Estimating Trade Elasticities for GTAP:

A Maximum Entropy Approach

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By Jing Liu,
Channing Arndt,
And Thomas Hertel

Center for Global Trade Analysis, Purdue University

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1. Introduction

Computable General Equilibrium (CGE) models have been widely used for quantitative analysis of global economic issues. However, CGE models are frequently criticized for resting on weak empirical foundations. Criticism focuses on the use of apparently arbitrary values for behavioral parameters as well as the lack of model validation. Length of run considered in a CGE simulation is also an issue as researchers often do not have clear guidelines as to the appropriate choice of parameter values and model closures for short run vs. medium vs. long run simulations. These deficiencies are particularly problematic in light of the fact that model conclusions are often quite sensitive to these assumptions (Arndt et al., 1997; Roberts, 1994).

This paper presents an approach to trade parameter estimation for one of the most widely employed global CGE models in use today, namely the Global Trade Analysis Project (GTAP) model. We build the simulation model on the work of Arndt, Robinson, and Tarp (1999), who have conducted a similar exercise for a CGE model of Mozambique.

1.1. Behavioral Parameters in GTAP

The GTAP model has its root in SALTER Project[1], and it adopts the SALTER substitution parameters. However, the parameter file of SALTER was largely the result of *ad hoc* literature review, and the extent of validation work with the GTAP to date has been quite limited. An exception is made by Gehlhar (1994). For trade policy applications, the most important parameters are the elasticities of substitution between domestic and imported products (Φ_D) and among imports from different sources (Φ_M). The econometric work underpinning these trade elasticities is particularly limited, and the parameter values currently used by GTAP are the subject of considerable controversy.

Currently, the Φ_D values for most 45 GTAP sectors fall between 2.0 to 4.0, and the Φ_M values are set twice as large as the corresponding Φ_D values (table 4). Some "structuralist" economists argue that the chosen values are too large and do not sufficiently reflect institutional rigidities in trade. Other "market-oriented" economists argue that the GTAP trade elasticities are too small and do not permit patterns of trade to change sufficiently. Theory provides no support to either side of this debate. The magnitude of trade parameter values is purely an empirical question. Perhaps the views held by "structualist" economist are more suitable on a short run basis while the view of "market-oriented" economists may be more suitable on a longer run basis.

The purpose of this paper is to estimate the values of the Armington trade substitution elasticities most consistent with historical experience in entropy sense.

[1] A multinational general equilibrium model by Australian Industrial Commission (Jomini, et al, 1991)

1.2. Brief Literature Review

There are so far two major approaches for parameter estimation (Hansen and Heckman, 1996): the calibration method and the econometric method. Some studies also include a validation procedure to test the quality of estimation results.

Normally, the calibration method applies after the analytic framework of the model is already established. It focuses on the selection of a particular functional structure and its associated parameterization. The parameters to be calibrated are determined by forcing the model to replicate the data of a chosen benchmark year. While the calibration method usually requires a very limited amount of data, it has been widely criticized for its lack of statistical validity (Mckitrick, 1995 &1998; Jorgenson, 1984).

The econometric approach to CGE parameter estimation requires substantial time series data. It typically starts with the specification of an equation system and simultaneously estimates all the coefficients of this system. The benchmark data can then be computed using the general equilibrium model itself (Mckitrick, 1998). While this method is in principle preferred to the calibrated method, it suffers from criticism in several aspects (Arndt, et al.1998), among which are the onerous data requirements and the violation of general equilibrium (GE) conditions when estimation is performed.

Efforts have been made to evaluate or estimate parameters within a GE framework (Gehlhar, 1994; Arndt et al 1998). In the study by Gehlhar, the investigation of Armington specification mainly serves for sensitivity analysis. The candidates of alternative model structures and their associated parameters are compared with each other based on simulation results. In the case, Arndt, Robinson, and Tarp (1998) introduced a maximum entropy (ME) approach for the parameterization procedure in the general equilibrium (GE) context. Their study turns out to be fairly successful - even for a country whose data are quite limited.

The ME approach is similar to the econometric method plus it has the merits of remaining consistent with a GE framework. In addition, it is also able to utilize all available information and provide statistical tests for estimated parameter values. Thirdly, it imposes very few limits on the selection of parameters while it allows prior information, such as the relevant ranges of parameters to be reflected in the procedure. Fourth, it is able to estimate a relatively large numbers of parameters without requiring copious data. Finally, it can utilize incomplete and/or non-compatible data that are normally unusable for econometric purposes.

1.3. General Approach

This study adopts a similar approach to that employed by Arndt, Robinson and Tarp. This is applied to a 10-region, 10-industry aggregation of version 4 of the GTAP database with an emphasis on the East Asian economies over the 1986-95 period. This was a period of rapid change in the pattern of trade. The relevant historical data in time series format (1986, 1989, 1992, and 1995) have been collected. The base year is 1995. The time series data trace historical changes (backward) in time in important economic indicators such as GDP, imports/exports, factor endowments, investment, government consumption, Saving as well as tariff and non-tariff protection levels. Some of the data are used as shocks to the economy in this backcasting simulation exercise. Others are set as historical targets. Hicks-neutral technical change in value-added is introduced to explain the difference between the overall rate of economic growth and the rate of growth in factor endowments.

We employ a modified version of the GTAPinGAMS[2] model developed by Rutherford (1998). GTAPinGAMS is a simplified GTAP model written in the GAMS language designed to run with GTAP database. GTAPinGAMS differs from standard GTAP in several aspects. First, it employs simpler functional forms to represent private demand (Cobb-Douglas vs. CDE). Second, it treats investment, saving, and government consumption as exogenous rather than endogenous. Third, it is a static model and does not consider technological factors in the production structure. Nevertheless, GTAPinGAMS can easily be modified technically to meet the requirement for this study.

In this study, This *Cobb-Douglas* model is revised to accommodate more complex functional forms. It is extended to incorporate a *Linear Expenditure System* (LES) preference structure and *Constant Elasticity of Substitution* (CES) production functions. The investment, saving, and government consumption remain exogenous and are set at their observed levels for each years. Technical changes are incorporated into the model as endogenous variables. Finally, a time index is introduced for our simulations since multiple points in time are involved in this study. By pinning down the model structure and permitting the parameters to vary, the corresponding estimated endogenous variables may be compared to the historical targets in order to determine the preferred values for trade elasticities. A composite entropy measure is used to set up the formal optimization problem with the solution to this problem determining the revised values for the trade parameters.

2. The Model and The Database

2.1 The Analytical Structure of the Modified GTAPinGAMS

The GTAPinGAMS model is a multi-purpose framework that can be used by researchers for quantitative analysis of global economic issues. The structure of the modified model is quite standard in nature. Factor endowments combine in a CES function to produce value added. Value added combines with intermediate inputs in a Leontief fashion to produce final goods. Imported and domestic goods are combined in a CES fashion in the tradition of Armington (1969). The final demands in each region are determined by a super household, which is endowed with primary factors, tax revenue, and an exogenously specified net transfer from other regions. Total income is allocated to investment, public and private demands. Investment and public output are exogenous while private demand is determined by utility maximizing behavior represented by a *Linear Expenditure System* (LES)[3] functional structure. Imports to different usages (private demand, public demand, and intermediate demand) share the same regional composite within the import aggregate. A CES aggregation across imports from different regions forms the total import composite. Transportation costs are proportional to trade and are defined by a Cobb-Douglas aggregate of international transport inputs supplied by different countries. Goods produced for exports substitute perfectly with goods produced for domestic consumption (e.g. no transformation function between domestic goods and exports).

[2] The reason to choose GTAPinGAMS instead of standard GTAP lies in the faculty of the GAMS language to solve optimization problems for non-square systems.

[3] The calibration of LES functional structure is independent of GTAPinGAMS model and our simulations. The details are included in the appendix C.

The analytical structure of GTAPinGAMS is built up by employing two types of algebraic equations to establish linkages for all variables. One type of equation reflects the accounting relationships among variables and the other type (behavioral equations) imposes behavior on agents using specific functional forms. The selection of a functional form for behavior equations generally reflects the trade-off between the structural flexibility of the model and the empirical convenience. A model with a more flexible structure imposes fewer restrictions on behavioral equations, but normally requires more information for parameterization, which unfortunately often relies on literature reviews and means of calibration. Among the behavioral equations, the Armington trade structure and its associated elasticities (Φ_D and Φ_M) are the topic of this paper. Parameter Φ_D reflects the ease of substitution between domestic goods and composite imports from same product category, and Φ_M reflects the ease of substitution among imported goods from different sources (Huff, Hanslow, and Hertel, 1998). For instance, a value of Φ_D equal to zero means non-substitution between domestic and imported goods while a value of infinity means they are perfect substitutes.

2.2: The Aggregation

Theoretically, the aggregation could be conducted at a highly disaggregated level as there are 45 sectors and 40 regions in the version 4 GTAP database. However, the computational burden and the sheer magnitude of data call for a more compact aggregation. Our 10-region by 10-sector aggregation strategy (shown in tables 1 and 2) is based on the earlier work of Mark Gehlhar (1994) with the emphasis on East Asia. A small change of this regional aggregation relative to Gehlhar is to have China as an individual region in this study.

There are two reasons for such aggregation. The first is that Asian economies are among the most dynamic during the periods of interest in this study. A second is to facilitate the comparison between the two studies. The sectoral aggregation mainly reflects the consideration of differences of substitutability of goods from different sources.

Table 1: 10 Sector Aggregation

AGR	& Agriculture
PAG	& Processed Agriculture
FMN	& Fuels And Minerals
CTX	& Clothing And Textiles
OLT	& Other Light Manufactures
CHM	& Chemicals
MEV	& Machinery-Equipment-Vehicles
BAM	& Basic Manufactures
NSV	& Non-traded Services
TSV	& Traded Services
CGD	& Capital goods

Table 2: 10 Region Aggregation

USC	& North American Free Trade Area
MEX	& Mexico
JPN	& Japan
KOR	& Korea
TWN	& Taiwan
THA	& Thailand
IDN	& Indonesia
CHN	& China
REA	& other East Asia
ROW	& All other regions (Including EU)

2.3 Maximum Entropy: Theory and Application

The maximum entropy approach defines a function as a measure of the uncertainty, or entropy, of a collection of events while satisfying certain constraints. Its sister formulation, Minimum Cross Entropy (MCE) is to define a measurement of distance from some prior distribution. MCE finds solutions as close as possible to these prior distributions while satisfying given constraints. Similar to some standard econometric method such as Ordinary Least Square (OLS) approach, ME/MCE offer alternative ways for parameter estimation. MCE is used in this study since we may utilize the information in Table 4. The basic idea is to collect some macro data such as GDP as the targets and others such as factor endowments as the exogenous shocks to the economy. MCE is then used to obtain a set of values for Armington substitution parameters (Φ_D and Φ_M) in the GTAPinGAMS model that result in a minimum discrepancy between the actual targeting data and the predicted values.

Following the notation by Arndt et al. (1998), we may view the standard GTAP model in the following form:

$$F(X_t, Z_t^o, Z_t^u, \mathrm{B}, \delta) = 0 \quad \forall \quad t \in T \tag{1}$$

where F is an I-dimensional vector valued function, X_t is an I-dimensional vector of endogenous variables such as prices and quantities, Z_t^o and Z_t^u are vectors of exogenous variables. While Z_t^o is observable over time, Z_t^u is unobservable except at base year. **B** is a K-dimensional vector of behavioral parameters that can be chosen by the analyst, and δ is a second vector of behavioral parameters whose values are either preset by the model or can be computed by calibration based on the combination of choice of **B**, the exact form of F, and base year data. The elements of F capture economically coherent production and consumption behavior as well as macroeconomic constraints. Static CGE analysis proceeds by changing the vector of exogenous variables Z_t^o, and examining the resulting vector of endogenous variables, X, which satisfies the above system.

The solution to the CGE model implies a predicted historical time path for variables of interest. We may then compare the actual historic time paths for key variables with their predicted values in the following manner:

$$Y_t = G(X_t, Z_t^o, Z_t^u, \mathrm{B}, \delta) + e_t \tag{2}$$

where Y_t is an N dimensional vector of historical targets, G is a function producing the vector of model predicted values for the targets, and e_t is an N dimensional vector representing the discrepancy between historical targets and predicted values. Calibration to the benchmark data implies that $e_t=0$ in the base year. Assume G_t is the vector of predicted values, an entropy measure can be developed based on Y_t and G_t. By minimizing this entropy measure, a vector of behavioral parameters B can be computed which permits the model to best track historical experience.

In this study, the Armington substitution parameters (Φ_D and Φ_M) belong to the vector B. Other behavioral parameters (part of the δ parameter vector) are set at current values in GTAP. Historical data to be targeted by the model in this phase of the study include gross domestic product (GDP), shares of commodity exports in total exports and share of commodity imports in total imports each aggregated region, the regional share of exports to GDP, and the regional share of imports to GDP. Data for the historical targets are gathered at three-year-intervals[4] to avoid excessive impact from short-term peculiarities such as recession. The exogenous variables Z_t^o for this study include: endowments, investment, saving, investment and government consumption. Changes in level of protection and transportation margins are also considered in this study. The parameterization proceeds by fixing Z_t^u and δ at the base year level and imposing the economic shocks given by Z_t^o. The solution to the endogenous variables of interest (X) can be viewed as an implicit function of the choice of the trade parameters B (Φ_D and Φ_M in this study). The estimated values of historical targets

$$Y_t^E = G(X_t, Z_t^o, Z_t^u, B, *) \qquad (3)$$

are associated with Φ_D and Φ_M by an explicit or implicit functional relationship. The values of B therefore are determined by Y_t^E and the historical targets Y_t in entropy sense (please refer to equation 2 above). In addition, the fitting of Y_t^E in respect to Y_t reflects how well the model performs.

This approach may have several liabilities. First, both the omission of Z_t^u and the pre-selection of the behavioral functional forms can result in a bad fit of estimated values and the corresponding targets. It is difficult to tell which is to blame in such cases. Second, we fix the values of other behavioral parameters to which our targets may be highly sensitive. To reduce the impact from the second problem, we put weights on those targets, such as export shares, that are sensitive to the trade substitution parameters but insensitive to other behavioral parameters. For the first problem, the best thing we can do is to include all exogenous variables that are available and believed to have significant impacts on the targets.

For this particular study, the entropy function is designed in the following way. It consists of five parts. First part is the GDP entropy. We observe regional GDP at different point in time $GDP^o(r,t)$, we set a upper and lower bound values, respectively, for example let

$$GDP^u(r,t) = 1.5 * GDP^o(r,t); \text{ and } GDP^L(r,t) = 0.5 * GDP^o(r,t). \qquad (4)$$

We choose a prior distribution of GDP(r,t) values for instance as $(p^o_1, p^o_2, p^o_3) = (0.25, 0.5, 0.25)$ corresponding to $GDP^u(r,t)$, $GDP^o(r,t)$, and $GDP^L(r,t)$ respectively. Note that $\Sigma_i p^o_i = 1$ and the following constraints hold:

$$GDP^o(r,t) = 0.25 * GDP^u(r,t) + 0.5 * GDP^o(r,t) + 0.25 * GDP^L(r,t). \qquad (5)$$

Now suppose we obtain the estimated values of

$$GDP^E(r,t) = P^1(r,t) * GDP^u(r,t) + P^2(r,t) * GDP^o(r,t) + P^3(r,t) * GDP^l(r,t) \qquad (6)$$

[4] The three-year average data are the ideal, however, it is difficult to obtain them for some variables.

Where variable $P^i(r,t)$ positive[5] and satisfies the normalization condition

$$P^1(r,t) + P^2(r,t) + P^3(r,t) = 1 \quad (7)$$

The cross entropy of each region at time t is now defined as

$$Entropy(r,t) = Sum(i, P^i(r,t)* \log(P^i(r,t)/p^o_i(r,t))). \quad (8)$$

Please note that to minimize the above entropy is to make $P^i(r,t)$ as close to the prior distribution $p^o_i(r,t)$ as possible while satisfying other constraints. The entropy value in equation (8) reaches the lower bound of zero when $P^i(r,t)=p^o_i(r,t)$. If we assign a positive number of w(r,t) as the weight to each entropy(r,t) and sum them over regions and time, we have:

$$Entropy(GDP) = Sum((r,t), w(r,t)*entropy(r,t)) \quad (9)$$

We obtain the entropy measure for export shares and other targets in a similar fashion. Finally, we may assign different weights w_i to these targets and sum them up to form the objective function.

$$Objective = E_i w_i\, Entropy(target\ i) \quad (10)$$

2.4. The Data

Exogenous variables may be classified into two categories, which partially reflect a causality relationship between them. The first type of variables generally contributes significantly to the change of the second type of variables. In running the simulation, the variables in the first category are served to shock the model. While the second category is primarily limited by data availability, they are selected such as to reflect their relevancy with the parameters to estimate. The variables in this second category are used as targets. In this study, we seek to replicate as close as possible the economy situations in the past by obtaining as many relevant exogenous variables as possible. So far, the first category includes factor endowments in five categories (Table 3), investment, government consumption, tariff, and net capital transfer. The second category includes GDP, exports, and imports.

Table 3: Primary Factor Identifiers in the GTAPinGAMS Model

LND	& Agricultural land
SKL	& Skilled labor
LAB	& Unskilled labor
CAP	& Capital
RES	& Natural Resources

The optimum Armington parameters are determined by the best fit measured by a composite entropy formula, between the targets and their corresponding expected values after the shock. Unlike most forecasting studies or policy analyses where the simulation results reflect the impacts of shocks regardless of the time, the entropy value of this study measures the composite accuracy of the backward forecast for the past several periods. Several terms in the objective function are expressed as the sum over a time index. The base year is 1995 as in GTAP version 4 and 1986, 1989, and 1992 are selected as targeting years[6]. Therefore we focus on the relative values of the target and shock data in time series form to avoid the inconsistency caused by the measurement discrepancy between GTAP and other data sources. The ratios of historical targets

[5] The solutions to $P^i(r,t)$ are not unique for satisfying constraints 6 and 7. However, it is unique when we maximize the cross entropy.

[6] The reason to have all periods in time set in 3-year interval is mentioned later.

and shocks data to their 1995 values can be used to derive the historical targets and exogenous shocks in scale term if necessary.

Appendixes A and B record the details of obtaining the macro/trade data and protection data, respectively. Due to the space limitation, they are not included in this paper[7]. In general all but land endowment data and most national account data such as investment and GDP are of good quality and they are quite compatible with the GTAP database. The time-series trade data are prepared by Mark Gehlhar (1998). The data record merchandise bilateral trade values at FOB values in current US dollars. The data are of good quality but they do not include service trade transactions. . The net capital inflow data from national account database provided by Zhi Wang (1995) are not directly compatible with GTAP database and therefore some adjustments have been imposed. The protection data used in this study are weak. They are introduced to mirror the trend of regional economic integration during the period of study. Therefore, we expect a general trend of reduction in tariff and non-tariff barriers over time. However, the estimated protection data only cover the average tariff equivalent of all regions imposed on outside world. In words, they are not measured in bilateral terms as the study desires. Due to our suspicion of the data quality on protection and net capital inflow, we attempt to isolate the impacts of these data on the results.

Table 4 lists the Armington Parameters (Φ_D and Φ_M) and the value-added substitution parameter Φ_{va} currently in use. They serve three purposes. First, they provide the starting point in running the simulation. Second, they are to be compared with the corresponding estimated parameters[8]. Third, they impose implicit constraints on the optimization problem as the basis of cross entropy measurement.

Table 4: Parameter File

	Φ_D	Φ_M	Φ_{va}
AGR	2.44	4.88	0.24
PAG	2.40	4.80	1.23
FMN	2.41	4.82	0.4
CTX	3.32	6.64	1.26
OLT	2.15	4.30	1.26
CHM	1.90	3.80	1.26
MEV	3.10	6.20	1.26
BAM	3.47	6.94	1.26
NSV	4.00	8.00	1.32
TSV	4.00	8.00	1.41

3. Experiments and The Results

3.1: Experimental Specification and Common Assumptions

Several assumptions have been made in running the simulations. The same assumptions apply to all scenarios as well as to sensitivity analysis. The first assumption concerns the issue of technological progress. During the period of this study, economic growth (measured by GDP) in

[7] Interested party may contact Jing Liu by sending email to liuj@agecon.purdue.edu to request a copy of the appendices and the GAMS programs.
[8] The value-added substitution parameters have been kept constant throughout this study.

several Asian regions could hardly be explained by factor accumulation and international trade alone. There is significant technological catch-up in these regions. To implement this, technology progress variables are included and are endogenously determined. The variables are defined as time and region specific but are Hicks-neutral across sectors. The later assumption might be relaxed in the future.

The second specification concerns the Armington parameters (Φ_M and Φ_D) and their relationship. This study assume both Φ_M and Φ_D are sector and time specific and satisfy constraints:

$$\Phi_{M(i,t)} = 2\Phi_{D(i,t)} \quad (11)$$

$$\Phi_{D(i,t)}/\Phi_{D(i,t-1)} = (1+\lambda_i) \quad \text{with } \lambda_i \text{ non-negative.} \quad (12)$$

Constraint (11) simply keeps the relationship between Φ_M and Φ_D as currently used by GTAP model. Constraint (12) reflects the potential relation between Armington parameter values and the length of time. Our hypothesis is that trade elasticities tend to become bigger over a longer length of run, therefore $\lambda_i \geq 0$.

The third specification deals with the entropy measurement of objective function. As mentioned earlier, it currently includes the entropies of five terms. The different weights are assigned to GDP entropy and others. We put same weight to all five entropies in the objective function. For weights assigned to in-group entropy component, there is no discrimination for each individual of any entropy group regarding sectors, regions, and periods. That is, same weight is assigned to each of these components. Nonetheless, the objective function is still heavily biased in favor of trade related entropies since four out five entropy terms are associated with trade. Also considered in this study is a case where we put 1/10 of weights of other entropy to GDP to favor the entropies of trade related terms.

Finally, the weighted average output price worldwide is fixed as numeraire for all three periods, and this numeraire is set equal to that of the base year.

3.2. Simulation Approach[9] and Experiment Design

This study includes six alternative estimation exercises. In all scenarios, the macro shocks are imposed. Macro shocks include factor endowment shocks, government consumption shocks, and investment shocks for each region and time period. The first scenario (experiment A) only contains macro shocks but excludes tariff shocks based on original GTAPinGAMS Cobb-Douglas structures. Experiment B includes the tariff shocks but uses the same simple structures as in scenario one. The third scenario excludes the tariff shocks but adopts the more complicated functional forms for both private demand and production structures. Experiment D examines the impact of shocks to *net capital inflow* on the results of estimation. Experiment E includes all shocks and adopts the functional form changes. Experiment F examines the impact on the estimation of relative weights assigned to different entropy terms in the objective function. Table 5 summarizes the experiments.

[9] Due to the computational complexity, the programming approach can be described as progressive. Under this modified framework, the whole estimation procedure can be divided into several stages such that the more complicated simulation can start from the "close point" to the optimal solution. This is to save mount of computer time and to facilitate GAMS solvers to find the new equilibrium solution.

Table 5: Summary of Main Experiments						
Shock\Experiment	A	B	C	D	E	F
Macro Var. shocks[a]	Yes	Yes	Yes	Yes	Yes	Yes
Functional Form change[s]	No	No	Yes	Yes	Yes	Yes
Tariff Shocks	No	Yes	No	Yes	Yes	Yes
Net Capital Inflow	Yes	Yes	Yes	No	Yes	Yes
Weights Ratio[c]	1:1	1:1	1:1	1:1	1:1	1:10

a: Macro variables includes endowments for skilled labor, unskilled labor, capital stock, agricultural land, government consumption, and total national investment.
b: In some experiments, we use LES functional form to represent private demand and CES to represent factor demand. In original model, however, both demands are represented by simpler Cobb-Douglas functions.
c: The number shows the ratio of entropy weights in the objective function: GDP entropy to trade related entropies.

3.3 Results

Table 6 shows the estimation results. The results turn out quite different across scenarios. Compared to experiment A, the incorporation of tariff shock (experiment B) produces much smaller elasticities for all but *Processed Food* (PAG). Except sectors of *Agriculture* (AGR) and *Processed Food* (PAG), the results from functional form changes (experiment C) are fairly similar to experiment A, where neither functional form changes nor tariff shock is imposed. The incorporation of both functional form changes and tariff shock (experiment E) results in a much smaller estimated elasticities for almost all sectors. Most significant exists for sectors FMN where the estimates in experiment C is substantially lower than these from experiments A ~ C.

There are striking observations from the comparison among experiments A, B, C and E in table 6, and some tentative remarks are available. First, the imposition of tariff shocks (experiments B vs. A and E vs. C) generally results in smaller estimates for trade elasticities. This suggests that the reduction of tariff is one reason to promote international trade and that the ongoing structure changes of regional trade commodity shares in the world markets are partially driven by tariff incentive. Second, the functional form changes (experiments C vs. A and E vs. B) produce bigger estimates for sectors AGR and PAG, smaller estimates for sector FMN, and similar estimates for other sectors. In light of the fact that compared with Cobb-Douglas private consumption utility function, the introduction of minimum subsistence level in LES functional form has more impact on agriculture and processed food sectors since LES function tends to have inelastic demands for these two primary sectors. The estimates for sector *Fuel and Minerals* (FMN) appear to be quite sensitive to experimental specifications.

The importance of the shocks of net capital inflow is evident from experiment D where such shocks are not imposed. Compared with experiment E, it has modest impact on the estimates for all sectors but CTX, OLT, MEV, and BAM. The lesson here is that more reliable data for net capital inflow is desirable for better estimation. Experiment F is associated with sensitivity analysis. Compared with experiment E, it produces mixed results. Its estimates are larger for two sectors (FMN and CHM), smaller for sector CTX, and similar for others. The results call for an appropriate weighting strategy for different entropies in the objective function. The estimates for FMN again differ significantly across experiments D~F.

Table 6: Substitution Parameters Φ_D in Term of Length of Time										
		Experiment A			Experiment B			Experiment C		
	Current	3-year	6-year	9-year	3-year	6-year	9-year	3-year	6-year	9-year
AGR	2.44	1.62	2.42	3.63	1.08	1.08	1.08	3.37	5.05	7.58
PAG	2.40	1.97	2.96	4.44	2.59	3.89	5.84	2.69	4.03	6.04
FMN	2.41	6.91	9.91	14.21	4.15	6.23	9.35	6.39	8.46	11.21
CTX	3.32	4.92	7.24	10.65	3.39	3.39	3.39	5.64	7.94	11.17
OLT	2.15	3.53	5.30	7.95	3.07	3.07	3.07	3.47	5.17	7.68
CHM	1.90	4.42	5.14	5.98	3.71	3.71	3.71	4.05	4.32	4.61
MEV	3.10	7.20	9.07	11.42	6.25	6.31	6.37	7.22	8.70	10.49
BAM	3.47	3.90	3.90	3.90	2.09	2.09	2.09	3.70	3.70	3.70
		Experiment D			Experiment E			Experiment F		
	Current	3-year	6-year	9-year	3-year	6-year	9-year	3-year	6-year	9-year
AGR	2.44	3.12	4.68	7.02	1.89	2.83	4.24	2.46	3.69	5.53
PAG	2.40	2.47	3.70	5.55	3.24	4.86	7.29	3.50	4.81	6.60
FMN	2.41	3.11	4.67	7.00	1.44	2.04	2.90	6.43	8.57	11.43
CTX	3.32	2.81	2.81	2.81	3.08	3.08	3.08	1.45	1.57	1.70
OLT	2.15	3.53	3.53	3.53	2.62	2.62	2.62	2.59	2.59	2.59
CHM	1.90	4.01	4.23	4.46	2.39	2.39	2.39	4.11	4.44	4.80
MEV	3.10	5.60	5.66	5.73	4.77	4.92	5.08	6.21	6.22	6.23
BAM	3.47	1.87	1.87	1.87	1.57	1.57	1.57	1.01	1.01	1.01

Table 7: Measurement of Goodness of Fitting						
	GDP Fitting[(1)]			Total Trade Fitting[(2)]		
Length of Run	3-year	6-year	9-year	3-year	6-year	9-year
Experiment A	1.00	1.01	1.00	1.00	1.11	1.26
Experiment B	1.00	1.01	0.99	1.00	1.09	1.21
Experiment C	1.01	1.00	0.96	1.01	1.09	1.20
Experiment D	1.02	0.97	0.89	1.01	1.04	1.08
Experiment E	1.02	1.01	0.94	1.00	1.07	1.13
Experiment F	1.03	0.93	0.81	1.03	0.97	0.97

1. The number is the ratio of predicted global GDP over the actual GDP.
2. The number is the ratio of predicted global trade value over the actual trades.

Several measurements of goodness of fit are reported in table 7, which lists two ratios of estimated value in the global basis over targets (explicit or implicit) under different scenarios. The first one for GDP and the second one for total trade values (exports or imports). The closer the number to one, the better is the prediction. Apparently, there is a balance between GDP fitting and trade fitting for experiments. Compared with experiment E, experiments A~C better predict GDP with the sacrifice of poor prediction of total trade flow, and experiments D and F predict the long run total trade flow slightly better but predict much more poorly the long run GDP. In this backcasting exercise, all but experiment F over-predict the total trade flows for years 1986 and 1989. Since trade flows fall as one moves back in time, this means that the model under-predicts the rate of export/import growth. This again confirms the finding by Gehlhar (1994). In addition, all experiments predict extremely well the short run GDP and trade flows. Most Scenarios perform reasonably well in the prediction of intermediate run (6-year). Experiment F appears to hold trade by under-predicting GDP seriously. Combine both GDP and trade flow fittings, experiment E is clearly superior to other experiments.

The estimated trade elasticities on experiment E are more or less in line with our expectations. Three sectors agriculture (AGR), processed food (PAG) and fuel and minerals (FMN) are found quite sensitive to the length of run. In the short run (3 years: 1995-92) three (AGR, FMN, and BAM) out of the eight sectoral GTAP trade elasticities reported in Table 4 are too large, and two others (CTX and OLT) remain roughly the same. Thus the short run results validate the structuralists arguments. However, in the long run (9 years: 1995-86) most of the GTAP trade elasticities are much smaller than those estimated using this approach[10]. Thus a reconciliation between the structuralist and market-oriented trade economists may be possible, by taking into account differing lengths of run.

More specifically, it is found that the GTAP elasticities of substitution among imports of agricultural products are about right in the short to intermediate run (1-3 years) in experiment E. They are too small over the longer run (9 years). Similar patterns hold for fuel and mineral products. In general, substitution possibilities for most products in the intermediate run (6 years) are close to current values in use. The results for sectors CTX and OLT are a bit of puzzle. The elasticities for these two sectors are expected to be larger in the long run. The multi-fibre agreement (MFA) quota system used by OECD governments may be responsible for such results in the CTX sector. Further analysis is required to explain the results for OLT.

Table 8 below shows just how poor the experiment F in predicting the GDP when we further break down the GDP fitting into to regional level. It depresses GDP targets to cover the under-prediction of trade flows. Actually, there are other factors not considered in this study so far that may contribute to the faster trade flows in the period of interest. Transportation cost is one among others.

Table 8: GDP fitting (The Ratio of Predicted GDP to GDP Targets)

	Experiment E			Experiment F		
	3-year	6-year	9-year	3-year	6-year	9-year
USC	1.03	1.03	0.99	1.04	1.11	1.04
MEX	1.04	1.09	1.12	1.27	1.27	1.24
JPN	1.01	1.04	1.00	0.89	0.94	0.82
KOR	1.02	0.99	0.94	1.03	0.88	0.82
TWN	1.03	0.99	0.99	1.00	0.87	0.92
THA	1.03	1.05	1.08	1.13	1.16	1.14
IDN	0.97	1.04	1.11	0.97	1.37	1.60
CHN	1.02	1.09	1.35	1.21	1.59	1.90
REA	0.98	0.96	0.88	0.96	0.92	0.80
ROW	1.02	0.98	0.87	1.06	0.79	0.62
Overall	1.02	1.01	0.94	1.03	0.93	0.81

Overall is the Ratio of Predicted Global GDP to Actual GDP.

[10] CTX, OLT, BAM are the only exceptions.

3.4. The Issue of Transportation Cost and Imports vs. Exports

We suspect that transportation cost is one important factor for our consistent over-prediction of total trade flows for year 1986. Since the transportation unit cost data are not available, we simply increase backwardly the transportation cost by certain portion and investigate the impact on the prediction of total trade flows[11]. The results suggest that reduction of transportation cost does affect the trade flows. Approximately, the decrease of transportation unit cost by 10 percents will results in the increase of trade flows by 2-3 percents. Nevertheless, there are potentially other factors promoting trade flows beside transportation cost. Among the potential candidates are the increase of product differentiation and the non-homothetic demands.

Since trade patterns from the exporting side differs from importing side, we conduct two experiments using different targets. One has targets the regional exports share to GDP and the commodity shares of exports in each region. The other has targets the regional imports share to GDP and the commodity shares of imports in each region. The results (not shown here) indicate that the estimators differ significantly between these two experiments. Further, when we include in targets both exports and imports related terms (experiment E in previous section) the estimators are general fell between those of the above two experiments. Experiment E outperforms these two experiments by a clear margin in predicting long run total trade flows.

3.5. Summary and Conclusion

In summary, the estimated Armington parameters from the ME approach are in line with our expectation for most sectors. The experiments using different targets point out the unbalanced development between trade inflow (imports) and outflow (exports). It reveals that generalizing the functional forms representing consumer and producer behavior is key to obtaining good estimates of trade elasticities in such back-casting exercises. The results also suggest that the impact of net capital inflow on the estimated elasticities could not be ignored and more reliable data will be key for obtaining better estimates. We also note that the model systematically over-predicts total export values in the backward forecast from 1995-1986. I.e. it under-predicts the historical growth in trade. Reductions in protection levels only partially explain this rapid growth the trade/GDP ratio over this period. This is a puzzle faced by many other researchers. One hypothesis is that non-policy trading costs (e.g., transport and coordination costs) have fallen rapidly over this period. Another is that home-preference biases have been eroded. Clearly further research will be required on this topic. We believe that the approach used in this paper offers a logical way of discriminating among some of the alternative hypotheses.

[11] We do not include the experiments and results in details here due to space constraint.

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