOSUR.

<< Insert table 1 here>>

Table 2 presents the average import tariff in each country by commodity. Within MERCOSUR, the structure of tariffs is very different. Brazil has significant barriers on machinery, equipment and transport equipment while Argentina and Uruguay have larger import tariffs on textiles and clothing. NAFTA countries have overall low tariffs, unless for processed food and clothing in the US and Canada. The EU has large trade barriers in agricultural and food products as import tariffs and export subsidies.

<<Insert table 2 here>>

Table 3 shows import and export shares of MERCOSUR countries. The diversified export profile in MERCOSUR countries is an interesting feature, in contrast with a more similar import profile, dominated by manufactures and machinery. Brazilian exports are more diversified than those for Argentina and Uruguay. For the latter two countries, agriculture and processed food exports are very important. The larger shares of Brazilian exports are in machinery, manufactures and transport equipment.

<<Insert table 3 here>>

Two basic simulations provide the benchmark in the present paper. The FTAA simulation eliminates import tariffs and export subsidies among three blocs: NAFTA (United States, Canada and Mexico), MERCOSUR (Brazil, Argentina and Uruguay) and Rest of the Americas (RA). Also, remaining tariffs and subsidies within NAFTA are eliminated, as are those within the RA region.   Each country retains its external tariffs and subsidies autonomously. This experiment is basically joining three FTA's (MERCOSUR, NAFTA and RA) into a single free trade area with differentiated external trade barriers by country.

The EUMERC experiment is a free trade area between MERCOSUR and the European Union. Therefore Brazil, Argentina, Uruguay and European Union will eliminate import tariffs and export subsidies in their bilateral trade flows. As before, each country will have its own external policies with non-bloc countries.

The macroeconomic closure employed in the simulations is a key feature of the results. Macroeconomic consistency in an open economy implies that net investment (savings less investment) in any region must equal its trade balance (exports less imports).   In the experiments to be conducted here, the trade balance is endogenous, thus it will respond to fill net investment necessities.

4. FTAs Simulation Results

Although sectoral results are also important, the focus will be on the welfare implications for MERCOSUR economies, the most usual way to identify the complete gain/loss for an economy due to an exogenous change. Welfare impacts of liberalization process are second-best implications, where policy reforms in one sector are influenced by the presence of

distortions in related markets. Martin (1997) provides a framework based on the balance-of-trade function, where welfare impacts of trade reforms in the presence of continuing distortions can be evaluated. This approach is also broadly consistent with the approach to welfare evaluation used in AGE models such as GTAP (Hertel and Martin, 2001).

In the GTAP model, the analysis of the costs and benefits can be evaluated by undertaking a welfare analysis and decomposing the changes in welfare into their component parts. [4] In the FTA's simulations carried out in this paper, such welfare changes come from allocative or terms of trade effects. Since a short-run environment is assumed, there is no scope for endowment or technical efficiency contributions. Allocative efficiency gains arise from changes in resource allocations relative to pre-existing distortions. For example, a second-best welfare gain (improved allocation) appears from output reduction in a subsidized activity. There are also contributions to welfare from changes in relative prices, as producers and consumers adjust their purchasing and sales patterns in response to a policy change. Terms of trade effects come from export to import relative price changes; there is a welfare improvement if the export price rises relative to the import price, in a country or region. This decomposition can also be extended to other CGE models, as shown in Hanslow (2000).

Table 4 provides a summary of the welfare changes in the FTAA scenario. Some results will be highlighted: i) all non-FTAA countries have welfare losses, ii) RA countries have the biggest welfare gains, due to positive terms of trade, iii) Argentina and Uruguay are the only FTAA countries that show welfare losses, caused by terms of trade, iv) Brazil obtains welfare gains, as a result of allocation effects.

<center>*<<Insert table 4 here>>*</center>

Further decomposition of Brazilian allocation gains (table 5) helps in the understanding of the effects of the trade liberalization experiment. In this table, the welfare gains are divided up by sectors and type of distortion (tax). The totals for these two types of breakdown are the same. From the first decomposition, we can observe that almost 70% of the allocation gains come from machinery and equipment, other manufactures and transport equipment. From the tax decomposition, 66% of the gains come from input taxes. Therefore, most of the allocation gains come from substitution of domestic inputs by imported ones in those three

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[4] Huff and Hertel (2000) describe the welfare change decomposition in the GTAP model. This decomposition can also be extended to other CGE models, as shown in Hanslow (2000) .

sectors. This is not an obvious result, if one considers that the import taxes on these goods were not the most affected by the FTA liberalization.

<<Insert table 5 here>>

The small welfare losses for Argentina and Uruguay are due to terms of trade. From these results, the overall price index for Argentinean exports dropped by 0.78%, and also its import price index declined by 0.34%.

The EUMERC experiment is a free trade area between MERCOSUR and the European Union. Therefore Brazil, Argentina, Uruguay and European Union will eliminate import tariffs and export subsidies in their bilateral trade flows. As before, each country will have its own external policies with non-bloc countries. This proposal has a significant impact on sectoral outputs. As would be expected, free access to the EU market generates a big boost to food production in MERCOSUR, whose outputs rises by 4.74% in Brazil, 6.8% in Argentina and 26.6% in Uruguay. The drop in other sectors output is a consequence of general equilibrium feedbacks and the short-run environment: wherein resources have to move away from other sectors in order to increase exports and food production.

The welfare changes decomposition in each country for the EUMERC simulation is shown in table 6. As in the FTAA experiment, all non-EUMERC regions have welfare losses. Brazil again obtains welfare gains as a result of allocation effects. Argentina and Uruguay have welfare gains in an FTA with the European Union, in contrast with the FTAA case. For these two countries, these gains are driven by terms of trade effects, due to the increase in food exports to the EU. An interesting result is the negative terms of trade effect for Brazil, in contrast to the positive ones in the FTAA case.[5] Further decompositions for this result illustrate the general equilibrium feedbacks that usually are not considered in partial equilibrium analysis.

<<Insert table 6 here>>

Table 7 shows the decomposition for terms of trade effects in Brazil in both experiments. In the FTAA scenario, the decline in import prices is the most important effect, driving the positive results.   Note the negative effect from falling export prices, especially in manufactures and food. The EUMERC experiment shows a striking difference; the larger

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[5] The very similar absolute value for terms of trade welfare change in both simulations (US$ 234 millions) is just a coincidence.

negative effect comes from rising import prices of agriculture and food. There are also losses from falling export prices of these goods. A closer look at the changes in import prices can explain this apparent puzzle.

<<Insert table 7 here>>

The changes in food import prices in Brazil by source are shown in table 8. The total price change of imported agriculture and food is the weighted sum of price changes by country source. As the trade barriers in agriculture and food are eliminated in the EU, the demand for these products rises, and thus their prices. Brazil benefits by exporting more of these products, but also the import bill for these products rises, as Brazil imports significant amounts from Argentina and the European Union. The price of food imports from the EU rises nearly 30%, and because the import substitution in the model is imperfect (it cannot move completely away from food imports from EU), the imported food price index rises by 11%. Almost 80% of this effect comes from more expensive imports from the EU (30% of Brazilian food imports come from the EU). These are trade diversion effects implied by the short run closure.

<<Insert table 8 here>>

Thus, the elimination of food exports subsidies in the EU is good for Brazilian exports, but has a negative effect on the price of imported products. This negative effect is even more important in Brazil as its imports of agriculture and food products depend on Argentina (75% of imported wheat in Brazil comes from there) and European Union supply (40% of imported dairy products, for example). These effects generate the terms of trade loss for Brazil in the EUMERC experiment.

In the next section, some analysis will be conducted to explore the sensitivity of these results to selected parameter estimates. First a brief introduction to Gaussian Quadratures and its use for systematic sensitivity analysis is presented. Thereafter, the results obtained using this methodology in the above simulations are presented and discussed.

5. Systematic Sensitivity Analysis and Gaussian Quadratures [6]

A general equilibrium model can be seen in general form as:

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[6] This summary fallows Arndt (1996).

$$F(v,a)=0 \tag{1}$$

where v represents a vector of endogenous variables and a vector of exogenous variables (parameters, endowments, shares, etc.). A solution to equation (1) can be defined as $v^*(a)$ with $v^*(a) \equiv H(a)$ as a vector of results of interest. Economic models usually employ estimates of the behavioral parameters; for example, in a trade policy study, estimates of import substitution elasticities are used. As these estimates are random variables, the calculation of mean results for the endogenous variables takes the form:

$$E[H(a)] = \int_{\Omega} H(a)g(a)da \tag{2}$$

Similarly, calculation of the variance of the results can be calculated as:

$$E[(H(a) - E[H(a)])^2] = \int_{\Omega} (H(a) - E[H(a)])^2 g(a)da \tag{3}$$

where $g(a)$ is the multivariate density function.

In (2) and (3), the general equilibrium simulation is treated as a problem of numerical integration. The advantage of this approach is the ability to deal simultaneously with the solution for the general equilibrium model and the randomness of exogenous variables. This approach is more accurate than basing analysis on mean values for key exogenous variables,[7] and estimates of standard deviations can be easily obtained from the estimated means.

Numerical methods, such as Monte Carlo or Gaussian Quadrature, can be employed to calculate mean values in (2). Once estimated mean values for model results have been obtained, estimates of standard deviations are can be calculated. Under specific distributional assumptions, this permits systematic investigation of the impact of uncertainty with respect to values of exogenous variables. Chebychev's inequality can also be used to place confidence bounds on model results. Confidence intervals can provide important information about robustness of some of the results relative to different values in the exogenous variables

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[7] In general, the expected value of a function is not equal to the value of the function evaluated at the expected value of exogenous variables: $E[H(a)] \neq H(E[a])$. If H(.) can be well approximated by a linear function in the region of integration, Ω, the right hand side of this equation is a good approximation to the integral in equation (2). Significant approximation error in the estimate of the mean of results can be obtained in linear approximations to H(.), as we are employing mean values for exogenous variables. For example, in a non-linear model such as GTAP, simulating the model once at mean values for exogenous parameters, as is the common practice, may produce poor approximations of mean results. The extent of misrepresentation of mean results is dependent on the particular model, aggregation, and simulation employed.

vector. They can also help analysts to identify results that are highly dependent on the values employed for underlying exogenous variables.

Application of methods of numerical integration can be exemplified in the simple case of a univariate integration problem:

$$\int_a^b f(x)g(x)dx \tag{4}$$

where $g(x)$ is the density function.

If the integrand is difficult to evaluate analytically, as in most of the AGE models, one can evaluate the integral numerically. In general, numerical approximations of the integral take the form:

$$\sum_{j=1}^{J} w_j f(x^j) \tag{5}$$

where J represents the total number of evaluations of $f(.)$ and w_j represents the weight associated with each evaluation (Haber, 1970).

The Monte Carlo approach represents a special case where J pseudo-random numbers are generated from the distribution $g(x)$ over the interval $[a,b]$. Then, the integrand is evaluated J times, and a weight of $1/J$ is attached to the result from each evaluation. The approximation will be good under extremely mild conditions for the integrand, if J is sufficiently large. Rutherford *et al.* (1997) have applied a Monte Carlo approach to sensitivity analysis in a CGE model, using the procedures developed by Harrison and Vinod (1992). They evaluated five simulations 1000 times each in order to obtain means and standard deviations for the main results[8].

AGE models usually represent cases where the integrand is difficult to evaluate. Hence, it will be appropriate to keep the number of evaluations of the integrand, J, small; therefore, appropriately chosen points, within the interval $[a,b]$, and associated weights, w need to be considered. Formulas to produce sets of points and associated weights are called quadratures. Gaussian Quadratures (GQ) are especially appealing. For the case of the integration problem in equation (5), an order d GQ solves the system of equations:

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[8] They employ a 3 region-39 sectors model to study welfare impacts of Marocco's free trade agreements with the European Union.

$$\sum w_j (x^j)^S = \int_a^b (x)^S g(x) dx, \qquad s = 0,1,2,...,d \qquad\qquad (6)$$

GQs are methods developed to approximate integration problems accurately while requiring a limited number of evaluations of the integrand. This was very useful before the advent of the computer; nowadays, the current computing technology makes Monte Carlo methods for approximating solutions to univariate integration problems very easy. However, in the multi-variate case, Monte Carlo approximations are not always so practical. The development and regular use of extraordinarily complex multivariate integrands, for example, in a global general equilibrium model, has revealed that, in most of the cases, Monte Carlo simulations are not feasible, even with the best available computing technology[9].

Given a continuous distribution for several variables, a Gaussian quadrature for this distribution is a discrete distribution whose first several moments are identical with those of the continuous distribution. The quadrature is said to be of order d if the first d moments agree. The GQ method, as implemented in the RunGTAP software, follows a method developed by Stroud (1957) for drawing order three GQs for symmetric distributions. Because these have order three, the first 3 moments are the same as those for the continuous distribution. The first moment is the mean, and because the first and second moments are the same, so are the standard deviations. These quadratures are only valid for distributions made up of one or more symmetric distributions, which vary independently. This methodology is very appealing because of its modest requirements. For a model with n random exogenous variables, this method permits systematic sensitivity analysis (SSA) with respect to these n exogenous variables using only $2n$ points or solves of the model.[10]

The following formula was developed by Stroud (1957) for deriving equally weighted, order three quadratures for symmetric, independent distributions of mean zero and standard deviation one. Let n be the number of random exogenous variables and Γ_k $(\gamma_{k1}, \gamma_{k2}, ..., \gamma_{kn})$ be the kth quadrature point ($k=1,2,...,$ 2n). With $r=1,2,...,$ n/2|, where n/2| denotes the greatest integer not exceeding $n/2$, points may be derived by:

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[9] The GQ approach is also embedded in a very popular CGE software, GEMPACK. Therefore, for systematic sensitivity analysis, the GQ approach is ready to use for CGE modelers.
[10] As Arndt (1996) have explained "conducting systematic sensitivity analysis on a model that takes five minutes to solve using 1000 Monte Carlo repetitions would take nearly 3.5 days. At five minutes per solution, the method developed by Stroud permits accurate sensitivity analysis with respect to 15 random exogenous variables in 2.5 hours (2*15*5/60=2.5). If results can be well approximated by an order three polynomial, the GQ sensitivity analysis will be very accurate despite the limited number of evaluations of the model"

$$\gamma_{2r-1} = \sqrt{2}\cos\left(\frac{(2r-1)k\pi}{n}\right) \qquad \gamma_{2r} = \sqrt{2}\sin\left(\frac{(2r-1)k\pi}{n}\right) \tag{7}$$

Since the weights, w_k, are equal and must sum to one, then $w_k = 1/2n$.

Stroud proves that points derived from the above formula satisfy the following condition for an order d approximation of a multivariate distribution of the endogenous variables x:

$$\sum_{j=1}^{J} w_j \prod_{m=1}^{M}(x_m)^{l_m} = \int_{\Omega}\left[\prod_{m=1}^{M}(x_m)^{l_m}\right]g(x)dx \tag{8}$$

for all combinations of non-negative integers l_m such that $\sum_{m=1}^{M}l_m \le d$.

Consider performing sensitivity analysis with respect to a symmetrically distributed random variable x ($x_1, x_2, ..., x_n$), a column vector of size n with mean μ and variance covariance matrix Σ. If Σ is diagonal, the desired quadrature, Φ, can be obtained by:

$$\Phi = \mu + \Gamma\sqrt{\Sigma} \tag{9}$$

If Σ is not diagonal, a diagonal matrix, D, can be obtained using a Cholesky factorization, $\Sigma = LDL^t$. The quadrature from equation (9) is transformed to $\Gamma^* = \Gamma L$ and the desired quadrature Φ can be obtained by:

$$\Phi = \mu + \Gamma^*\sqrt{D} \tag{10}$$

It is not clear how many orders a GQ approximation should have to produce an accurate fit. The result obviously depends on the integrand, in this case the general equilibrium model, on the simulation and aggregation implemented. The SSA implemented is based on Stroud's quadrature, which is a particular Gaussian quadrature of order 3. Experience indicates that the estimates of the means and standard deviations produced are usually fairly accurate. Arndt (1996) has made some comparison for the GTAP model and has concluded that order three approximations were quite good, as order three and order nine approximations matched to the first four decimal points. In general, higher order quadratures produce better approximations than lower order quadratures.

In summary, Gaussian quadratures can provide a practical tool to conduct systematic sensitivity analysis in large models. Two conditions must be met in order to employ this analysis. First, random exogenous variables are assumed to be distributed symmetrically.

Secondly, the model results should be reasonably well approximated by an order three polynomial. In this case, the Stroud formula presented above can be easily employed to obtain quadratures, or points where the model will be evaluated. From this method, it is possible to obtain good approximations of means of model results and associated standard deviations. This additional information is very important to access the robustness of model results, as opposed to simply running the model at mean values for random exogenous variables.

In the next sections, the simulation results presented in section 4 will be tested for two key points in our simulations, shocks and trade elasticities, using the above methods. Two sets of sensitivity tests are implemented. First, SSA analysis is applied to the shocks in each simulation (FTAA and EUMERC) with default parameters. Secondly, trade elasticities are tested using the default shocks (the full trade liberalization in FTAA and EUMERC). Although the mean and standard deviations are obtained for all endogenous variables only the welfare results will be discussed in this paper.

5.1 Shocks

Usually, in AGE trade liberalization simulations, the experiment focuses on the elimination of import tariffs, exports and output subsidies following the most plausible sequence of implementation. Therefore, there is an intrinsic uncertainty in the tariff reduction. Empirically, in a first instance, these agreements tend to be less aggressive in the rate cuts, and usually a tariff cut schedule is set among the countries. For the AGE analysis, the size and timing of tariff changes are important factors driving the results, because they determine the size and sequence of the shocks required in the simulations.

The SSA in the two simulations was implemented setting an interval for each specific bilateral rate cut. Although this range depends on the specific flow, it follows a simple rule. The change in the trade tax (import tariff and export subsidy) is calculated for each good i from region r to region s in each simulation, $t(i, r, s)$, thereby eliminating the bilateral barrier. Each FTA simulation is again carried out with shocks of $2/3*t(i, r, s)$, with this change rate going up and down by 50%. Therefore the interval is set to $[1/3*t(i, r, s), t(i, r, s)]$, i.e., going from one-third of the change that eliminates the tariff, $1/3*t(i, r, s)$, to the change that effectively eliminates it, $t(i, r, s)$, with mean/mode of $2/3*t(i, r, s)$. The analysis assumes

independent, symmetric, triangular distributions.[11] Systematic Sensitivity Analysis provides means and standard deviations results for the endogenous variables, associated with these ranges.

Table 9 summarizes the welfare results in each Mercosur country for these ranges of shocks. The *Full* column brings the result of the FTAA and EUMERC simulation discussed above. The *1/3 Cut* column is the lower bound for the trade liberalization.[12] The *Mean* and standard error (*SD*) columns are obtained via SSA with the specification discussed above. The 90% confidence intervals are constructed using Chebyshev's inequality (Greene, 1993).

<<Insert table 9 here>>

The results show that point estimates for high/low values can be misleading. Note that some 90% intervals are very different from the Full-1/3 cut estimates. This finding implies that although the model equations are linearized, the results for some endogenous variables are not linear in the shocks.

An important result is that the estimated standard deviations are higher (as a proportion of the estimated means) for Argentina and Uruguay; the sensitiveness of welfare results for these countries are connected with the source of welfare gains. As can be seen in table 9 and 13, the welfare gains/losses for these countries are driven by terms of trade effects. Therefore, if the degree of liberalization changes, the impacts in these countries are important. On the other hand, results for Brazil seems to be very robust to the range of shocks, as they are driven more by allocation effects.

5.2 Parameters

In the GTAP model and framework, two sets of elasticities in the Armington demand structure determine the substitution possibilities between domestic and the composite import, ESUBD, and among imports from different sources, ESUBM. Table 10 shows the default values in the aggregation used in this paper. One observes that ESUBM roughly equals twice ESUBD for each commodity. This is an empirical regularity found in systems of demand estimations and should be kept in mind when implementing systematic sensitivity analysis on the Armington structure Huff *et al.* (1997).

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[11] The distribution is independent by countries *r* and *s*, not by commodity *i*. The hypothesis is that if some good is included in the agreement then all countries should be compromised in some trade barrier cut in that commodity. Computationally this also reduces the number of simulations in the SSA analysis from 200 to 80.
[12] These results are obtained from simulations with 1/3 of the FTAA and EUMERC shocks.

<<insert table 10 here >>

Smaller trade elasticities imply less substitution among imported sources and between domestic and imported composite in the GTAP model. The change in the results will depend on the interaction of the tariff cuts, price responses and these elasticities. It would be expected, for example, that the increase in Argentinean processed food exports to the European Union in the EUMERC simulation would be lower when the trade elasticities are lower. In general, an increase in the Armington elasticity between domestic and composite imports increases the welfare benefits of trade integration. Larger substitution among imports from different sources reduces the welfare benefits of tariff reductions, *ceteris paribus*.[13]

The second group of sensitivity analyses will be carried out in the parameters ESUBM and ESUBD. The full liberalization experiments discussed above (FTAA and EUMERC) are employed using the Gaussian Quadrature approach to establish confidence intervals for the main results. The range for the elasticities is set to +/- 50% around the default value (table 10), with independent, symmetric, triangular distributions for the two parameters.[14]

Table 11 summarizes the sensitivity of welfare results in each MERCOSUR country for this range in the elasticities. The Default column provides point estimate results for the default values. The *Mean* and standard error (*SD*) columns are obtained via SSA and the 90% confidence intervals are constructed using Chebyshev's inequality (Greene, 1993).

<<insert table 11 here>>

We observe that standard deviations results are also very high compared with their means in most of the cases. Only for Brazil in the EUMERC scenario, is the 90% confidence intervalgood enough. In the other cases, standard deviations are between 4 and 2 times their means; in this case, welfare gains can be very low, for example for Brazil in the EUMERC simulation. This is important information that is rarely revealed in the use of point estimates. For Argentina and Uruguay, the confidence intervals show that welfare gains can be very

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[13] For a graphical explanation of these effects and a simulation exercise in a CGE model, see Rutherford et al. (1997) pages 258-261.

[14] In each simulation we kept the default relation in the Armington structure, ESUBM=2*ESUBD. Despite a literature search for elasticity values, there are a high degree of uncertainty for these elasticities/parameters, so the 50% interval is an *ad-hoc* and parsimonious hypothesis. Long-run studies with the GTAP model (Hertel and Martin, 2001; Hertel *et al*., 1999) have chosen two times the default parameters values, although this is also an *ad-hoc* hypothesis. A 100% interval was also tested in the present study, and the resulting mean and standard deviations were very close to those reported in table 11.

low, or negative, in both simulations. As in the SSA for shocks, results for these two countries are very sensitive as terms of trade effects dominate the welfare effect (table 4 and 6).

6. Conclusions

Some general policy conclusions can be taken from the present paper. From the MERCOSUR perspective, a free trade area with the European Union seems to be preferable, in terms of welfare gains, to further hemispheric integration through FTAA. However, these results revealed themselves to be very sensitive to the shocks and some of the parameters in the GTAP model. The GTAP model has been widely used for policy makers and researchers in Brazil to analyze trade policy issues (e.g. Gurgel *et al.* 2002; Pereira 2001; Figueiredo *et al.* 2001) but the sensitivity of the results to parameter specification has not been considered properly.

Sensitivity tests in the model showed strong evidence of welfare gains for Brazil, in the case of free trade areas such as FTAA or with the European Union. Allocation effects were the key aspect driving Brazilian welfare gains; therefore, the model revealed itself to be robust to different degrees of trade liberalization or trade elasticities. However, for Argentina and Uruguay, welfare gains are due to terms of trade impacts, therefore they depend heavily on the magnitude of the shocks (degree of trade liberalization) and the trade elasticities.

More general and methodological considerations can also be taken from the present paper. Given the intrinsic uncertainty in the shock magnitudes and parameter values, sensitivity tests, such as those carried out in this paper, are an important next step in the more formal evaluation of the robustness of AGE analysis. However, some important points should be addressed in the future in order to have a better understand of the models results sensitivity. Similar to the fields of influence approach for input-output models developed by Sonis and Hewings (1992), attention needs to be directed to the most important synergetic interactions in a CGE model. It is important to try to assemble information on the parameters, shocks and database flows, for example, that are the analytically most important in generating the model outcomes, in order to direct our efforts to a more detailed investigation.

Some implications for policy makers in Mercosur can be highlighted from the analysis in this paper. CGE models are often used to make projections about different trade policy strategies; very detailed models are often required in order to obtain results that can be useful for those

countries.   While the availability of models has been grown substantially, the quality of data and analysis needs to be improved. For example, relevant parameters in those models are usually taken from the literature, or are based on typical values. Sensitivity analysis is a necessary tool to make CGE models predictions more valuable for policy makers. Systematic sensitivity analysis, as shown in this paper, represents a powerful tool to be applied to large models, when the uncertainty about parameters and shocks are the usual circumstances. As Mercosur countries are meeting together to discuss different trade agreements, a common framework about models, parameters and analysis would be very important to improve their negotiation capacity. Put together, FTAA and EU-Mercosur negotiations can have a synergetic relation for Mercosur countries, especially to enhance the strategic position for the bloc and the potential gains for all countries.

References

Armington, P. S. 1969. A theory of demand for products distinguished by place of production. *International Monetary Fund Staff Papers* 16:159-178.

Arndt, C. 1996. An introduction to systematic sensitivity analysis via gaussian quadrature. West Lafayette, Indiana: Center for Global Trade Analysis, Purdue University.

Coyle, W., M. Gehler, T.W. Hertel, Wang. Z., and W. Yu. 1998. Understanding the Determinants of Structural Change in World Food Markets. *American Journal of Agricultural Economics* 80 (5):1051-1061.

Deardorff, A. V., and R. M. Stern. 1986. *The Michigan Model of world production and trade*. Cambridge: The MIT Press.

DeVuyst, E. A., and P. V. Preckel. 1997. Sensitivity analysis revisited: a quadrature-based approach. *Journal of Policy Modeling* 19 (2):175-185.

Diao, X., and A. Somwaru. 2000. An inquiry on general equilibrium effects of Mercosur - an intertemporal world model. *Journal of Policy Modeling* 22 (5):557-588.

Figueiredo, A. M. R., A. V. Ferreira, and E. C. Teixeira. 2001. Impactos da integração econômica nas *commodities* da economia brasileira e da União Européia. *Revista Brasileira de Economia* 55 (1):77-106.

Francois, J. F. 2000. Assessing the results of General Equilibrium studies of multilateral trade negotiations. New York: United Nations, UNCTAD.

Francois, J. F., and C. R. Shiells. 1994. *Modeling trade policy : applied general equilibrium assessments of North American free trade*. Cambridge ; New York, NY, USA: Cambridge University Press.

Frankel, J. F. 1997. *Regional trading blocs in the world economic system*. Washington: Institute for International Economics.

Gehlhar, M. 1997. Historical Analysis of growth and trade patterns in the Pacific Rim: An evaluation of the GTAP framework. In *Global Trade Analysis : modeling and applications*, edited by T. W. Hertel. New York: Cambridge University Press.

Greene, W. H. 1993. *Econometric analysis*. 2nd ed. New York: Macmillan.

Gurgel, A. C., M. B. Bitencourt, and E. C. Teixeira. 2002. Impactos dos Acordos de Liberalização Comercial Alca e Mercoeuro sobre os Países Membros. *Revista Brasileira de Economia* 56 (2):335-369.

Haber, S. 1970. Numerical evaluation of multiple integrals. *SIAM Review* 12:481-525.

Haddad, E. A., and E. P. Domingues. 2000. Strategies of Regional Integration: The Case of Brazil. Paper read at Inaugural Workshop of the Hewlett Brazil Project, November, 9-10th, at University of Illinois at Urbana-Champaign.

Hansen, L. P., and J. J. Heckman. 1996. The Empirical Foundations of Calibration. *The Journal of Economic Perspectives* 10 (1):87-104.

Hanslow, K. J. 2000. A general welfare decomposition for CGE models. West Lafayette, Indiana: Center for Global Trade Analysis, Purdue University.

Hertel, T.W., W. Martin, K. Yanagishima, and B. Dimaranan. 1996. Liberalizing Manufactures Trade in a Changing World Economy. In *The Uruguay Round and the Developing Countries*, edited by W. Martin and A. Winters. New York: Cambridge University Press.

Hertel, T. W., and W. Martin. 1999. Would Developing Countries Gain from Inclusion of Manufactures in the WTO Negotiations? Paper read at WTO and The Millennium Round, at Geneva.

———. 2001. Second-Best Linkages and the Gains from Global Reform of Manufactures Trade. *Review of International Economics*:215-232.

Huff, K. M., K. Hanslow, T. W. Hertel, and M. E. Tsigas. 1997. GTAP behavioral parameters. In *Global trade analysis: modeling and applications*, edited by T. W. Hertel. Cambridge ; New York: Cambridge University Press.

Huff, K. M., and T. W. Hertel. 2000. Decomposing welfare changes in GTAP. West Lafayette, Indiana: Center for Global Trade Analysis, Purdue University.

Jackson, R. W. 1986. The 'Full Distribution' Approach to Aggregate Representation in the Input-Output Modeling Framework. *Journal of Regional Science* 26 (3):515-531.

Martin, W. 1997. Measuring welfare changes with distortions. In *Applied Methods for Trade Policy Analysis: A Handbook*, edited by J. F. Francois and K. Reinert. Cambridge: Cambridge University Press.

McKitrick, R. R. 1998. The econometric critique of computable general equilibrium modeling: the role of functional forms. *Economic Modelling* 15 (4):543-573.

Pereira, L. V.. 2001. Impactos da Alca e do acordo Mercosul-União Europeia nas economias brasileira e argentina: um mapeamento preliminar. *Revista Brasileira de Comércio Exterior* 13 (67):31-34.

Sonis, M., and G. J. D. Hewings. 1992. Coefficient change in input-output models: theory and applications. *Economic Systems Research* 4:143-157.

Stroud, A. H. 1957. Remarks on the disposition of points in numerical integration formulas. *Math. Tables Aids Comput.* 11:257-261.

Ten Raa, T., and P. K. Jansen. 1998. Bias and Sensitivity of Multipliers. *Economic Systems Research* 10 (3):275-283.

West, G. R. 1995. Comparison of Input-Output, Input-Output+Econometric and Computable General Equilibrium Impact Models at the Regional Level. *Economic Systems Research* 7 (2):209-227.

Wigle, R. 1991. The Pagan-Shannon approximation: unconditional systematic sensitivity in minutes. *Empirical Economics* 16:35-49.

Yang, Y., W. Martin, and K. Yanagashima. 1997. Evaluating the benefcts of abolishing the MFA in the Uruguay Round package. In *Global Trade Analysis : modeling and applications*, edited by T. W. Hertel. New York: Cambridge University Press.

Table 1: 'Average' Import Tariff Rates by Source (%)

	Brazil	Argentina	Uruguay
Source:			
USCAN	6.55	4.35	3.05
EU	8.36	5.46	2.80
Japan	7.87	4.08	2.62
NIASCH	8.74	6.80	2.53
Mexico	10.91	5.07	3.89
RA	9.01	8.64	4.96
ROW	9.81	7.35	1.32

Table 2: 'Average' Import Tariff Rates by Commodity (%)

	Brazil	Argentina	Uruguay	USCAN	Mexico	EU1[1]	EU2	RA
AGR	2.01	2.88	0.96	3.45	0.70	9.72	5.30	0.48
MNG	9.28	9.34	1.27	0.89	2.91	0.27	0.19	7.94
PFD	2.04	5.27	2.40	8.01	1.10	22.20	6.43	12.45
TXT	9.18	7.78	6.19	5.84	3.25	4.23	1.48	11.11
CLG	13.96	10.54	7.31	10.97	2.98	9.34	6.28	19.99
IRS	4.80	2.80	1.23	1.36	2.68	2.51	0.56	4.28
M_E	9.74	3.25	0.72	0.93	2.06	1.92	0.80	4.85
OMF	6.77	4.66	2.02	1.66	2.05	2.30	0.77	6.62
TRE	9.60	5.62	1.69	1.02	3.53	4.50	1.01	10.27

[1] This column excludes intra-European Union trade in estimating the average

Table 3: Trade shares (%)

	Imports			Exports		
	Brazil	Argentina	Uruguay	Brazil	Argentina	Uruguay
AGR	5.13	2.09	4.55	11.4	18.9	11.2
MNG	8.13	3.30	5.81	6.6	7.9	0.9
PFD	4.01	3.52	7.27	16.8	23.0	20.7
TXT	2.26	2.21	2.74	1.9	1.3	6.6
CLG	0.61	1.21	2.05	0.6	0.3	1.2
IRS	0.72	2.49	1.98	8.4	2.5	0.6
M_E	25.71	25.75	16.88	10.8	5.1	2.8
OMF	23.86	28.90	26.54	25.6	14.5	19.4
TRE	14.06	14.38	16.56	9.2	19.9	15.6
SVCES	15.51	16.14	15.62	8.7	6.6	21.0
total	100	100	100	100	100	100

Table 4: Welfare changes (US$ millions), FTAA simulation

	Allocation	Terms of Trade	Investment	Total

Brazil	1769	234	278	2281
Argentina	26	-124	-99	-197
Uruguay	9	-20	-6	-17
USCAN	443	908	1611	2962
Mexico	54	254	66	374
RA	796	2901	608	4305
EU	-301	-1916	-641	-2858
Japan	43	-692	-847	-1496
NIASCH	-150	-1104	-716	-1970
ROW	-123	-474	-264	-861
Total	2566	-32	-10	2524

Table 5: Welfare changes decomposition in Brazil (US$ millions), FTAA simulation

Allocation effects decompositions

I. By Sector		II. By Type of Tax	
AGR	284	Production	-21
PFD	92	Inputs	1181
TXT	25	Consumption	321
CLG	26	Export	131
M_E	646	Import	157
OMF	426		
TRE	299		
SVCES	-47		
total	1769		1769

Table 6: Welfare changes (US$ millions), EUMERC scenario

	Allocation	Terms of Trade	Investment	Total
Brazil	2030	-234	1063	2857
Argentina	80	787	232	1099
Uruguay	120	438	92	650
EU	1092	743	-41	1794
USCAN	-58	-464	-376	-898
Mexico	-14	-31	-10	-55
RA	-37	-189	3	-223
Japan	-6	-365	-591	-962
NIASCH	-78	-212	-258	-548
ROW	14	-508	-136	-630
Total	3143	-36	-22	3085

Table 7: Terms of Trade Welfare changes (US$ millions)

Simulation	Sector	World	Export	Import	Total
FTAA					
	Agriculture	-3	-336	-44	-383
	Food	14	-119	-16	-121

	Others	-1	-144	884	740
	Total	11	-599	824	234
	Agriculture	-6	-511	-188	-704
EUMERC	Food	17	-221	-348	-552
	Others	8	1081	-68	1021
	Total	18	350	-604	-234

Table 8: Food import prices changes in Brazil

Simulation	Source	Price Change (%)	Share (%)	Effect (%)
	USCAN	-0.33	10.3	-0.03
	Argentina	-0.43	24.3	-0.10
FTAA	Uruguay	-0.54	11.0	-0.06
	RA	-5.04	8.5	-0.42
	Others	-0.002	45.9	-0.10
	Total		100	-0.71
	EU	30.90	30.3	9.35
EUMERC	Argentina	3.70	24.3	0.90
	Uruguay	13.19	11.0	1.44
	Others	-0.0004	34.4	-0.01
	Total		100	11.69

Table 9: Systematic Sensitivity Analysis - Shocks
   Welfare Changes (US$ millions)

	Full[1]	1/3 Cut[2]	Mean	SD	90% CI	
FTAA simulation						
Brazil	2283	930	1712	301	760	2664
Argentina	-197	8	-42	72	-271	187
Uruguay	-18	-1	-10	4	-23	3
EUMERC simulation						
Brazil	2858	1094	2073	531	393	3754
Argentina	1100	234	581	296	-354	1517
Uruguay	650	89	287	117	-84	658

[1]Complete FTA implementation
[2] Incomplete FTA implementation, 1/3 of Full cuts

Table 10: Default parameters in the GTAP model[1]

	ESUBD	ESUBM
AGR	2.36	4.55
MNG	2.80	5.60
PFD	2.45	4.74
TXT	2.20	4.40
CLG	4.40	8.80
IRS	2.80	5.60

M_E	2.80	5.60
OMF	2.27	4.71
TRE	5.20	10.40
SVCES	1.95	3.81

[1]These values depend on the aggregation employed

Table 11: Systematic Sensitivity Analysis – Elasticities
    Welfare Changes (US$ millions)

	Default	Mean	SD	90% CI	
FTAA simulation					
Brazil	2281	2319	359	3453	1185
Argentina	-99	-207	104	122	-537
Uruguay	-17	-18	6	1	-37
EUMERC simulation					
Brazil	2857	2931	860	5649	212
Argentina	1099	1110	435	2486	-265
Uruguay	650	652	174	1203	101

APPENDIX 1:

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1. United States and Canada (**USCAN**)
2. European Union (**EU**)
3. **Japan**
4. Hong Kong, Korea, Taiwan, Indonesia, Malaysia, Philippines, Singapore, Thailand, South Asia and China (**NIASCH**)
5. **Mexico**
6. **Brazil**
7. **Argentina**
8. **Uruguay**
9. Rest of America (**RA**)
10. Rest of World (**ROW**

Regional and Commodity Aggregation

1. Agriculture (AGR)
 Paddy rice
 Wheat
 Cereal grains
 Vegetables, fruit, nuts
 Oil seeds
 Sugar cane, sugar beet
 Plant-based fibers
 Crops
 Bovine cattle, sheep and goats
 Wool, silk-worm cocoons
 Forestry
 Fishing
 Processed rice
2. Mining (MNG)
 Coal
 Oil
 Gas
 Minerals
 Mineral products
3. Processed Food (PFD)
 Animal products
 Raw milk
 Bovine cattle, sheep and goat
 Meat products
 Vegetable oils and fats
 Dairy products
 Sugar
 Food products
 Beverages and tobacco products

4. Textiles (TXT)
5. Wearing apparel (CLG)
6. Ferrous metals (IRS)
7. Machinery and Equipment (M_E)
 Electronic equipment
 Machinery and equipment
8. Transport Equipment (TER)
 Motor vehicles and parts
 Transport equipment
9. Other manufactures (OMF)
 Leather products
 Wood products
 Paper products, publishing
 Petroleum, coal products
 Chemical, rubber, plastic products
 Metals
 Metal products
 Manufactures
10. Services (SVCE)
 Electricity
 Gas manufacture, distribution
 Water
 Construction
 Trade, transport
 Financial, business, recreational services
 Public admin and defense, education, health
 Dwellings