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A Globally Consistent Framework for Reliability-based Trade Statistics Reconciliation in the Presence of an Entrepôt

ABSTRACT

This paper develops a mathematical programming model to reconcile trade statistics subject to a set of global consistency conditions in the presence of an entrepôt. Initial data reliability serves a key function for governing the magnitude of adjustment. Through a two-stage optimization procedure, the adjusted trade statistics are achieved as solutions to a system of simultaneous equations that minimize a quadratic penalty function. As an empirical illustration, the model is applied to reconcile the 2004 trade statistics reported by China, Hong Kong and their major trading partners, initialized with detailed estimates of bilateral trade flows, re-export markups, cif/fob ratios and data reliability indexes.

Key words: trade statistics reconciliation, entrepôt trade, data reliability, global consistency

JEL classifications: F1, C61, C81

I. Introduction

It is a stylized fact and a new aspect of modern world trade that growth of international trade has led to the emergence of quite a few entrepôts such as Hong Kong, Singapore and Rotterdam (Krugman, 1995). An entrepôt facilitates trade flows among countries, but has also become a key culprit of large discrepancies in official trade statistics between some of the major trading powers in the world.

Bilateral trade statistics reported by exporting and importing countries have never been the same. Among the conventional causes of the discrepancies are transportation cost, timing, mis-invoicing and difference in classification. Accordingly, the commonly used methods to reconcile bilateral trade statistics have been to choose either the importer's or exporter's data, or some weighted average of the two, as more reliable. Examples of such work are seen in Statistics Canada's development of the *World Trade Analyzer* database and in Gehlhar (1996) for the Global Trade Analysis Project (GTAP) database, where reporter- and sector-specific reliability indexes are constructed to screen the data and *cif/fob* margins are estimated for all bilateral trade flows at sector level. Though differing in details, these reconciliation procedures fall into the category of "partially consistent approach", i.e., conflicting data between one pair of countries are adjusted based solely on the information on bilateral trade data and the two countries themselves but independent of how much official trade data differ between another pair of countries and how they are adjusted.

With the emergence of entrepôt trade, the discrepancy problem between the mirrored trade statistics is compounded. The most notable case has been the China-US trade with Hong Kong as an entrepôt. A large share of China's trade with the world passes through Hong Kong, but current reporting practices in China and their trading partners do not fully reflect this fact. This is in part because traders often do not know the final destinations when goods leave China. In these cases, they are recorded as exports to Hong Kong by the Chinese Customs. For this reason, Chinese Customs statistics show that Hong Kong is one of China's largest export destinations, behind the Unites States but at par with the EU 15 countries in recent years. In fact, Hong Kong re-exports most its imports from China to other countries. On the other hand, the US Customs treats all goods from China, directly or indirectly through Hong Kong, as Chinese imports, including the value added to the goods by Hong Kong middlemen. As a result, discrepancies in the official data on the bilateral trade arise, and its increasingly large magnitude has not only caused concerns among policy makers in the two countries, but has also motivated quite a few studies to reconcile the conflicting official trade statistics between China and its major trading partners.

Key components of those studies on trade data reconciliation in the case of China and Hong Kong include estimation of Hong Kong re-export markups, which are key information but not part of the Hong Kong official trade statistics, as well as the *cif/fob* ratios which are a traditional concept in explaining discrepancies in official trade statistics reported by exporting and importing countries. On the re-export markup estimation, there are two threads in the literature. One is based on detailed trade data, including studies by the Joint Commission on Commerce and Trade (JCCT) (1995), using solely Hong Kong trade data, and by Feenstra et al (1998, 1999), using both China and Hong Kong trade data; and the other is based on surveys conducted by the Hong Kong Census and Statistical Department (HKCSD) and published in various issues of the *Hong Kong Monthly Digest of Statistics*, and interviews reported in Fung (1996) and Fung and Lau (1998). Among these estimates, Feenstra et al (1998, 1999) are able to produce origin- and destination-specific markups to reconcile various aggregate estimates reported in JCCT (1995), HKCSD, Fung (1996) and Fung and Lau (1998). Subsequent studies on the reconciliation of recent Chinese trade flow with the US, Canada and 69 trading partners follow either the survey and interview approach (Fung and Lau, 2001, 2003; Fung, Lau and Xiong, 2006; Schindler and Beckett, 2005), or combine it with the JCCT approach (Bohatyretz and Santarossa, 2005).

On the estimation of *cif/fob* ratios, almost all above mentioned studies use an *ad hoc* and one size-for-all estimate, though differing in value across studies. Those studies either attempt to use a large amount of trade statistics to estimate the Hong Kong re-export markups, or to include into data adjustment a wide range of factors contributing to the discrepancies, or to identify behaviors of traders that may lead to mis-invoicing of China and Hong Kong's trade statistics. They constitute valuable contributions to improving our understanding of the complicated issues. These studies still belong to the traditional "partially consistent approach", because estimation of the Hong Kong re-export markups for one pair of origin and destination countries and adjustment of their trade flow do not depend on each other, nor do they depend on the re-export markup estimation and data adjustment for another pair of countries. Therefore, like trade data reconciliations in conventional cases, the theoretically intrinsic global consistency for the world trade data can not be ensured in the adjusted bilateral trade flows in the case of trade through an entrepôt. In addition, the "partially consistent approach" is unable to fully utilize all official trade statistics from China, Hong Kong and their trading partners simultaneously. This calls for a new approach to trade data reconciliation, which is the very motivation of this paper.

The paper has two goals. First, it develops a mathematical programming model to reconcile trade statistics subject to a set of global consistency conditions in the presence of an entrepôt. Data reliability is made a key determinant of the adjustment magnitudes. Through a two-stage optimization procedure, the adjusted trade statistics are achieved as solutions to a system of simultaneous equations that minimize a quadratic penalty function. Secondly, develop an implementation procedure that link the model with real world trade statistics through several key steps. As an empirical illustration, the model is applied to China, Hong Kong and their major trading partners, using the most detailed 2004 trade data. The model is initialized with reported and adjusted trade flows and estimated re-export markups, *cif/fob* ratios and data reliability indexes, all updated from the literature.

The paper is organized as follows. Section two specifies the two-stage optimization framework and discusses its theoretical and empirical properties. Section three outlines the major steps to implement the model with real world trade statistics, including the preparation of initial *fob/cif* ratio and Hong Kong's re-export markup estimates, and the choice and estimation of reliability weights for major variables in the model. Model adjusted results, illustrated by China, Hong Kong and their major trading partners, are presented and compared with the initial estimates in section four. The paper concludes with a discussion on limitations of the study and directions of future research.

II. The Mathematical Programming Model

Consider there are n+2 countries in the world economy, including a home country (H) and an entrepôt (E). At the global level, all the n+2 countries engage trade with rest of the world on m commodities; at regional level, the home country H and the entrepôt E both engage in bilateral trade with n partner countries and also with each other. E is the only entrepôt between H and the *n* partner countries. E earns a markup by conducting re-export activities. This markup is the difference between the price at which the entrepôt E buys goods and the price at which it sells the same goods.

The programming model deals with the data reconciliation problem first at the global level and then focus on the region that has an entrepôt. At the first stage, the model adjusts total exports to and imports from the world for the *m* commodities by each of the *n*+2 countries according to the condition that global export supply equals global import demand. At the second stage, the model focuses on trade between H and E, as well as their trade with the other *n* countries, taking H and E's total exports to and imports from the world derived from the first stage as fixed and adjusting their distribution among the *n* partner countries and estimate E's re-export markups for each commodity.

In each stage, weights are assigned to the variables in the objective functions reflecting their reliabilities and thus helping determine the adjustment magnitudes. Basically, the more reliable the initial trade statistics are, the less they need to be adjusted. The goal of the adjustment at each stage is to make the adjusted data satisfy a set of global or bilateral consistency conditions that would eliminate statistical discrepancies in partner reported trade data.

2.1 First-stage

The notations used to specify the first stage programming model are as follows:

WX_i^s = Exports to the world of sector *i* by country *s*

WM_i^r = Imports from the world of sector *i* by country *r*

WTX^s = Total exports to the world by country s

WTM^r = Total imports from the world by country r

All valued at fob price;

RIX_i^s = reporter reliability index of sector i by exporter s

RIM_i^r = reporter reliability index of sector I by importer r[1]

Sectoral index *i* is defined over commodity set I ∈ {1, 2, …, m}; country indices *s* and *r* are defined over country set W ∈ {1, 2, …, n, H, E}.

Using above notation, the first stage programming model is specified as:

Objective function:

$$\text{Min S} = \sum_{s=1}^{n+2}\sum_{i=1}^{m}\frac{(WX_i^s - WX0_i^s)^2}{(1-RIX_i^s)WX0_i^s} + \sum_{r=1}^{n+2}\sum_{i=1}^{m}\frac{(WM_i^r - WM0_i^r)^2}{(1-RIM_i^r)WM0_i^r}$$
$$+ \sum_{s=1}^{n+2}\frac{(WTX^s - WTX0^s)^2}{(1-RIX^s)WTX0^s} + \sum_{r=1}^{n+2}\frac{(WTM^r - WTM0^r)^2}{(1-RIM^r)WTM0^r} \qquad (1)$$

Constraints:

Country total exports

$$\sum_{i=1}^{m} WX_i^s = WTX^s \qquad \text{for all s} \qquad (2)$$

Country total imports

$$\sum_{i=1}^{m} WM_i^r = WTM^r \qquad \text{for all r} \qquad (3)$$

World market equilibrium at sector level

$$\sum_{s=1}^{n+2} WX_i^s = \sum_{r=1}^{n+2} WM_i^r \qquad \text{for all i} \qquad (4)$$

The model is used to reconcile IMF reported country total *merchandise* trade statistics ($WTX0^s$ and $WTM0^r$) and each country reported total exports to and imports from the world at sector level ($WX0_i^s$ and $WM0_i^r$) based on UN COMTRADE data.[2] It results in a set of country and sector level total exports and imports, which satisfy the condition that world total export supply equals world total import demand.

2.2 Second-stage

2.2.1 General Assumptions and Mathematical Notation

Suppose all partner countries except one report their exports to and imports from H and E. H and E also report their exports to and imports from all their partner countries and trade flows between them. In addition, E reports the origin and destination of all commodities it re-exports bound for and coming from H and other partner countries. The markup from such activities is unreported, thus it must be estimated. Assuming all reporting countries, including H, can correctly identify the country of origin of their imports, either the imports are directly from the partners or indirectly from E. The home country H, however, can not identify the final destinations when exports leave their ports for E.

The notation used to describe the reported trade statistics and their relationships are as follows (expressed in annual bilateral flows, in dollar values):

DX_i^{sr} = Direct exports of commodity *i* from country *s* to country *r*. When the source country *s* denotes E, this flow comprises domestic exports, inclusive of earnings from re-exportation of that commodity. When the destination country *r* denotes E, it is the partner countries' exports that remain in E

RX_i^{sr} = Indirect exports of commodity *i* via E from origin country *s* to destination country *r*, inclusive of E's re-export earnings

TX_i^{sr} = Total exports of commodity *i* from country *s* to country *r*. For *s* equals E, this corresponds to domestic exports plus re-exports

DM_i^{sr} = Direct imports of commodity *i* by country *r* from country *s*. When *r* corresponds to E, it is imports for domestic use, for *s* equals E it is partner's imports originated from E

TM_i^{sr} = Total imports of commodity *i* by country *s* from country *r*

RXM_i^{sr} = E's markup earnings by re-export commodity *i* originated from country *s* to final destination country *r*

XER_i^r = Statistical discrepancy of commodity *i* in mirrored trade flows, in the direction of H and E export, partner country *r* imports

MER_i^r = Statistical discrepancy of commodity *i* in mirrored trade flows, in the direction of H and E import, partner country *r* exports

cif_i^{sr} = the *cif/fob* ratio for commodity *i* shipped from country *s* to country *r*. It is a fixed parameter in the model and used to convert imports to their *fob* valuation.

All trade flow variables have directions: the first superscript indicates the source country and the second refers to destination country. For exports (DX and TX), source country are the reporter, while for imports (DM and TM), destination country are the reporter. Exports are valued at fob basis and imports are valued at cif basis.

This completes the notation required for the second stage programming model. We now turn to the accounting identities describing the relationship among bilateral trade flow statistics reported by Home country H, entrepôt E and their partner countries. They are divided into four sections: those dealing with exports from H/E, those dealing with imports by H/E, those dealing with bilateral H-E trade, and those dealing with global consistence.

2.2.2 H and E Exports, partners import

For all r ∈ {1, 2, …, n} and all s ∈ {1, 2, …, n, H,E}:

$$cif_i^{H,r} TX_i^{H,r} + cif_i^{E,r} DX_i^{E,r} + XER_i^r = TM_i^{H,r} + DM_i^{E,r} \quad (5)$$

Equation (5)[3] states that the sum of any particular partner's imports of H and E-originated products should equal the sum of H's total exports and E's domestic exports to that partner adjusted for H to E *cif/fob* margin, plus a statistical discrepancy. Left hand of this equation is actual exports from H and E while the right hand is the imports statistics published by partner countries.

$$TX_i^{H,r} = DX_i^{H,r} + \frac{(RX_i^{H,r} - RXM_i^{H,r})}{cif_i^{H,E}} \quad (6)$$

Equation (6) defines that the home country H's total exports to a particular partner equal its direct exports plus entrepôt E's re-exports for H to that partner minus E's re-export makeup adjusted by H-E *cif/fob* ratio.

$$DX_i^{E,r} = TX_i^{E,r} - \sum_s (RX_i^{sr} - RXM_i^{sr}) \quad (7)$$

In equation (7), E's domestic exports to a particular partner equals to its total exports to that partner minus its re-exports for all other countries to the particular partner and plus its markup earnings from re-exports.

$$TM_i^{E,r} = DM_i^{E,r} + cif_i^{E,r} \sum_s (RX_i^{sr} - RXM_i^{sr}) \quad (8)$$

Equation (8) indicates partner's total imports from entrepôt E equals partners' imports of E's domestic products plus E's re-exports to the partner from all sources adjusted by E's re-export markup and the *cif/fob* ratio from E to the partner.

$$DM_i^{H,r} = TM_i^{H,r} - cif_i^{E,r} (RX_i^{H,r} - RXM_{it}^{H,r}) \quad (9)$$

Equation (9) indicates that a partner's direct imports from home country H equal its total imports from H minus E's re-exports for H to that partner adjusted by E's re-exports markup and E to partner's *cif/fob* ratios.

2.2.3 H and E imports, partner exports

For all s ∈ {1, 2, …, n} and all r ∈ {1, 2, …, n, H, E}:

$$DM_i^{s,H} + TM_i^{s,E} - MER_i^s = cif_i^{s,H} DX_i^{s,H} + cif_i^{s,E} TX_i^{s,E} \quad (10)$$

Equation (10) states that the sum of H's direct and E's total imports of products originated from any particular partner should equal to the sum of that partner's direct exports to H and its total exports to E adjusted by *cif/fob* margin, plus a statistical discrepancy. Similar to equation (5), left hand of this equation is actual imports by H and E while right hand is the exports statistics published by partner countries.

$$DM_i^{s,E} = TM_i^{s,E} - \sum_r (RX_i^{sr} - RXM_i^{sr}) \quad (11)$$

Equation (11) requires E's domestic use of imports plus its re-exports for a particular partner minus re-exports markup equals E's total imports from that partner country.

$$DM_i^{s,H} = TM_i^{s,H} - cif_i^{E,H} (RX_i^{s,H} - RXM_i^{s,H}) \quad (12)$$

Equation (12) states that home country H's direct imports from a partner equals H's total imports from that partner minus E's re-exports to H for that partner adjusted by E's re-export earnings, as well as E to H *cif/fob* ratios.

$$TX_i^{s,H} = DX_i^{s,H} + \frac{(RX_i^{s,H} - RXM_i^{s,H})}{cif_{it}^{s,E}} \quad (13)$$

Equation (13) reveals that partner's total exports to H equals partner's direct exports to H plus E's re-exports to H for that partner, adjusted by E's re-export markup and the *cif/fob* ratio from the partner to E.

$$DX_i^{s,E} = TX_i^{s,E} - \frac{\sum_r (RX_i^{sr} - RXM_i^{sr})}{cif_i^{s,E}} \tag{14}$$

From equation (14) we see that a partner's exports to the entrepôt E, destined for E's domestic use, must equal its total export to E minus its re-exports via E to all destinations, adjusted by E's re-export markup and the partner to E's *cif/fob* ratios.

2.2.4 H-E bilateral trade

Equation (15) states that the home country H's actual exports to the entrepôt E for E's domestic use must equal its direct exports to E minus E's re-exports for H to all other trading partners adjusted by the entrepôt's re-export markup and H to E *cif/fob* ratios.

$$TX_i^{H,E} = DX_i^{H,E} - \frac{\sum_r (RX_i^{H,r} - RXM_i^{H,r})}{cif_i^{H,E}} \tag{15}$$

$$DM_i^{H,E} = TM_i^{H,E} - \sum_r (RX_i^{H,r} - RXM_i^{H,r}) \tag{16}$$

Equation (16) defines entrepôt E's imports from H for domestic use as equaling its total imports from H minus its re-exports for H to all destinations adjusted by its markup earnings.

$$DX_i^{E,H} = TX_i^{E,H} - \sum_r (RX_i^{s,H} - RXM_i^{s,H}) \tag{17}$$

$$TM_i^{E,H} = DM_i^{E,H} + cif_i^{E,H} \sum_r (RX_i^{s,H} - RXM_i^{s,H}) \tag{18}$$

Equation (17) indicates that E's domestic export to H equals its total exports to H minus its re-exports to H from all other partners adjusted by its markup earnings. Equation (18) states that H's total imports from E equal its imports of goods with E origin plus E's re-exports to H from all sources adjusted by re-exports markup and the E to H *cif/fob* ratios.

2.2.5 Global balance and objective function

For all r ∈ {1, 2, …, n, H, E}:

$$\sum_r DX_i^{H,r} + \sum_s \sum_r (RX_i^{sr} - RXM_i^{sr}) + \sum_r DX_i^{E,r} = WX_i^E + WX_i^H \quad (19)$$

$$\sum_s TM_i^{s,H} + \sum_s \sum_r (RX_i^{sr} - RXM_i^{sr}) + \sum_s DM_i^{s,E} = cif^E WM_i^E + cif^H WM_i^H \quad (20)$$

Equation (19) describes that the sum of after-adjustment actual exports from home country H and entrepôt E to all its partners should still equal the sum of their reported total exports to the world, with WX_i^E and WX_i^H derived from the first stage model and taken as fixed in the second stage. This means that the adjustments in the second stage made by the model do not change the total exports to the world by H and E from solution of the first stage programming model, it merely estimates E's re-export markup and rearranges the destinations of H's exports to account for these re-exports. Equation (20) states that the home country H and entrepôt E imports and E's re-exports minus the re-export markups after adjustment should still equal the sum of H and E's total imports from the world, with WM_i^E and WM_i^H derived from the first stage model and taken as fixed in the second stage. The adjustments made by the second stage model only change the markup estimates and rearrange the sources of H and E's imports, not the total. A *cif/fob* adjustment is needed to the results from the first stage model. This is because each country's total imports in the first stage model are valued at *fob* price, while they are valued at *cif* price in the second stage model.

Given these accounting relationships among mirrored trade flow statistics, what remains is to develop a criterion for changing the reported statistics so that they conform with the linear accounting constraints. Either a cross-entropy (Harrigan and Buchanan, 1984; Golan et al., 1994) or a quadratic objective penalty function can be specified. We choose to use a quadratic function as follows for computational efficiency reasons[4]:

$$Min \qquad S = \frac{1}{2}\left\{\begin{aligned}&\sum_{i\in M}\sum_{s\in W}\sum_{r\in W}\frac{(DX_i^{sr} - DX0_i^{sr})^2}{wdx_i^{sr}} + \sum_{i\in m}\sum_{s\in W}\sum_{r\in W}\frac{(DM_i^{sr} - DM0_i^{sr})^2}{wdm_i^{sr}}\\ &+\sum_{i\in M}\sum_{s\in W}\sum_{r\in W}\frac{(TX_i^{sr} - TX0_i^{sr})^2}{wtx_i^{sr}} + \sum_{i\in m}\sum_{s\in W}\sum_{r\in W}\frac{(TM_i^{sr} - TM0_i^{sr})^2}{wtm_{it}^{sr}}\\ &+\sum_{i\in m}\sum_{s\in W}\sum_{r\in W}\frac{(RXM_{it}^{sr} - RXM0_{it}^{sr})^2}{wrxm_i^{sr}} + \sum_{i\in M}(xer_i^2 + mer_i^2)\end{aligned}\right\} \tag{21}$$

where variables with a 0 at the end denote initial estimates and an additional "w" before the variable in lower case indicates the reliability measure for that variable.

In short, the reconciliation problem at the second stage is to modify a given set of bilateral trade flow statistics with equation (21) as the objective function and equations (5) - (20) as constraints.

2.3 Properties of the reconciliation model

There are several desirable analytical properties of the two-stage optimization model specified above. Firstly, the estimates of markups and trade flow adjustments are made in a globally consistent and simultaneous manner. The model re-directs sources and destinations of home country H's and entrepôt E's exports and imports, estimates E's re-export markup, allocates statistical discrepancies to trade flows among H, E and their trading partners, and adjusts bilateral trade balances between the home country and all its partners simultaneously. In doing so it imposes global consistency on the adjusted trade flow data, which is a necessary condition for any world trade data set destined for analytical purposes (such at GTAP).

Secondly, the model is formulated as a nonlinear programming problem subject only to linear constraints. Therefore, depending on the reliability weights chosen, the model solutions can represent a broad range of linear statistical estimators. For instance, if the weights are all equal to one, the solution of the model gives a constrained least squares estimator. If initial estimates are taken as the weights, the solution of the model gives a weighted constrained least square estimator, which is identical to the Friedlander-solution, and a good approximation of the RAS solution. If the weights are proportional to the variances of the initial estimates, and the initial estimates are statistically independent, the solution of the model yields best linear unbiased estimates of the true unknown matrix (Byron, 1978), which is identical to the Generalized Least Squares estimator if the weights are equal to the variance of initial estimates (Stone, 1984; Ploeg, 1984). Furthermore, as noted by Stone et al. (1942) and proven by Weale (1985), in cases where the error distributions of the initial estimates are normal, the solution also satisfies the maximum likelihood criteria.

Thirdly, by understanding the model's solution as estimators of an underlying statistical model, and assuming the initial estimates are unbiased estimates of the true unknown values, in all but the trivial case, the adjusted estimates from the model solution will always better approximate the unknown true values than do the associated initial estimates (Harrigan, 1990). This is because adding valid constraints or further restricting the feasible set through the narrowing of interval constraints cannot move the adjusted estimates away from the true values unless the additional constraints are non-binding (i.e., they have no information value). The optimization process has the effect of reducing, or at least not increasing, the variance of the initial estimates. This desirable property is simple to show by using matrix notation. Define **W** as the variance matrix of initial estimates $\overline{\mathbf{D}}$, **R** as the coefficient matrix of all linear constraints. The least squares solution (equivalent to the solution of the quadratic programming model described above) to the problem of adjusting $\overline{\mathbf{D}}$ to **D** that satisfies the linear constraint, $\mathbf{R} \bullet \mathbf{D} = \mathbf{0}$ can be written as:

$$\mathbf{D} = (\mathbf{I} - \mathbf{W}\mathbf{R}^{T}(\mathbf{R}\mathbf{W}\mathbf{R}^{T})^{-1}\mathbf{R})\ \overline{\mathbf{D}} \tag{22}$$

Thus,

$$\text{var}(\mathbf{D}) = (\mathbf{I} - \mathbf{W}\mathbf{R}^{T}(\mathbf{A}\mathbf{W}\mathbf{A}^{T})^{-1}\mathbf{R})\mathbf{W} = \mathbf{W} - \mathbf{W}\mathbf{R}^{T}(\mathbf{R}\mathbf{W}\mathbf{R}^{T})^{-1}\mathbf{R})\mathbf{W} \tag{23}$$

Since $\mathbf{W}\mathbf{R}^{T}(\mathbf{R}\mathbf{W}\mathbf{R}^{T})^{-1}\mathbf{R})\mathbf{W}$ is a positive semi-definite matrix, the variance of adjusted estimates will always be less, or at least not greater than the variance of the initial estimates as long as $\mathbf{R} \bullet \mathbf{D} = \mathbf{0}$ holds[5]. *This is the fundamental reason why such a reconciliation framework will provide improved trade statistics.* In summary, imposing equations (5) to (20) will definitely improve, or at least not worsen, the initial statistics, since we are sure from international economics that those constraints must be true for any well defined trade statistics.

Finally, we turn to the choice of weights ($wdx_{i,}^{sr}\ wtx_{i,}^{sr}\ wdm_{i,}^{sr}\ wtm_{i,}^{sr}\ wrxm_{i,}^{sr}$) in the objective function. They have a very important impact on the model solution. The model uses these weights to determine by how much an initial estimate may be changed. For instance, using the initial trade statistics as weights has the advantage that each entry of the trade flow data is adjusted in proportion to its magnitude, in order to satisfy those consistency constraints. The variables cannot change signs and the larger the trade flows, the more adjustment takes place. However, while these features are intuitively appealing, the drawback is that the adjustment relates directly to the size of the initial trade statistics, and does not force the unreliable trade data to absorb the bulk of the required adjustment. Indeed, it is only under very special assumptions that this commonly used weighting scheme (and the one underlying RAS) will yield best unbiased estimates. Specifically this requires the following two assumptions: (1) the initial estimates for different trade flows are statistically independent, and (2) each error variance is proportional to the corresponding initial estimates. In practice, they do not hold for trade data. Therefore, the efficiency of the model will be improved if the error structure of the initial trade statistics is available. So, in a more sophisticated weighting scheme, the larger the variance, the smaller its contribution to the objective function, and hence the lesser the penalty for each adjusted trade statistics to move away from their initial value (only the relative, not the absolute size of the variance affects the solution). A small variance of the initial trade statistics indicates, other things being equal, that it is more reliably reported data and thus should not be required to change by as much. In contrast, a large variance of the initiate estimates indicates unreliably reported data that may be adjusted considerably. In sum, we would like to adjust the trade data on an unreliably reported route more than the reliably reported one.

Advantages of such an optimization framework in adjusting international trade statistics are also significant from an empirical perspective. Firstly, it offers valuable additional detail, specifically: entrepôt E's re-export markup rate on each country's re-exports via E as percent of the country's total exports and imports is estimated, along with the adjusted bilateral balance of trade among H, E and their partner countries by each covered commodity.

Secondly, it provides considerable flexibility. It permits a wider variety and volume of information to be brought into the reconciliation process. For example, the ability to introduce upper and/or lower bounds is one of the flexibilities not offered by commonly used scaling procedures such as RAS. Therefore, it is very easy to restrict the value of the adjusted trade statistics to be non-negative. This is a very desirable property in adjusting bilateral trade flow data. It is also very flexible regarding to the required known information. For example, it allows the possibility that some of the bilateral trade statistics are missing and the total exports and imports by H and E to the world are not known with certainty. In the real world, missing bilateral trade is common and a country's total exports or imports generally lie within some range. By incorporating terms similar to bilateral trade variables in the objective function to penalize solution deviations of the world totals from statistical sources, the optimization approach allows reconciliation of these world totals with bilateral trade flows.

A final advantage of the optimization approach is that alternative measures of the reliability of the initial data can be easily included in the reconciliation process. As noted before, these weights should reflect the relative reliability of the original trade statistics. The interpretation is straightforward. Statistics with higher reliability should be changed less than statistics with a lower reliability, thus the best available information can always be used to insure that statistics reported by reliable trade routes or reporters are not perturbed by the reconciliation process as much as statistics reported by unreliable trade routes or reporters.

III. Linking the Model with Trade Statistics

There are several key steps in implementing this two-stage optimization model with actual trade statistics. First, all variables in the model need to be correctly linked with officially reported statistics; second, entrepôt E's markup earnings from its re-exports and all bilateral *cif/fob* margins need to be computed independently or estimated based on information from other sources, so that the optimization model can be properly initialized; and finally, a full set of reliability weights in the objective function need to be selected in order to obtain meaningful solutions. We will discuss those issues one by one in four steps below and use trade statistics between China (H), Hong Kong (E) and their major trade partners as an illustration.

3.1 Obtaining initial estimates for all bilateral trade variables in the model from observed or derived trade statistics

Variables in the first stage programming model could be initialized easily from publically available sources. For instance each country's total exports to and imports from the world (WTX^s and WTM^r) could obtained from various version of IMF financial statistics, while each country's sector level exports to and imports from the world (WX_i^s and WM_i^r) could be aggregated directly from detailed merchandise trade statistics from UN COMTRADE.

In the second stage model, initial estimates can be directly obtained from existing bilateral trade statistics for four sets of variables for out-bond trade of H and E. They are: H's direct exports to partner countries ($DX0_i^{H,r}$), E's total exports to partner countries ($TX0_i^{E,r}$), and partner's total imports from H ($TM0_i^{H,r}$) and imports of product originated from E ($DM0_i^{E,r}$). Similarly, there are also four sets of variables for which initial estimates could be obtained directly from existing data for in-bond trade of H and E. They are: partner countries total exports to E and direct exports to H ($TX0_i^{s,E}$ and $DX0_i^{s,H}$), and H and E's total imports from partner countries ($TM0_i^{s,H}$ and $TM0_i^{s,E}$). We call these eight sets variables as observable variables.

There are eight sets unobservable variables in the second stage model, four for each trade direction. For out-bond trade of H and E, they are H's total exports to partner countries ($TX0_i^{H,r}$), E's domestic exports to partner countries ($DX0_i^{E,r}$),[6] partner countries' direct imports from H ($DM0_i^{H,r}$), and partner countries' total imports from E ($TM0_i^{E,r}$). Their initial estimates can be derived from observed data according to equations (6), (7), (8) and (9) respectively (they are left hand variables in these equations) if we are able to obtain initial estimates of E's re-exports by origin and destination ($RX0_i^{sr}$), and we also be able to know E's re-export markup ($RXM0_i^{sr}$) and the *cif/fob* margin for all bilateral routes. Similarly, for in-bond trade of H and E, the initial estimates of the four additional sets of unobservable variables can be computed from observed data according to equations (11), (12), (13) and (14) respectively (they are left hand variables in these equations) under the same conditions. These four set variables are E's imports from partner countries for domestic use ($DM0_i^{s,E}$), H's direct imports from partner countries ($DM0_i^{s,H}$), and partner countries' total exports to H and their exports for E's domestic market ($TX0_i^{s,H}$ and $DX0_i^{s,E}$).

The initial estimates for bilateral trade variables between E and H can be obtained from existing trade statistics reported by H and E or derived from observed trade data in the same fashion in both trade directions according to equations (15) to (18). The observed statistics are $DX0_i^{H,E}$, $TX0_i^{E,H}$, $TM0_i^{H,E}$ and $DM0_i^{E,H}$. The only difference is that $TX0_i^{H,E}$ is H's actual exports to E, equals its direct exports to E minus all its re-export to other countries via E.

In summary, there are eight sets of variables required in each direction, four of which can be obtained directly from existing reported trade statistics. The remaining four sets unobservable variables can be derived from existing trade statistics based on the four sets accounting identities specified in the optimization model. Therefore, as long as we can obtain estimates for E's re-exports ($RX0_i^{sr}$), re-exports markup ($RXM0_i^{sr}$) and *cif/fob* margins (cif_i^{sr}), all variables in the two-stage optimization model specified in this paper are fully initialized.

Using trade statistics between China (H), Hong Kong (E) and their partner as an illustration example, we first obtain China and Hong Kong reported trade statistics from Chinese Customs authorities and the Hong Kong Census and Statistical Department, then download their partner countries' reported trade data from UN COMTRADE. The initial estimates of Hong Kong's re-exports by origin and destination ($RX0_i^{sr}$) are also provided by Hong Kong Census and Statistical Department based on its re-exports statistics. The estimates of initial Hong Kong re-exports markup ($RXM0_i^{sr}$) and the *cif/fob* margins between China, Hong Kong and their trading partners are computed by the authors and described in the following sections.

3.2 Calculate initial Hong Kong re-export markup rates

The initial estimation of Hong Kong re-export markup rates follows the spirit of Feenstra *et al* (1998, 1999), the SAS programming procedures of which are documented in Chapter 2 of Yao (2000). While Feenstra *et al* only report overall markup rates for China trade with the US and a few other selected countries, Yao is able to produce markup rates at 6-digit HS commodity and individual country levels. Yao also provides the markup rates tailored for trade data reconciliation in the GTAP version 5 database. This paper uses the same methodology and updated SAS procedures to estimate the average 2003-05 markup rates, as well as their trade weighted standard deviations to provide the necessary initial inputs for the mathematical programming model.

The key features of Feenstra *et al* (1998, 1999) include:

1. They use very detailed China and Hong Kong trade data at both the commodity level (SITC for early years and 6-digit HS for 1994 and onward) and country level. As a result, the markup rate estimates are also at the same detailed levels. The overall markup rate is weighted average of those disaggregate markup rates.
2. The Hong Kong import data does not have information on the final destination countries but with China trade data, which identifies the final destination countries and origin countries that go through Hong Kong, they are able to produce better markup rate estimates for China-originated goods; for China-bound goods, the markup rate estimates do not show any regular patterns.
3. The markup rate estimates are sensitive to outliers. By assuming that Hong Kong cannot re-export significantly more than it imports in the same year, records with re-export quantity more than double import quantity are treated as erroneous observations and are deleted from the markup rate calculations.
4. Three methods produce three sets of markup rates and their aggregate values coincide with findings from JCCT (1995), which are based on the analysis of Hong Kong trade data only, Hong Kong Census surveys and Fung and Lau (1998) interviews. They reconcile all three sets of markup rates with precise economic interpretations. Specifically, **Method A** markup rates refer to those based on source generic Hong Kong import unit values but destination specific Hong Kong re-export unit values, and coincide with JCCT (1995) findings; **Method B** markup rates are based on Hong Kong import and re-export unit values both of which are source or destination generic, and coincide with Hong Kong Census survey results; and coinciding interview results reported in Fung and Lau (1998), **Method C** markup rates are based on Hong Kong import unit value (adjusted with China export data) and Hong Kong re-export unit values, both of which are source or destination specific and therefore are more accurate for China-US trade.

The markup rate is defined as the share of value added by Hong Kong middlemen in the total re-export value. Let the unit-value of Hong Kong import be denoted by $PM_i=VM_i/QM_i$ where VM_i is the value and QM_i is the quantity of imports, and i denotes the HS codes. Let the unit-value of Hong Kong re-exports be denoted by $PX_i=VX_i/QX_i$, where VX_i is the value and QX_i is the quantity of re-exports. Thus the relationship between the aggregate markup rate (*RXMR*) and disaggregate markup rate ($RXMR_i$) can be shown by the following formula:

$$RXMR = \frac{\sum_i \left(PX_i QX_i - PM_i QX_i\right)}{\sum_j PX_j QX_j} = \sum_i \left(1 - \frac{PM_i}{PX_i}\right)\left(\frac{PX_i QX_i}{\sum_j PX_j QX_j}\right)$$

$$= \sum_i RXMR_i \left(\frac{PX_i QX_i}{\sum_j PX_j QX_j}\right) = \sum_i RXMR_i \frac{RX_i}{\sum_j RX_j} \qquad (24)$$

The above formula shows that when using this definition, re-export values should be used as compatible weights.

For purposes of using the programming model to solve for the final markup rate estimates, standard deviations are needed to measure the scope of variations of the estimates, and to inform the model how much adjustment should be allowed. The trade weighted variance and standard deviation of the markup rates are given as:

$$Var(RXMR_i) = \frac{\sum_k RX_k (RXMR_k - \overline{RXMR_i})^2}{\sum_j RX_j}, \text{ and } STD(RXMR_i) = \sqrt{Var(RXMR_i)} \qquad (25)$$

where indexes *j* and *k* represent the group of 6- digit HS codes within GTAP sector *i*. Again, re-export values are chosen as weights to calculate the average markup rate variance from 6-digit HS level to GTAP sector level.

To have better estimates for the trade weighted mean and variance of the markup rates, we first add up the annual data on Chinese exports, Hong Kong imports and re-exports over the years 2003,2004 and 2005. So the markup rates should be interpreted as the trade weighted average over the three years. When calculating the Method A markup rates, only Hong Kong data are used and therefore markup rates are at the 8-digit HS level. But in Method C markup rate estimation, we need to combine the Chinese export data with Hong Kong data. Because China and Hong Kong trade data are comparable only at the 6-digit HS level, Method C markup rates are estimated at 6-digit HS level. As final outputs, markup rates are aggregated up to GTAP sector and region levels. To fully reflect the extent of the markup rate spread over commodities, their variances and standard deviations are also calculated over 6-digit HS codes for a given pair of GTAP origin and destination countries at the GTAP sector level.

All initial markup rate estimates in our illustration example are Method A markup rates except for China originated goods, which have Method C markup rates. Method C could also apply to China bound goods when the unit values of Hong Kong re-exports to China are adjusted with Chinese import data, but we choose not to do so because Method A markup rates for China bound goods do not show any regular patterns over years and it does not appear to be worth the extra effort to improve it with Method C.

After obtaining those estimates at the GTAP sector and region level, we replace negative markup rates with zeroes to keep them consistent with our mathematical programming model specifications, which do not permit negative values at the aggregated level.[7] Eliminating negative values only slightly increases the overall markup rates (from 29% to 30.0%) for goods of Chinese origin, and increases the overall markup rates for goods of Chinese origin destined to the US from 32.6% to 33%. For goods destined to China, however, the increase due to removing the negative values are quite large, but they still lie within or close to the range of surveys by the Hong Kong Census and Statistical Department as reported in Table 2.6 of Fung *et al* (2006), or within the range of unreported initial estimates for the westbound US-China trade over 2001-05.

3.3 Bilateral trade cost and estimates of cif/fob margins

As discussed earlier, one source of discrepancies in reported trade flows is the costs associated with shipping goods. These costs are recorded by the importing country, but not included in the exporter's customs value at the port of origin. Although shipping costs alone are a minor contributor to the overall discrepancies found in bilateral trade statistics (Ferrantino and Wang, 2007), failing to take these costs into account in our model presents a problem for consistency and accuracy in the estimation of re-export markups. Bilateral transport margins can vary considerably by sector and trading partner. We therefore control for transportation costs on a bilateral basis when we initialize the model.

The problem with bilateral *cif/fob* margins between China & Hong Kong and their trading partners is that they cannot be reliably imputed from counterpart trade flow data. This is because the difference between the importer's *cif* value and the counterpart exporter *fob* value rarely reflect actual shipping margins.[8] Accordingly, with no direct observations of the *cif/fob* margins between China & Hong Kong and their trading partners, we opt to draw on transport cost sources having highly accurate shipping cost information. The transportation cost data we draw upon is primarily from the U.S. Census Bureau, foreign trade statistics where there is extensive margins information of for cross-border flows and long distant transactions recorded and compiled consistently with goods trade.[9]

We refer to the *cif/fob* ratio expressed as the difference between the customs value and the *cif* value. Having the comprehensive commodity and partner coverage, this extensive dataset permits us to calculate sector aggregates from highly detailed bilateral commodity trade data. The trade data with corresponding transport cost information is available at the most detailed level (10–digit HS) for all merchandise trade and for all U.S. trading partners. Thus we are able to calculate *cif/fob* margins for all U.S. trading partners directly. We assume that product level margins for U.S. cross-border flows are similar for other cross-border flows including trade between Hong Kong and China. Similarly, we adopt the same bilateral product margins for other partners. For example, goods shipped between the U.S. and African countries require the same margins as those between China and African countries. However, because aggregate sector margins are trade-weighted, they will vary by each partner due to differences in the composition of trade.

Generally, bulk goods with low unit values such as coal, iron ore, hides and skins, and bananas have higher transportation margins in the range of 20 to 40 percent. The cost of shipping raw or bulky-type goods is relatively expensive compared to goods with a high unit value which can be shipped in compact forms. Goods with high unit value such as computer components, precious metals, and jewelry commonly have transportation margins below 1 percent. However, within each aggregated sector there can be both high-unit value goods and low unit value good which largely affects the range of bilateral aggregate margins. Thus longer distance between partner pairs does not necessarily correspond to a higher margin at the aggregate sector level.

The bilateral sector margins between China (or Hong Kong) and a particular partner are calculated using their bilateral trade as weights to sum up their corresponding transport margins estimated from US Census data set at the 6-digit HS level. Because of differences in commodity composition of trade flows, bilateral *cif/fob* margins for any aggregate sector will vary. For example, bilateral margins for the machinery and equipment sector (table 1) fall above or below the global merchandise average of 4 percent. The bilateral margins at the aggregate sector level are largely determined by the detailed content of the underlying bilateral trade flows. High unit value goods such as turbo-jets and other high-technology components (belonging to HS categories 8409-8411) can be shipped long distances even by air because the shipping cost represents a relatively small share of total value. Timeliness of delivery is critical for such high value goods. The transportation margin (*cif/fob*) of this HS subgroup for all U.S. partners is 1.016. In contrast, another subgroup of machinery and equipment items such as air conditioners, pumps, fans with lower unit values have a higher *cif/fob* margin (1.041).

(Insert Table 1 here)

Each exporting country differs in its proportion of high value and low-value content supplied which, in turn, has implications for the aggregate bilateral transport margins. To illustrate this point we use the two HS categories shown in table 1 and show how the trade ratio of low value to high value goods differs substantially by exporting country. Generally, the content of developing countries' manufactures differs from that of high income countries within any aggregated sector. For example Japan, Canada, Germany and the United Kingdom export a higher proportion high-value machinery and equipment than do China, Hong Kong, Mexico, and India. In fact China exports nearly 9 times more of the low-value category in machinery equipment than for the high-value category. Because of the higher transport margins on low-value goods, China's transport margin for exports is relatively high for its aggregate machinery and equipment sector (1.066). Although Brazil, India, and Mexico export a similar proportion of low value machinery and equipment, the aggregate *cif/fob* margin for Mexico is substantially lower (1.011) than for India and Brazil. This is largely because of the close proximity to the United States where efficient ground transportation is relatively cheap in comparison to ocean shipping by vessel transportation required for India and Brazil.

The lowest and most uniform transportation sectors margins are those of the electronic equipment sector. This, despite the fact that computer components such as chip sets and circuit boards (HS-8471) are most often transported by air rather than vessel because of the time sensitive nature of these goods in the supply-chain management. Most countries supply a wide array of electronic items within the electronics sector where there is no clear specialization. These high-technology goods have some of the highest unit values of all merchandise goods. Slight bilateral differences arise because only from subtle differences in the electronic content such as the lower value products of microphone, speakers, telephones and parts (HS-8518) which have a higher transport margins than computer components. For example Costa Rica supplies a higher content of high-value computer chip sets than does India and China, making its aggregate margin for electronic equipment lower.

A full set of estimates for transport margins between China (Hong Kong) and their trading partners are required to initialize the model, including many non-U.S. bilateral trade flows. To complete the estimation, specific margins are first calculated at the 6-digit HS level for all HS categories from U.S. Census' data but are grouped into two sets. One set is for countries that border each other and the other is for non-bordering countries. Then *cif/fob* margins for each route between China & Hong Kong and their trading partners at each GTAP sector is calculated as associated trade flow weighted average from 6-digit HS level based on whether the pair borders each other. For instance, the same 6-digit HS margin between U.S. and Mexico is applied to China and Hong Kong's trade, while the same 6-digit HS margin between U.S. and China is used to China and Brazil trade.

(Insert Table 2 here)

Table 2 lists aggregate *cif/fob* margins for China's major exporting sectors to the U.S. and its other major partner countries. China's *cif/fob* margins with Hong Kong are considerably lower than trade with other partners due to the close proximity. There are some variations by importer due to the content of trade. We also assume that trans-Pacific and trans-Atlantic trade routes for the same goods would have the same margins. Although we do not have route specific information on freight rates, it is reasonable to assume that international shipping services are supplied by transportation firms outside the U.S. and that the same carrier shipping machinery from China to Brazil likely provides shipping services for goods shipped from China to the United States. Thus can we assume transport margins for the same goods would be similar as good carried on similar vessels from China to Brazil as China's exports to the United States.

Having specified initial values for all the variables in the model, there is only one issue left before we can solve the optimization model: How should the reliability weights in the objective function (RIX_i^s and RIM_i^r in equation (1); $wdx_i^{sr} wtx_i^{sr} wdm_i^{sr} wtm_i^{sr} wrxm_i^{sr}$ in equation (21)) be determined? These will, in turn, determine which and how much of the initial estimates should be adjusted to reconcile these trade data from different sources. This is the topic of the next section.

3.4 The choice and estimation of reliability weights

From statistical point of view, the best way to systematically assign reliability weights in the objective function is to obtain estimates of the variance-covariance matrix of the initial trade flow statistics. Then the inverted variance-covariance matrix may be justified as the best index of the reliability of entries in the trade flow matrix. However, the lack of consistent historical data often makes the estimation of the variance-covariance matrix associated with the initial trade flow statistics very difficult to implement. For example, the common practice in SAM balancing exercises is assign differing degrees of subjective reliabilities to the initial entries of the matrix follow the method proposed by Stone (1984),[10] almost no attempt to date has been made to statistically estimate data reliability such as error variance of the initial estimates from historical data, except Weale (1989), who developed a statistical method that uses time series information on accounting discrepancies to infer data reliability in a system of national accounts. Theoretically speaking, a similar statistical method can be applied to the historically reported discrepancies of bilateral trade data to derive those variances associated with international trade statistics. In practice, however, the historical data and knowledge of the changes in related country's trade reporting system are too demanding and make such a statistic method less attractable in large empirical applications. Therefore, we suggest the following two types of reliability indexes as a practical alternative.

3.4.1 Route Reliability indexes

Trade data reported by each country and its partners are often used in the international economic literature to check the quality of trade statistics. An approximate match of mirror statistics suggests that trade data reported via that route are reliable. Therefore, an index based on discrepancies between two "reported" trade flows for the same trade route may provide a means of determining data reliability.

As described earlier, in adjusting inconsistent bilateral trade flow statistics to satisfy the consistency requirements, it is crucial for the reconciliation procedure to more favorable towards changing the less reliable route than the more reliable route. For example, past statistical information suggested that US-Japan trade is one of the most consistently reported trade flows. Thus, minor or no adjustment is needed on this particular route while more adjustment should occur where there is less certainty about the reported trade flow. Because a small discrepancy in mirror trade statistics may indicate a reliable trade route, while a large discrepancy may indicate unreliable reported data, mirror statistics and their discrepancies also directly provide useful information to construct some sort of reliability index to inform the model how the initial estimates should be adjust in the reconciliation process.

In fact, when we assign initial estimates for the 16 sets of trade flow variables in both trade directions in the optimization model either directly from reported trade statistics or by derivations from them, we also obtain 8 sets of mirrored trade data. The discrepancies computed from each mirrored pair divided by corresponding sum of mirrored flows thus can be used to construct an index which reflects the reliability of the associate initial estimates of the reported trade flows in some extent, although we are not sure how large the associated variance really may be. Using mathematical notation:

$$PDX_i^{cs} = PDM_i^{cs} = 2 \times \frac{\left| DM0_i^{cs} - cif_i^{cs} DX0_i^{cs} \right|}{cif_i^{cs} DX0_i^{cs} + DM0_i^{cs}} \tag{26}$$

$$PTX_i^{cs} = PTM_i^{cs} = 2 \times \frac{\left| TM0_i^{cs} - cif_i^{cs} TX0_i^{cs} \right|}{cif_i^{cs} TX0_i^{cs} + TM0_i^{cs}} \tag{27}$$

$$PDX_i^{sc} = PDM_i^{sc} = 2 \times \frac{\left| DM0_i^{sc} - cif_i^{sc} DX0_i^{sc} \right|}{cif_i^{sc} DX0_i^{sc} + DM0_i^{sc}} \tag{28}$$

$$PTX_i^{sc} = PTM_i^{sc} = 2 \times \frac{\left| TM0_i^{sc} - cif_i^{sc} TX0_i^{sc} \right|}{cif_i^{sc} TX0_i^{sc} + TM0_i^{sc}} \tag{29}$$

where indexes “c” is indexed over set {H, E} and variables with a prefix “P” are reliability index for that variables.

All these reliability indexes have a value between 0 and 2, defined in the spirit of Ferrantino and Wang (2007). A smaller value of the indexes indicates the initial estimates are relatively reliable for the associated trade route. The weights in the objective function (equation (21)) of the model can be assigned by multiplying these indexes by their corresponding initial values, e.g., $wtx_i^{sr} = PTX_i^{sr} \times TX0_i^{sr}$. With such a weighting scheme, we encourage the model to change initial estimates of those unreliable trade routes more than those reliable ones in the reconciliation process, because a larger index makes the weights larger thus adjustment of the corresponding initial estimates has a smaller contribution to the value of the objective function and will be adjusted more in the reconciliation process. For instance, China-Japan trade in both directions will adjust less proportionally than China-Togo trade, because China and Togo reported trade has a much larger absolute discrepancy than China and Japan reported trade.

3.4.2 Reporter reliability indexes

The reliability weights defined above only consider the relative quality of initial estimates among all the bilateral routes. Such weights treat the reported trade statistics from both reporters equally and do not distinguish which reporter is more reliable. In the case there is very unreliable reporter in the pair, it may adjust the reliable data reported by the partner too much thus loss original accurate information from the reliable partner. This is undesirable. To correct this problem, a reporter's reliability index needs to be developed. Such an index should be able to deal with three critical issues.

The first issue is related to the difference of reporting countries in their ability to report bilateral commodity trade. Variability in reporting quality across countries is highly relevant information for the problem we try to solve in our proposed modeling approach. As discussed earlier, the adjustment process hinges heavily on the relative reliability of the each reporting countries. An indicator of reporter reliability is basically a measure of how consistency a country reports its trade relative to their trading partners. However, judging a country's trade data based on a single bilateral flow alone is a poor reference, because a partner can misrepresent its trade thereby potentially discrediting a reliable reporter. Therefore, a good reporter reliability measure should take all reporting countries in the world into account in assessing a country's reporting reliability.

The second issue is what exactly should be captured by the reliability measure. The size of discrepancies could be incorporated into a measure of reliability such as relative route reliability index we defined earlier. However, placing emphasis on the magnitude of discrepancies only may over-penalize the reliability of a legitimate reporter. A poor reporter that makes an error for a given trade flow usually makes a similar error with other partners. For example a reporter that has mistaken the identity of one of its partners has implicitly made a mistake for others. It brings a systemic bias for that reporter. This type of problem should be detected and reflected in the reporter reliability measure without penalizing the reliable reporter.

The third issue is the capability of the measure to reflect both sector- and country-specific reliability information for each country as an exporter and as an importer. Countries typically have commodity specific strength and weaknesses. For example one exporting country may have an excellent reporting record on steel but at the same time is highly inconsistent in its reporting practice in organic chemical trade.

All three issues discussed above are effectively dealt with in the reliability index developed by Gehlhar (1996) where reporter reliability indices were used to make a discreet choice whether to disregard or accept reported trade flows. The index is calculated as the share of accurately reported transactions of a reporter's total trade using a threshold level. It assesses reporter reliability from a complete set of global reporting partners, captures the reporter's ability to accurately report without interferences from gross discrepancies in reporting, and contains exporter and importer-sector specific reliability information. Specifically, the importer-sector specific and exporter-sector specific reliability indexes in the objective function of the first stage model (equation (1)) are defined as:

$$RIM_i^r = \frac{MA_i^r}{\sum_s M_i^{sr}} \qquad where \qquad MA_i^r = \sum_{s \in AL_{it}^{sr} \leq 0.20} M_i^{sr} \qquad AL_i^{sr} = \frac{\left|M_i^{sr} - X_i^{sr}\right|}{M_i^{sr}} \tag{30}$$

$$RIX_i^s = \frac{XA_i^s}{\sum_r X_i^{sr}} \qquad where \qquad XA_i^s = \sum_{s \in AL_{it}^{sr} \leq 0.20} X_i^{sr} \qquad AL_i^{sr} = \frac{\left|M_i^{sr} - X_i^{sr}\right|}{M_i^{rs}} \tag{31}$$

Weighted by related trade flows, the reporter reliability indexes for each country could be obtained as follows:

$$RIM^{r} = \frac{WM_{i}^{r}}{\sum_{r} WM_{i}^{r}} RIM_{i}^{r} \tag{32}$$

$$RIX^{s} = \frac{WX_{i}^{s}}{\sum_{s} WX_{i}^{s}} RIX_{i}^{s} \tag{33}$$

where M_t^{sr} and X_t^{sr} are sector i imports and exports reported by country r and s respectively, both measured at fob prices. Under such defined reporter reliability indexes, the size of the discrepancies becomes immaterial because inaccurate transactions are treated the same regardless of the magnitude of the inaccuracy. The indexes have the flexibility of being implemented at the detailed 6-digit HS level and can be aggregated to any sector level. We computed such reporter reliability measures for China & Hong Kong and all their partners at the GTAP sector level. Major data are from UN COMTRADE with supplements from country sources.

After RIM and RIX calculated for each trading countries including China and Hong Kong in the model for each GTAP sectors, the weights in the objective function (equation (21)) of the second stage model can be assigned by multiplying one minus these indexes with their corresponding initial values for each variable in the model. The complete set of weights in equation (21) is defined as follows:

$$wtx_{i}^{sr} = (1 - RIX_{i}^{s}) PTX_{i}^{sr} \times TX0_{i}^{sr} \tag{34}$$

$$wtm_{i}^{sr} = (1 - RIM_{i}^{r}) PTX_{i}^{sr} \times TM0_{i}^{sr} \tag{35}$$

$$wdx_{i}^{sr} = (1 - RIX_{i}^{s}) PDX_{i}^{sr} \times DX0_{i}^{sr} \tag{36}$$

$$wdm_{i}^{sr} = (1 - RIM_{i}^{r}) PDX_{i}^{sr} \times DM0_{i}^{sr} \tag{37}$$

$$wrxm_{i}^{sr} = \lambda_{i}^{sr} \frac{STD(RXMR_{i}^{sr})}{RXMR_{i}^{sr}} RXM0_{i}^{sr} \tag{38}$$

where λ_i^{sr} are scale parameters to transfer $wrxm_i^{sr}$ into numerical value between zero and two and $STD(RXMR_i^{sr})$ is defined by equation (25).

With such a weighting scheme, we also encourage the model to change those unreliable initial data more than those reliable ones in the reconciliation process. It means the reconciled solution from the model not only adjust less to the reliable routes than the unreliable ones, but also adjust more to the relative unreliable reporter than the relative reliable reporter in each trade route, although in a rough manner.

IV. Results from the Model

The optimization model is coded in GAMS (Brooke *et al*, 2005), with more than 2.5 million equations and variables in its detailed 99-country and 42-sector aggregation (Wang, Gehlhar and Yao, 2007). It was solved using barrier method of the Cplex solver (GAMS Development Corporation, 2005) in a 32 bit dell computer with 3 GB memory.

4.1 Results from the first stage model

Our model entails enforcing global consistency which takes place in the first stage. We first establish consistency between country-reported commodity trade data and IMF's official total merchandise trade statistics. The model solves for the adjusted country total exports to and imports from the world for each covered sector and these sector totals for China and Hong Kong are retained for the second stage as controls.

We focus on results for country total adjustments to illustrate some key characteristics of the adjustment process. Each country's reliability as an exporter and importer is a key factor that governs the magnitude of adjustment of its total exports and imports (Figures 1-2). For the IMF country totals, the exporter and importer reliability curves (line with dot markers) follow quite close in shape and magnitudes with their respective adjustment curves (line with square markers). The magnitude of adjustment made by the model is relative small, less than 1 percent for most countries. We note also that exporters and importers' reliability is also fairly consistent for adjustments magnitudes made to covered sectors. As expected, both the country and sector patterns of the adjustments reflect their negative relationship with reporter's reliability, with the exception of a few outliers.

(Insert figures 1 and 2 here)

4.2 Adjusted trade flow and balance of trade between China, Hong Kong and their major trading partners

The second stage model results demonstrate the effectiveness of the model's capability in reconciling discrepant trade flows between China, Hong Kong and their major partners. Initial and adjusted estimates for the sectors aggregated into 24 regions are listed in Tables 3 and 4 for both trade directions. Comparisons of trade flows before and after adjustment are provided below.

(**Insert Table 3 and Table 4 here**)

The initial estimates listed in the upper panel of tables 3 and 4 show several key features of the data and adjustment process. First, reported westbound trade appears less problematic than reported eastbound trade, reflected by the more volatile statistical discrepancies in eastbound trade. The overall discrepancies are 6.4 percent in eastbound trade and 5.6 percent in westbound trade. However, 7 of the 22 reported bilateral routes have more than 30 percent statistical discrepancies in the eastbound trade, while only four routes in the westbound trade show such large discrepancies. Second, trade flows with developing country partners show greater discrepancies than developed countries in general, reflecting poor data quality on the part of these developing countries. Finally, extremely large discrepancies usually are associated with partners that have small trade values with China and Hong Kong, such as many African countries and in most cases these countries reported imports are less significantly than what China and Hong Kong reported exports to them, reflecting traders in those country under report their imports for tariff evasions.

There are three types of trade balances reported (Table 3). These include (1) China and Hong Kong's officially reported trade balance with their partner countries (difference between China and Hong Kong reported exports and imports before any adjustment), (2) the partner countries' officially reported trade balance with China and Hong Kong (difference between partner reported exports to and imports from China and Hong Kong before any adjustment), and (3) the balance of trade after initial Hong Kong re-exports and *cif/fob* adjustments.[11] As expected, China's trading partners reported much larger trade deficits with China than China reported trade surpluses with its partners. More strikingly, if excluding Hong Kong, China's other trading partners reported a deficit with China of $324.5 billion, while China also reported a trade deficit of $24.3 billion with these partners. Most of the initial adjusted trade balances fall between those two numbers. For example, the United States reported a $174 billion trade deficit with China, while China only report about $80.4 billion trade surplus with the United States. This number, after initial adjustment for Hong Kong re-exports markup earnings and cif/fob margins, becomes $109.4 billion, 36 percent higher than the Chinese data, but 37 percent lower than data reported by the United States.

Adjusted aggregate bilateral trade flow and balance of trade between China, Hong Kong and their major trading partners along with official trade balance reported by both sides are shown in lower panel of tables 3 and 4. For eastbound trade, Chinese total exports were adjusted upward by just 5%. However, the direction and magnitude of adjustment differs considerably by partners. China's reported exports to North American markets, Australia and New Zealand, the EU 15, and the EU 10 receive the largest upward adjustments ranging from 14% to 51%. Adjustments to China's exports to Russia, the Rest of Africa, the Rest of Asia, and the Rest of Europe have substantial downward adjustments of 39%, 29%, 20%, and 18%, respectively. This reflects the fact of a tendency by China's exporters to misidentify destinations by under-assigning exports for high-income markets but over-reporting exports to transition and less-developed economies.[12] Exports reported by China are reallocated to conform more closely to the partner reports while China's official reported exports to the world receive minimal adjustment.[13] For example, China's actual exports to the United States have an upward adjustment of 20%; for EU 15, it is 14.1%; for Japan, it is 5.6%; for Taiwan, it is 3.4 %; while for ASEAN, it is -4.5%, for Korea, it is -4%. These model-based adjustments can be viewed as corrective measures giving greater respect to the most reliable reporters in question. This also indicates that though there is still room for the model to further adjust Chinese exports to its major partners, relatively speaking, the quality of initial estimates is already much better than reported trade statistics as long as institutional factors that could distort official trade data are considered in the initial data adjustments.[14]

For westbound trade, the percentage adjustments made to China's imports are minor for high income partners of North America, the EU, and Japan. For the US exports to China, the model adjustment is only -5%; for Japan, 1%; and -2%, for the EU 15. China's total imports are left virtually unchanged with these minor adjustments to its leading suppliers (lower panel of table 4). China is considered a relatively reliable reporter when it comes to identifying sources of imported goods. Thus, when discrepancies arise with other significant suppliers adjustments fall largely on China's partners having a lower reliability than the import reliability for China. For example, exports from ASEAN and Taiwan were adjusted upwards by more than 40% to conform closer to China's actual import records.

Modest adjustments to import and export flows of major trading partners can translate into noteworthy changes in the model adjusted trade balances. For example, the model adjustment of China-ASEAN balance of trade is 135 times, for China-Japan trade balance it is 24%; for China-EU 15 trade balance it is 26%; and for the all-important China-US trade balance, there is additional 26% increase compared to the initial estimates. In short, because of large discrepancies to start with adjustments by the model makes a difference, sometimes a big difference in reconciling trade flows and in particular the trade balances between China and its major trading partners.

Nevertheless, most of the adjusted bilateral balance of trade lie reasonably between China's and its partner's officially reported data. The choice between China and its partner's trade is a compromise that hinges largely on individual country reporting quality. If the choice was made to completely disregard China' trade record it would result in extreme outcomes that may not be economically accurate for subsequent trade and policy analysis. For example, the model adjusted trade surplus for China is $127.6 billion, which is significantly higher than China officially reported surplus[15], but also significantly smaller than the $302 billion that partners reported as a trade deficit with China. At the bilateral level, for instance, the model adjusted trade balance between China and Canada is $7.6 billion in China's favor, which lies between the $0.8 billion China reported trade surplus with Canada and $13.5 billion Canada-reported trade deficit with China. Similarly, the model adjusted trade balance between China and the 15 members of European Union is $71 billion dollars in China's favor, which also lies between the $31 billion China reported trade surplus with EU 15 and EU 15-reported $99 billion trade deficits with China (bottom section of table 3).

4.3 Adjusted Hong Kong re-export markup rates

An important component of the modeling approach is the adjustments to the Hong Kong re-export markup rates. As shown in Table 5, the model decreases the markup rate for Chinese goods re-exported to the rest of the world from 30.9% to 27.5%, while for goods from rest of the world re-exported to China, the markup rate is decreased slightly from 11.6% to 10.2%. Because some data issues are still unresolved in the model, the accuracy of these adjustments is subject to further investigation.

In terms of country breakdowns, the model adjusts the markup rates for all destination countries in eastbound trade downwards. Among them, the China-US markup rate is reduced from 33% to 29.4%. In comparison, for westbound trade, the adjustment are made in different directions, Some of China's top deficit countries/region, such as Japan, Korea, and ASEAN, -- experience significant decreases in the markup rates for their goods shipped to China via Hong Kong, while others countries, such as Mexico, EU 10, rest of Africa, other reporting countries and non-reporting partner countries, experience dramatic increase in the markup rates of their re-exports to China through Hong Kong (Tables 3 and 4).

Results for eastbound trade experience relatively significant adjustments. However, the markup rates needs to be placed into perspective. Using the approach described in Section 3.2, we calculate the markup rates for the past 11 years (1995-2005), and as shown in Figure 3, a pattern has been revealed: China-US markup rates are consistently higher than the China-world markup rates and both are gradually increasing over time. The relative size of the model adjusted China-US versus China world markup rates is consistent with the patterns and their sizes after the model adjustment still lie in their respective historical range.

(**Insert Figure 3 here**)

The relatively significant adjustments of markup rates for Chinese goods may also have something to do with our model's treatment of the Hong Kong re-exports of Chinese goods back to China, totaling $34.8 billion in Hong Kong trade statistics (or $36.9 billion in Chinese Customs statistics).[16] In initializing our model, they are simply eliminated from the statistics of Hong Kong's re-exports, total exports and imports, but no similar adjustment has been made to

China's direct exports to Hong Kong, because there is no such information available in Chinese official export data. As a result, adjustments have to be made to account for the absence of round-tripping trade flow, which may be in part lead to the adjustment of the re-export markup rates for the Chinese goods.

In terms of sectoral breakdown, in eastbound trade, significant upward adjustments occurs in the lightly traded primary sectors such as plant-based fibers, forestry and fishing[17], meat and dairy products and processed food, while downward adjustments are made for quite a few manufacturing products. In westbound trade, there is a similar pattern, but the sector of other transportation equipments also has a big increase in markup rate (from 2.8% to 24.4%) and the biggest rise in markup rates go to wearing apparel (from 7.5% to 64.7%).

(Insert table 5 here)

Table 5 also presents the initial and model adjusted Hong Kong re-exports as percentage of China's total exports and imports. For eastbound trade, the model reduces the overall share of re-exports via Hong Kong in total Chinese exports by only 0.2% (from 12.9% to 12.7%). The sectors that are mostly affected are the sector of manufactures nec, (-4.1%), sector of machinery and equipment nec (1.8%), sector of electronic equipment (-1.7%) and sector of wood and paper products (-1.4%). For westbound trade, the overall share of Chinese imports via Hong Kong in total Chinese imports declines by 2% (from 14.4% to 12.4%). Noteworthy impacts occur in three sectors: sector of wearing apparel (-16%), sector of beverages and tobacco products (7.9%) and sector of electronic equipment (-6.3%).

Standard deviation of the markup rates is another indicator of the extent and scope of the model adjustment. As seen in Table 5, standard deviations for both east- and westbound markup rates are changed across sectors. In particular, the standard deviation for westbound markup rates is adjusted significantly, up from 1.8 to 4.8.

4.4 Hong Kong re-exports earnings and retained imports

The estimates for retained imports and domestic exports for Hong Kong reflect the economy's true manufacturing capacity as opposed to re-export activity. The first panel of table 6 summarizes Hong Kong's earnings from its re-export of China-originated goods to other countries, from re-exports other countries' products to China, and from re-exports of commodities among other countries via Hong Kong by sectors. It shows that for all sectors combined, re-export earnings from Chinese goods are highest in absolute value and also have significant adjustment in terms of the percentage change (-10.8%), followed by earnings for re-exports of China-bound goods in terms of both value and percentage change (-12.5%). For all other goods, their earnings are far smaller in terms of value and percentage change (2.6%). Similar to discussions in section 4.3 on the round-tripping of re-exported Chinese goods, the same explanation may also apply to the dramatic adjustments in re-export earnings from goods related to China.

The percentage changes in re-export earnings from China-bound goods vary the most, followed by earnings from Chinese goods. Adjustments in earnings from all other goods have the minimal variations across sectors in percentage terms.

Nevertheless, both the initial and the adjusted estimates show that Hong Kong's re-export activities and their associated earnings are mainly concentrated on a few finished goods manufacturing sectors. In eastbound trade, these products are: (1) electronic equipment, (2) other machinery and equipment, (3) other manufactures, (4) wearing apparel, (5) leather and sporting goods, (6) textiles, and (7) chemical, rubber and plastic products. These seven sectors account for 93 percent Hong Kong's markup earnings from re-exporting China originated goods to the world in the initial estimates, and 92 percent in the model adjust estimates. Electronics equipment, other machinery and chemical, rubber, and plastic products are the three major products that Hong Kong re-exports for other countries to China. Earnings from these three sectors constitute more than three quarter of Hong Kong's markup earnings in westbound trade for both the initial and adjust estimates. Qualities of these products are usually more difficult to observe and more likely to require the service of intermediation to resolve information problems in trade (Feenstra and Hanson, 2004). Therefore, these estimates would be considered as valid in economic terms.

(Insert table 6 here)

The second panel of table 6 lists initial and adjusted estimates of Hong Kong's retained imports from all its trading partners excluding and including China by sectors. The initial estimates fall close to the estimates for 2004 published by Hong Kong Census and Statistics Department at the aggregate level when excluding imports from China (68.7 and 72.5 billion U.S dollars respectively), while the model-adjusted estimates are significantly larger. However, carefully comparing the initial and adjusted estimates, we find our current treatment of Hong Kong re-exports of China-originated products to China in the model is a major contributing factor to such results. Recall the discussions on our model's treatment of the $34.8 billion round-tripping Chinese re-exports. It is very possible that the exporters mis-reported to Chinese Customs that such exports are bound for some other final destinations via Hong Kong for economic reasons, such as export rebates; but in fact these exports went back to China eventually as shown in both Hong Kong's re-exports and China's official imports statistics. Therefore, the model tends to over-estimate Hong Kong retained imports and introduces bias to its estimates of Hong Kong re-exports markup rates. For instance, the initial estimate of Hong Kong's retained imports for other machinery and equipments is just 7.8 billion, but after adjustment it jumps to 17.4 billion, while the corresponding Hong Kong re-exports from China back to China are 7.3 billion. Treating such round-tripping trade flows properly in the model will improve the accuracy of the final estimates.

4.5 Adjusted China's balance of trade at sector level

There are several interesting features of the model adjusted estimates of China's net exports to the world. First, there is no sign change among China officially reported net exports between the initial and model adjusted estimates for all but two sectors (beverages and tobacco products and other transport equipment). Furthermore, when trade with Hong Kong is included, both these two sectors are consistent to the net direction of the partner officially reported trade balances. Finally, by adjusting Hong Kong's re-exports back to China's total export and imports, the adjusted net trade flows show China's current comparative advantages in the world market more clearly. For instance, the adjusted net exports are significantly larger than China officially reported in most labor intensive products such as leather and sporting goods, wood products, other manufactures and electronic equipments. All these imply that Hong Kong's re-export activities facilitate China to fully realize its comparative advantages and the model did a reasonable job in adjusting China's net trade flows.

(Insert table 7 here)

China's sectoral trade balances with the United States are presented (second panel of table 7) to showcase the sectoral features of model adjusted bilateral net trade flows. It is shown that, for most sectors, adjusted net trade flows lie between China and the U.S. officially reported statistics, except for a few sectors which either are associated with very small trade balance or differ in sign in their respective official trade balances. In the cases that initial estimates of sectoral trade balances are out of the range, the model is able to realign the final estimates back to (or closer to) an acceptable range (vegetable and fruits, livestock, forestry and fishing, and metals). This further demonstrates the desirable attributes of the model as a tool for statistical reconciliation, and its ability to preserve the economic soundness in global trade flow.

V. Concluding Remarks

This study constructs a two-stage mathematical programming model to reconcile trade statistics subject to a set of global consistency conditions in the presence of an entrepôt. It also describes four steps that link the model with trade statistics from major international and national sources. Model application to China and Hong Kong yields significant and reasonable adjustments for key variables, including Hong Kong's re-export markup rates and Chinese trade balances with partners. Initial data reliability provides a key function for governing the magnitude of adjustments.

The model is a general one in the sense that it is potentially applicable to quite a few regions with extensive entrepôt activities in the world, not just the China-Hong Kong case. Its generality is also seen in its ability to accommodate various specifications of weights in the objective function and accordingly, produce different statistically meaningful estimates. It is general also because it has rich built-in structure for a vast range of trade data and related variables so that real world trade information can be fully utilized.

This study represents a methodological improvement in the field of international trade statistics reconciliation. It is the first attempt to deal with the complicated entrepôt problem with a general and globally consistent approach. To better appreciate our methodology and its potential applications, attention shall be paid to the following issues.

First, in our model application, we keep the official Hong Kong re-export statistics fixed, as it is the most reliable source with origin and destination information. In reality, such statistics may not be available for other entrepôts and they are also subject to errors as other trade statistics.

Second, our model application uses bilateral transport margins estimated based on US trade-related shipping cost information and they enter the model as parameters. The associated errors with these parameters may transmit through the model and thus have an impact on the accuracy of model outcomes. Therefore, sensitivity analysis for those parameters should be conducted in future studies.

Finally, our model application uses only one year's bilateral trade data. Three-year average would be better, as it helps smooth annual variation of the bilateral trade statistics and more importantly, reduce zero entries in the trade flow matrix. This would have a positive impact on the development of global consistent trade data for model-based trade policy analysis.

Footnotes

[1] Definition of these reporter reliability indexes and their estimation will be discussed in detail later at section 3.4.

[2] For most high income countries, the IMF merchandise trade data and COMTRADE data totals are identical. However, the IMF provides more accurate totals based on balance of payment information for countries prone to missing or unclassified trade where COMTRADE (Commodity Trade) is lacking.

[3] There is a condition for equation (5) to hold when the error term equals to zero: $cif_i^{H,r} = cif_i^{H,E} cif_i^{E,r}$. However, this will be not true for real world situation due to commodity composition of traded goods as we will demonstrate in section 3.3. Additional constraints are imposed to maintain consistency of the model in implementation.

[4] The quadratic function has a numerical advantage in implementing the model. It is easier to solve than the entropy function in very large models because they can use software specifically designed for quadratic programming. As showed by Canning and Wang (2005), the quadratic function is equivalent to the entropy function in the neighborhood of initial estimates, under a properly selected weighing scheme.

[5] Details of the derivation of equation (22) and (23) can be found in classic textbook of econometrics, such as of *Econometric Methods, second edition* by Johnston, pp 157-158.

[6] Although Hong Kong Census and Statistics Department also publishes Hong Kong's domestic

exports to all its partner countries, but the definition is different with what we defined in this paper. We include Hong Kong's re-exports markup into Hong Kong's domestic exports.

[7] The existence of negative markup rates at commodity level for a particular year does have its justification in the theories of intermediation, as discussed in section 2.1 of Feenstra and Hanson (2004). However, the same authors also attribute the negative markups at the aggregate level, say, at the 1-digit SITC level, to errors in markup rate calculations (Data Appendix C in Feenstra and Hanson, 2005) and do not accept those negative numbers in their econometric work. We share the same sentiments with them when replacing the negative aggregated markup rates with zeros in our mathematical programming model, though technically our model can handle the negative markup rates.

[8] Counterpart trade statistics can often yield unrealistic an even negative margins because of reported trade inaccuracies. We adopt an approach similar to that used for the construction of the GTAP database which incorporates actual transport margins for all bilateral trade flows for each merchandise sector.

[9] According to U.S. Census' definition, the *cif* (cost, insurance, and freight) value represents the landed value of the merchandise at the first port of arrival. It is the sum of two components of the traded values: the "customs value" and the "import charges". Consistency of transport cost is maintained when the *cif* value is computed by adding import charges to the customs value which excludes U.S. import duties. Import charges represent the aggregate cost of all freight, insurance, and other charges incurred in bringing the merchandise from alongside the carrier at the port of exportation in the country of origin and placing it alongside the carrier at its first port of entry. For overland shipments originating in Canada or Mexico, such costs include freight, insurance, and all other charges, costs and expenses incurred in bringing the merchandise from the point of origin where the merchandise begins its journey to the United States in Canada or Mexico to the first port of entry.

[10] Stone proposed to estimate the variance of x^0_{ij} as $var(x^0_{ij}) = (\theta_{ij}x^0_{ij})^2$, where θ_{ij} is a subjective determined reliability rating, expressing the percentage ratio of the standard error to the initial estimates of x^0_{ij}.

[11] Note that only the adjusted trade balances are listed in Table 4 and they are calculated in an opposite direction, i.e. they should have a same absolute value with what reported in Table 3, but with an opposite sign.

[12] Changes of this nature were made to China's exports in previous versions of the GTAP database but without the guidance of a formal optimization model. Over the last decade China's total exports have come closer in line with the total partner's trade even as bilateral discrepancies have widened for some partners such as Mexico and Russia.

[13] The model's objective of preservation of reliable reported trade comes into play as countries with weaker reporting records bear more of the adjustment. Both the initial bilateral discrepancy and country totals for merchandise trade govern the magnitude of the adjustment.

[14] An area of research in trade data estimation our model does not specially address is for missing bilateral trade (missing trade by both reporters). However, the model allows for conversions of zero to nonzero flows as long as one side of the two trading parties report trade transaction had occurred. This step improved our estimation of re-export margins.

[15] The balance of trade data reported here are calculated from current model data base, which is different from the officially reported data because our model database excludes utility trade (such as electricity) and HS Chapter 98 and 99. There are also 36.9 billion Hong Kong re-exports of China originated products back to China did not count as China's imports as described in the text. Therefore, China's trade surplus in the model is lower than 32 billion, the official 2004 number reported by China.

[16] This may be quite true in real world trade. For example, shipments of forest products from northwest port of Dalian can be made first by sea to Hong Kong and then to factories in Shenzhen by truck. This may be a lot cheaper than direct overland shipment. Other incentives such as export VAT rebate may also encourage round-tripping trade.

[17] Products in this sector (raw fish and seafood) are sometimes traded offshore and often misclassified as processed products or assigned to unidentified partners leading to a high frequency of missing flows. This circumstance may lead to an invalid solution at the bound due to excessive missing bilateral trade values in the initial data. The model is forced to adjust heavily on the relative few non-zero entries to fit the consistency constraints. This will result in very high re-export markup rates. When we allow the model to fill all missing trade in its optimization process, the solution improved. However, we do not have a firm empirical basis for such data filling. Therefore, we report the solution which allows missing flows appearing only once by the two reporters to be filled.

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Figure 1 The First Stage Adjustments and Reporter Reliability, IMF Country Total Exports, 2004

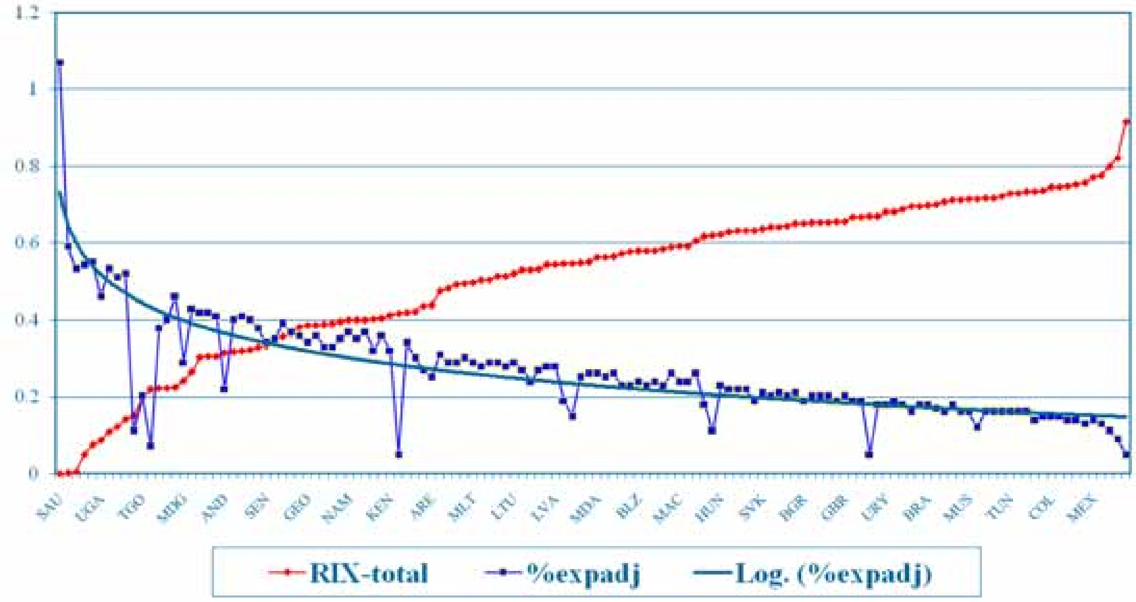

Figure 2 The First Stage Adjustments and Reporter Reliability, IMF Country Total Imports, 2004

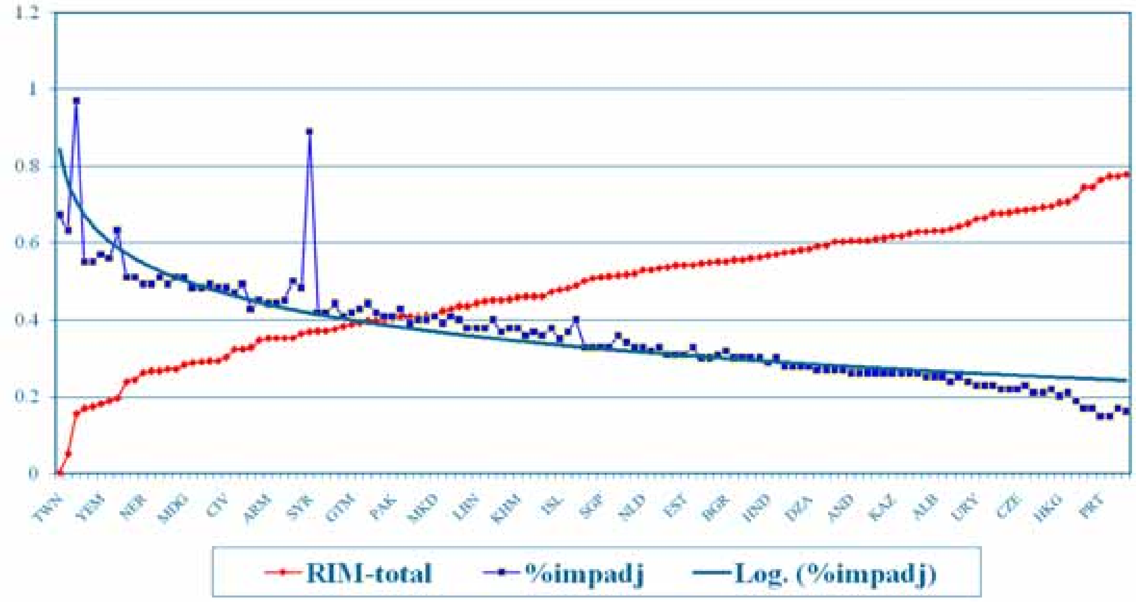

Figure 3 Hong Kong markup rates for re-export Chinese goods to the US and to the rest of the world, 1995 ~ 2005

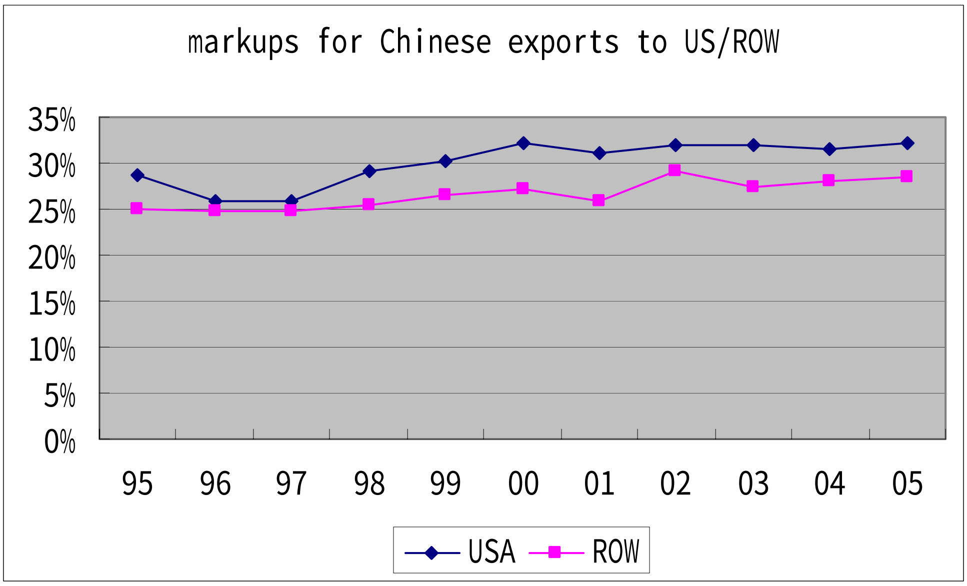

Table 1. Transport margins for selected US import flows for equipment sectors (cif/fob)

From\HS	8409-8411	8413-8415	Agg Mach & Equip	8471	8518	Agg Electr equip
Canada	1.010	1.013	1.012	1.019	1.047	1.004
Mexico	1.007	1.005	1.011	1.006	1.004	1.003
Costa Rica	1.014	1.128	1.025	1.002	1.003	1.012
Brazil	1.077	1.064	1.045	0.996	1.020	1.019
UK	1.005	1.034	1.031	1.026	1.077	1.022
Germany	1.018	1.029	1.034	1.017	1.022	1.020
India	1.070	1.087	1.052	1.020	1.026	1.026
China	1.036	1.088	1.066	1.039	1.093	1.023
HK	1.017	1.088	1.052	1.024	1.067	1.022
S Korea	1.026	1.062	1.055	1.029	1.078	1.016
Taiwan	1.034	1.064	1.046	1.025	1.043	1.019
Japan	1.028	1.030	1.033	1.022	1.053	1.022
Australia	1.020	1.050	1.034	1.018	1.034	1.020
S Africa	1.060	1.116	1.040	1.018	1.018	1.031
World	1.016	1.041		1.023	1.029	

Source: U.S. Census, foreign trade statistics using transport costs (c.i.f. / customs value)
Note: 8409-8411 products correspond to higher unit value components; 8413-8415 corresponds to lower unit value equipment.

Table 2. Aggregate transport margins for China's exports (cif/fob)

To \ Sector	Footwear	Chemicals, rubber & plastics	Electronic equip	Machinery & equip
Canada	1.076	1.085	1.024	1.065
Mexico	1.109	1.084	1.025	1.048
US	**1.072**	**1.093**	**1.023**	**1.066**
Costa Rica	1.080	1.080	1.028	1.067
Brazil	1.091	1.062	1.028	1.041
UK	1.091	1.095	1.026	1.066
Germany	1.094	1.082	1.022	1.054
India	1.080	1.054	1.020	1.046
HK	**1.020**	**1.019**	**1.007**	**1.016**
Taiwan	1.074	1.080	1.021	1.040
Japan	1.084	1.089	1.023	1.048
S Korea	1.072	1.092	1.024	1.039
Australia	1.079	1.091	1.024	1.064
S Africa	1.075	1.084	1.029	1.059

Source: Margins derived from U.S. Census, foreign trade statistics using transport costs (c.i.f. customs value)

Table 3 Initial and Adjusted Estimates of Bilateral Trade b/c China, HK and their Partners, Eastbound, 2004, mill US $

Country Name	China actual exp	China direct exp	HK total exp	HK dom exp	China re-exp via HK	Hong Kong re-export markup	total imp fr HK	actual imp fr China	imp of HK domestic products	Partner direct imp fr China	Re-exp as % of total exp to China	Stat discrep	HK re-exp markup rate	adj BOT w/ China	China reported BOT	reported BOT w/ China	adj BOT w/ HK	HK reported BOT	reported BOT w/ HK	cif/fob ratio, China to partner	cif/fob ratio, HK to partner
Variable in the model	TX0(CH,r)	DX0(CH,r)	TX0(HK,r)	DX0(HK,r)	RX0(CH,r)	RXM0(CH,r)	TM0(HK,r)	TM0(CH,r)	DM0(HK,r)	DM0(CH,r)	(RX0(CH,r)-RXM0(CH,r))/TX0(CH,r)	SDX(r)	RXM0(CH,r)/RX0(CH,r)	TX0(CH,r)-TX0(r,CH)	TX0(CH,r)-TM0(r,CH)	TX0(r,CH)-TM0(CH,r)	TX0(HK,r)-TX0(r,HK)	TX0(HK,r)-TM0(r,HK)	TX0(r,HK)-TM0(HK,r)	cif(CH,r)	cif(HK,r)
Initial Estimates																					
United States	148,395	125,118	43,924	17,680	35,587	11,743	37,044	208,153	9,141	182,798	15.8	17.9	33.0	109,345	80,396	-174,095	8,745	29,467	-28,110	1.056	1.064
Canada	10,060	8,161	3,132	1,100	2,761	819	2,689	18,526	552	16,484	19.0	35.9	29.7	4,514	816	-13,460	568	1,927	-2,157	1.072	1.052
Mexico	5,658	4,973	938	219	808	110	1,158	14,003	406	13,273	12.1	57.1	13.6	4,923	2,831	-13,529	15	542	-955	1.060	1.048
Australia & New Zealand	11,814	9,916	3,603	1,237	2,847	910	3,519	15,244	1,037	13,208	16.1	13.3	32.0	3,789	-3,038	-7,835	-298	1,418	-1,984	1.069	1.049
Japan	81,678	73,222	13,799	4,141	11,977	3,348	11,373	93,589	1,322	84,605	10.4	3.5	28.0	-6,444	-21,036	-22,981	-7,923	-19,126	690	1.065	1.041
Korea Rep	29,199	27,810	5,653	2,287	2,832	1,423	6,719	29,585	3,268	28,135	4.7	-2.2	50.3	-26,694	-34,350	20,173	-8,694	-7,244	4,262	1.068	1.025
Taiwan China	15,351	13,489	6,298	2,215	2,487	598	6,270	16,625	2,072	14,679	12.1	1.0	24.1	-31,093	-51,289	17,373	-13,793	-13,724	9,738	1.053	1.029
India	6,610	5,925	2,096	389	813	118	3,418	6,687	1,683	5,973	10.3	9.9	14.6	797	-1,776	-1,403	-1,636	-1,686	-1,393	1.060	1.019
Russia	9,371	9,103	427	113	361	88	337	4,734	10	4,450	2.9	-116.6	24.3	828	-3,009	3,635	14	-125	-237	1.078	1.041
Brazil	4,338	3,675	833	129	778	105	1,103	4,049	369	3,348	15.3	-6.7	13.5	-1,420	-5,030	1,388	-263	-61	-711	1.061	1.041
South Africa	3,423	2,952	745	132	581	101	1,061	3,578	419	3,072	13.8	4.5	17.4	2,202	411	-2,524	-150	50	-779	1.069	1.048
EU 15	119,561	99,815	34,640	12,642	28,914	8,805	35,732	154,305	12,793	133,311	16.5	15.1	30.5	56,614	30,990	-98,759	-570	12,510	-22,520	1.060	1.045
European FT	3,065	2,534	1,537	808	1,131	590	1,648	4,679	890	4,114	17.4	24.6	52.1	-687	-2,034	-1,431	-1,588	-2,140	748	1.066	1.038
EU 10	8,357	7,325	1,600	516	1,501	454	2,155	12,505	1,029	11,418	12.3	30.2	30.3	6,763	5,437	-11,099	301	1,142	-1,940	1.053	1.037
Rest of Europe	3,545	3,410	199	47	174	37	241	3,533	83	3,390	3.8	-6.7	21.0	2,616	1,933	-2,630	-80	142	-114	1.072	1.044
ASEAN	48,621	41,793	15,803	5,793	10,588	3,652	21,848	44,369	11,437	37,134	14.0	-2.7	34.5	-125	-20,659	-5,402	-16,887	-16,515	832	1.054	1.039
Rest of Asia	9,880	9,126	2,313	738	1,124	354	3,188	5,918	1,505	5,093	7.7	-47.2	31.5	6,892	5,822	-3,374	300	1,255	-2,750	1.073	1.072
Rest of Latin America	9,336	8,036	1,638	265	1,537	212	1,769	8,620	322	7,223	14.0	-13.4	13.8	1,067	-2,507	-703	127	787	-1,630	1.066	1.055
Midest and North Africa	16,602	15,342	2,210	519	1,641	353	3,308	15,259	1,551	13,912	7.6	-9.0	21.5	5,654	-553	-4,816	-1,264	213	-1,526	1.072	1.034
Rest of Africa	5,208	4,943	389	90	334	64	566	2,597	247	2,308	5.1	-96.4	19.1	2,353	2,012	178	65	103	-540	1.073	1.066
Other reporting countries	4,115	3,517	806	159	724	113	1,193	3,940	497	3,282	14.6	-4.0	15.6	2,077	-4,310	-1,996	53	532	-1,088	1.081	1.075
No reporting partner countries	12,364	11,256	2,403	404	1,363	235	39,743	1,179	37,678	0	9.0	63.7	17.2	12,191	-5,312	-1,179	-7,287	535	-32,052	1.073	1.035
Partner Total	566,552	491,440	144,986	51,620	110,863	34,233	186,080	671,679	88,310	591,213	13.5	6.0	30.9	156,164	-24,256	-324,470	-50,243	-9,997	-84,217	1.186	1.711
Hong Kong, China	34,433	100,215	0	0	0	0	0	12,650	0	82,410	0.0	-27.6	0.0	21,121	21,980	21,980	0	0	21,980	1.017	an
China	0	0	78,989	13,312	0	0	78,235	0	11,539	0	0.0	-25.4	0.0	0	0	0	-21,121	-3,422	21,980	na	1.015
World Total	600,985	591,656	223,975	64,931	110,863	34,233	264,315	684,329	99,849	673,623	12.5	6.1	30.9	177,285	-2,276	-302,490	-71,364	-13,419	-40,257	1.139	1.538
Adjusted Estimates																					
United States	179,178	154,628	37,707	10,190	35,587	10,444	40,971	188,361	11,708	161,619	13.8	0.0	29.4	137,570	80,396	-174,095	2,144	29,467	-28,104	1.056	1.064
Canada	13,695	11,625	2,837	637	2,761	646	3,004	14,618	692	12,395	15.2	0.0	23.4	7,588	816	-13,460	64	1,927	-2,154	1.072	1.052
Mexico	8,543	7,834	1,011	268	808	86	1,070	8,974	293	8,219	8.3	0.0	10.6	7,096	2,831	-13,529	208	543	-954	1.060	1.048
Australia & New Zealand	13,407	11,466	3,423	1,030	2,847	867	3,609	14,296	1,100	12,215	14.5	0.0	30.4	3,688	-3,038	-7,835	-408	1,418	-1,978	1.069	1.049
Japan	86,217	77,259	11,912	1,769	11,977	2,839	12,479	91,755	1,924	82,239	10.4	0.0	23.7	-4,883	-21,036	-22,981	-10,690	-19,126	695	1.065	1.041
Korea Rep	28,024	26,546	5,814	2,361	2,832	1,333	5,953	29,912	2,414	28,369	5.3	0.0	47.1	-38,437	-34,350	20,173	-4,196	-7,244	4,266	1.068	1.025
Taiwan China	15,878	13,943	6,327	2,198	2,486	525	6,516	16,688	2,273	14,668	12.2	0.0	21.1	-54,248	-51,289	17,373	-9,457	-13,723	9,744	1.053	1.029
India	6,940	6,227	2,589	862	813	90	2,641	7,356	884	6,613	10.2	0.0	11.1	189	-1,776	-1,403	-1,173	-1,686	-1,390	1.060	1.019
Russia	5,741	5,450	376	40	361	65	392	6,237	42	5,928	5.1	0.0	18.0	-3,688	-3,009	3,635	-63	-124	-237	1.078	1.041
Brazil	4,101	3,415	978	252	778	82	1,035	4,336	280	3,611	16.7	0.0	10.6	-2,999	-5,030	1,388	-72	-61	-709	1.061	1.041
South Africa	3,694	3,203	824	192	580	81	874	3,931	212	3,403	13.3	0.0	13.9	2,019	411	-2,524	-90	50	-777	1.069	1.048
EU 15	136,433	116,038	33,383	10,761	28,914	8,145	35,031	144,438	11,446	122,760	15.0	0.0	28.2	71,165	30,991	-98,759	-1,538	12,511	-22,490	1.060	1.045
European FT	3,521	2,956	1,386	626	1,131	555	1,439	3,744	648	3,144	16.1	0.0	49.1	-620	-2,034	-1,431	-1,778	-2,140	752	1.066	1.038
EU 10	9,946	8,861	1,729	594	1,500	401	1,807	10,433	629	9,291	10.9	0.0	26.7	8,273	5,437	-11,099	423	1,143	-1,935	1.053	1.037
Rest of Europe	2,906	2,767	205	50	174	32	215	3,111	54	2,963	4.8	0.0	18.3	2,408	1,933	-2,630	-406	144	-112	1.072	1.044
ASEAN	46,453	39,217	17,943	7,546	10,587	3,239	18,739	48,854	7,927	41,191	15.6	0.0	30.6	-23,286	-20,659	-5,402	-13,048	-16,514	858	1.054	1.039
Rest of Asia	7,883	7,110	2,509	936	1,123	334	2,706	8,453	1,027	7,607	9.9	0.0	29.7	5,523	5,822	-3,374	529	1,256	-2,740	1.073	1.072
Rest of Latin America	8,707	7,369	1,630	220	1,536	171	1,740	9,249	255	7,811	15.4	0.0	11.1	-1,069	-2,507	-703	25	788	-1,626	1.066	1.055
Midest and North Africa	15,875	14,561	2,556	815	1,640	298	2,669	16,988	860	15,585	8.3	0.0	18.2	652	-553	-4,816	-680	214	-1,519	1.072	1.034
Rest of Africa	3,693	3,416	420	111	334	51	454	3,954	125	3,652	7.5	0.0	15.4	642	2,012	178	13	104	-537	1.073	1.066
Other reporting countries	4,139	3,512	942	267	723	84	1,030	4,458	305	3,769	15.2	0.0	11.6	1,418	-4,310	-1,996	211	534	-1,085	1.081	1.075
No reporting partner countries	6,742	5,571	2,905	854	1,363	170	3,015	7,183	895	5,936	17.4	0.0	12.5	5,770	-5,307	-1,179	-330	535	-32,050	1.073	1.035
Partner Total	611,714	532,973	139,405	42,577	110,856	30,536	147,388	647,328	45,993	562,991	13.1		27.5	124,774	-24,249	-324,470	-40,312	-9,984	-84,079	1.059	1.063
Hong Kong, China	19,758	98,499	0	0	0	0	0	20,173	0	100,494	0.0	0.0	0.0	2,862	21,986	21,986	0	0	21,986	1.017	na
China	0	0	83,653	16,896	0	0	84,903	0	17,133	0	0.0	0.0	0.0	0	0	0	-2,862	-3,422	21,986	na	1.015
World Total	631,472	631,472	223,057	59,473	110,856	30,536	232,292	667,502	63,126	663,485	12.5	0.0	27.5	127,636	-2,263	-302,484	-43,174	-13,405	-40,108	1.058	1.055

Table 4 Initial and Adjusted Estimates of Bilateral Trade b/w China, HK and their Partners, Westbound, 2004, mill US $

Country Name	actual exp to China	direct exp to China	total exp to HK	exp remain in HK	re-exp to China via HK	HK re-exp markup	HK total imp	China actual imp	HK retained imp	China direct imp	Re-exp as % of total exp to China	Stat discrep	HK re-exp markup rate	adj BOT w/ China	adj BOT w/ HK	cif/fob, partner to China	fob/cif, partner to HK
Variable in the model	TX0(s,CH)	DX0(s,CH)	TX0(s,Hk)	DX0(s,Hk)	RX0(s,CH)	RXM0(s,CH)	TM0(s,HK)	TM0(s,CH)	DM0(s,HK)	DM0(s,CH)	RXM0(r,CH))/ TX0(r,CH)	SDX(s)	RXM0(CH,r)/ RX0(CH,r)	TX0(CH,r)- TX0(r,CH)	TX0(HK,r)- TX0(r,HK)	cif(s,CH)	cif(s,HK)
Initial Estimates																	
United States	39,049	34,058	15,509	8,935	5,795	674	14,457	44,722	7,716	39,510	12.9	5.4	11.6	-109,345	-8,745	1.027	1.023
Canada	5,546	5,066	1,067	531	585	78	1,205	7,346	640	6,829	9.0	17.1	13.3	-4,514	-568	1.089	1.054
Mexico	734	474	533	203	309	39	396	2,142	52	1,869	36.2	49.5	12.7	-4,923	-15	1.046	1.059
Australia & New Zealand	8,025	7,409	2,390	1,535	711	50	2,185	12,954	1,263	12,278	8.1	27.1	7.0	-3,789	298	1.088	1.083
Japan	88,122	70,608	32,981	12,064	20,625	2,459	32,925	94,258	11,235	75,851	20.3	0.3	11.9	6,444	7,923	1.045	1.040
Korea Rep	55,894	49,757	18,127	10,981	6,730	345	12,897	62,160	5,478	55,676	11.3	-4.3	5.1	26,694	8,694	1.059	1.033
Taiwan China	46,444	33,997	29,728	16,007	14,773	1,828	20,022	64,778	5,741	51,642	27.5	5.7	12.4	31,093	13,793	1.053	1.043
India	5,813	5,285	3,649	2,025	621	66	3,782	7,701	2,116	7,128	9.4	12.0	10.7	-797	1,636	1.113	1.015
Russia	8,543	8,369	345	99	195	8	552	12,111	286	11,917	2.2	26.1	4.0	-828	-14	1.077	1.068
Brazil	5,758	5,437	773	392	352	13	894	8,704	489	8,357	5.8	24.8	3.8	1,420	263	1.150	1.058
South Africa	1,221	1,054	564	282	184	10	696	2,541	397	2,363	14.0	43.7	5.6	-2,202	150	1.076	1.053
EU 15	62,947	55,546	23,503	13,211	8,771	1,079	22,130	68,824	11,403	60,994	12.0	1.3	12.3	-56,614	570	1.036	1.040
European FT	3,752	3,249	3,585	2,396	586	64	3,677	4,569	2,444	4,037	13.7	8.1	11.0	687	1,588	1.037	1.034
EU 10	1,594	1,406	504	215	232	39	458	1,889	160	1,694	11.9	7.6	16.8	-6,763	-301	1.031	1.034
Rest of Europe	929	904	167	127	42	15	57	1,477	14	1,449	2.9	24.6	35.2	-2,616	80	1.084	1.054
ASEAN	48,746	38,967	35,109	22,680	11,904	1,700	32,318	62,452	19,382	52,111	20.6	7.1	14.3	125	16,887	1.059	1.040
Rest of Asia	2,988	2,544	1,066	437	502	24	1,058	3,305	382	2,815	15.7	0.7	4.8	-6,892	-300	1.063	1.065
Rest of Latin America	8,269	7,917	558	138	428	60	851	10,543	408	10,167	4.4	16.8	13.9	-1,067	-127	1.080	1.055
Midest and North Africa	10,947	10,442	2,673	1,782	596	66	1,997	15,895	1,078	15,351	4.8	20.8	11.1	-5,654	1,264	1.079	1.031
Rest of Africa	2,855	2,776	210	25	87	5	285	2,931	65	2,847	2.8	-0.7	5.9	-2,353	-65	1.052	1.139
Other reporting countries	2,039	1,944	265	105	111	10	274	7,827	102	7,724	4.9	74.7	9.4	-2,077	-53	1.079	1.061
No reporting partner countries	173	0	7,944	7,691	191	18	1,868	16,568	1,594	16,391	98.5	58.4	9.4	-12,191	7,287	1.082	1.041
Partner Total	**410,388**	**347,209**	**181,251**	**101,863**	**74,329**	**8,652**	**154,984**	**515,696**	**72,445**	**449,000**	**16.0**	**5.4**	**11.6**	**-156,164**	**50,243**	**1.257**	**0.711**
Hong Kong, China	**13,312**	**78,989**	**0**	**0**	**0**	**0**	**0**	**11,539**	**0**	**78,235**	**0.0**	**-2.6**	**0.0**	**-21,121**	**0**	**1.015**	**na**
China	**0**	**0**	**100,215**	**34,433**	**0**	**0**	**82,410**	**0**	**12,650**	**0**	**0.0**	**-2.4**	**0.0**	**0**	**21,121**	**na**	**1.017**
World Total	**423,699**	**426,198**	**281,466**	**136,296**	**74,329**	**8,652**	**237,394**	**527,235**	**85,095**	**527,235**	**13.2**	**5.6**	**11.6**	**-177,285**	**71,364**	**1.244**	**0.624**
Adjusted Estimates																	
United States	41,608	36,530	14,696	8,046	5,795	587	15,231	42,644	8,415	37,345	12.3	0.0	10.1	-137,570	-2,144	1.027	1.023
Canada	6,106	5,625	1,103	573	585	78	1,180	6,738	621	6,222	8.2	0.0	13.3	-7,588	-64	1.089	1.054
Mexico	1,447	1,412	163	60	309	271	176	1,494	67	1,455	2.6	0.0	87.7	-7,096	-208	1.046	1.059
Australia & New Zealand	9,719	9,238	2,151	1,438	711	191	2,375	10,626	1,613	10,095	5.3	0.0	26.9	-3,688	408	1.088	1.083
Japan	91,099	72,899	34,044	12,459	20,625	1,755	35,918	94,958	13,547	75,841	20.4	0.0	8.5	4,883	10,690	1.045	1.040
Korea Rep	66,461	60,218	13,805	6,557	6,730	235	14,399	70,106	6,877	63,512	9.6	0.0	3.5	38,437	4,196	1.059	1.033
Taiwan China	70,126	57,608	25,431	11,655	14,773	1,759	26,615	73,013	12,313	59,812	18.3	0.0	11.9	54,248	9,457	1.053	1.043
India	6,751	6,222	3,657	2,035	621	66	3,746	7,558	2,090	6,985	8.1	0.0	10.6	-189	1,173	1.113	1.015
Russia	9,428	9,281	308	103	195	35	344	10,131	125	9,965	1.7	0.0	17.9	3,688	63	1.077	1.068
Brazil	7,099	6,780	695	324	352	14	756	8,231	363	7,865	4.7	0.0	4.1	2,999	72	1.150	1.058
South Africa	1,674	1,534	536	282	183	37	576	1,819	312	1,669	8.6	0.0	20.1	-2,019	90	1.076	1.053
EU 15	65,268	57,829	22,606	12,299	8,770	1,035	23,786	67,452	13,079	59,578	11.7	0.0	11.8	-71,165	1,538	1.036	1.040
European FT	4,141	3,624	3,592	2,403	586	50	3,730	4,281	2,500	3,736	12.8	0.0	8.5	620	1,778	1.037	1.034
EU 10	1,672	1,550	391	171	231	105	410	1,725	184	1,598	7.4	0.0	45.7	-8,273	-423	1.031	1.034
Rest of Europe	498	479	487	456	41	21	517	533	484	512	4.0	0.0	51.6	-2,408	406	1.084	1.054
ASEAN	69,738	59,281	33,674	20,594	11,904	1,013	35,309	72,835	21,721	61,804	15.4	0.0	8.5	23,286	13,048	1.059	1.040
Rest of Asia	2,360	1,925	1,023	407	501	33	1,117	2,501	457	2,022	19.5	0.0	6.7	-5,523	-529	1.063	1.065
Rest of Latin America	9,776	9,414	627	195	427	43	691	10,621	236	10,230	3.9	0.0	10.1	1,069	-25	1.080	1.055
Midest and North Africa	15,222	14,713	2,385	1,495	595	61	2,465	16,156	1,548	15,608	3.5	0.0	10.3	-652	680	1.079	1.031
Rest of Africa	3,051	3,010	246	98	86	42	283	3,222	108	3,176	1.4	0.0	48.5	-642	-13	1.052	1.139
Other reporting countries	2,721	2,683	156	57	111	71	167	2,932	62	2,891	1.5	0.0	63.7	-1,418	-211	1.079	1.061
No reporting partner countries	972	854	1,368	1,183	191	61	1,405	1,030	1,209	897	13.1	0.0	32.3	-5,770	330	1.082	1.041
Partner Total	**486,940**	**422,710**	**163,146**	**82,889**	**74,322**	**7,566**	**171,195**	**510,607**	**87,931**	**442,837**	**13.7**		**10.2**	**-124,774**	**40,312**	**1.049**	**1.061**
Hong Kong, China	**16,896**	**83,653**	**0**	**0**	**0**	**0**	**0**	**17,133**	**0**	**84,903**	**0.0**	**0.0**	**0.0**	**-2,862**	**0**	**1.015**	**na**
China	**0**	**0**	**98,499**	**19,758**	**0**	**0**	**100,494**	**0**	**20,173**	**0**	**0.0**	**0.0**	**0.0**	**0**	**2,862**	**na**	**1.017**
World Total	**503,836**	**506,363**	**261,645**	**102,647**	**74,322**	**7,566**	**271,688**	**527,740**	**108,104**	**527,740**	**11.5**	**0.0**	**10.2**	**-127,636**	**43,174**	**1.047**	**1.053**

Table 5 Initial and Adjusted Estimates of Hong Kong Re-exp Markup Rates (%) by GTAP Sectors, 2004, all partner average

	China & Hong Kong exports, Partner imports						China & Hong Kong imports, Partner exports					
	Initial Estimates			*Adjusted Estimates*			*Initial Estimates*			*Adjusted Estimates*		
Sector name	Hong Kong re-exports as percent of China's total exports	Hong Kong re-exports markup rate	Standard deviatio n of markup rate	Hong Kong re-exports as percent of China's total exports	Hong Kong re-exports markup rate	Standard deviation of markup rate	Hong Kong re-exports as percent of China's total imports	Hong Kong re-exports markup rate	Standard deviation of markup rate	Hong Kong re-exports as percent of China's total imports	Hong Kong re-exports markup rate	Standard deviation of markup rate
Food grain	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Feed grain	0.0	61.5	13.3	0.0	68.5	23.7	0.1	10.0	0.0	0.0	0.0	0.0
Vegetables fruit nuts	0.3	24.4	10.0	0.3	23.7	10.2	21.4	1.6	0.4	21.2	0.6	2.0
Oil seeds	0.1	32.7	10.9	0.1	11.4	11.7	0.1	4.6	0.7	0.1	0.0	0.0
Plant-based fibers	0.9	7.4	0.0	0.4	53.7	22.4	0.5	16.2	7.1	0.3	38.7	30.0
Crops nec	2.3	52.4	5.8	2.9	58.7	4.4	7.2	9.9	7.3	6.7	14.5	9.8
Livestock	0.6	37.0	13.0	0.7	35.5	9.2	21.4	6.2	1.6	22.2	7.4	8.5
Forestry and Fishing	2.5	32.2	11.0	2.0	94.4	8.8	3.3	4.9	2.9	2.2	28.6	24.2
Oil and gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal and Minerals nec	0.2	36.9	23.6	0.2	32.4	25.3	1.7	28.8	15.4	1.0	39.1	20.3
Meat and dairy	0.4	24.6	4.8	0.3	47.0	8.9	23.5	6.5	4.9	23.8	25.1	15.1
Processed Food	1.3	25.7	5.6	1.1	41.3	5.7	4.7	5.3	1.4	4.5	8.2	9.8
Beverages and tobacco products	9.1	35.7	9.1	8.9	41.7	9.5	20.6	28.6	12.2	28.5	31.7	18.2
Textiles	10.6	30.8	7.5	10.3	29.1	7.8	24.7	8.4	1.6	24.7	7.2	7.6
Wearing apparel	14.4	39.3	6.1	15.0	37.3	6.7	23.6	7.5	2.9	7.6	64.7	17.3
Leather products	27.9	15.3	3.1	26.8	14.8	3.1	35.4	11.7	3.7	36.4	11.1	10.2
Wood and paper products	7.9	43.4	5.5	6.5	43.5	5.3	8.6	5.7	2.0	7.6	6.4	6.3
Petroleum coal products	0.1	6.4	4.7	0.1	3.5	1.7	2.0	3.9	3.1	2.3	1.6	2.4
Chemical rubber plastic products	5.8	34.8	4.7	5.6	34.3	4.7	13.8	7.9	1.8	14.2	7.9	3.8
Mineral products nec	2.7	32.9	7.6	2.6	34.3	7.5	9.4	9.1	1.7	9.3	9.5	2.2
Metals	0.9	20.3	6.8	1.0	17.5	7.8	10.0	4.7	2.6	10.6	9.5	4.6
Metal products	8.4	33.7	5.2	8.9	31.0	5.3	8.2	5.4	1.7	7.6	1.8	4.8
Motor vehicles and parts	0.2	49.6	9.8	0.3	41.9	10.8	7.2	5.2	1.2	7.7	0.9	3.4
Transport equipment nec	1.6	19.1	9.1	2.1	20.1	9.0	1.9	2.8	0.8	1.4	24.4	22.9
Electronic equipment	15.2	24.1	9.4	13.5	22.9	9.4	25.4	16.1	4.1	19.1	12.6	6.9
Machinery and equipment nec	15.3	34.3	5.6	17.1	21.7	6.7	10.9	8.7	3.7	9.0	5.2	6.5
Manufactures nec	30.0	40.8	5.2	25.9	39.7	5.0	19.7	10.1	2.3	21.7	10.0	11.1
All sectors	12.9	30.9	4.2	12.7	27.5	4.3	14.4	11.6	1.8	12.4	10.2	4.8

Table 6 Initial and Adjusted Estimates of Hong Kong's Re-export Earnings and Retained Imports, 2004, mill US $

	Re-export Earnings						Retained Imports			
	Re-export for China		Re-export to China		Others		Excluding China		Including China	
Sector name	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Food grain	0	0	0	0	0	0	2	9	2	9
Feed grain	0	0	0	0	0	0	12	13	14	14
Vegetables fruit nuts	2	2	4	1	2	2	650	721	834	870
Oil seeds	0	0	0	0	0	0	11	29	14	32
Plant-based fibers	0	0	2	6	0	0	71	96	71	96
Crops nec	39	43	4	6	9	13	167	206	254	304
Livestock	5	5	53	63	5	5	515	459	855	787
Forestry and Fishing	13	38	3	19	21	77	486	641	568	646
Oil and gas	0	0	0	0	0	0	0	4	255	191
Coal and Minerals nec	6	6	89	121	142	142	834	681	961	792
Meat and dairy	2	4	25	95	14	25	1,015	602	1,416	1,001
Processed Food	53	86	22	34	43	45	2,085	2,056	2,625	2,693
Beverages and tobacco products	39	46	59	65	135	135	467	348	919	866
Textiles	2,178	2,062	404	345	236	236	1,882	2,252	3,929	5,903
Wearing apparel	4,621	4,388	36	309	125	125	542	884	5,083	6,394
Leather products	1,489	1,442	244	230	209	210	1,348	1,741	1,348	1,741
Wood and paper products	1,263	1,266	61	69	18	19	1,216	1,878	2,137	3,031
Petroleum coal products	1	0	9	4	27	27	4,476	5,255	4,766	5,657
Chemical rubber plastic products	1,310	1,293	827	824	369	369	5,958	6,010	6,730	7,244
Mineral products nec	136	141	28	29	14	14	974	865	1,307	1,325
Metals	54	47	195	396	26	56	2,843	3,472	3,417	6,837
Metal products	866	797	25	8	30	30	516	1,587	846	1,587
Motor vehicles and parts	25	21	62	11	26	26	1,275	1,020	1,411	2,599
Transport equipment nec	38	39	4	36	140	140	1,441	1,982	1,677	2,363
Electronic equipment	8,239	7,831	5,318	4,172	2,943	2,942	29,350	30,124	29,350	30,124
Machinery and equipment nec	7,367	4,663	1,118	663	883	934	7,806	17,400	7,806	17,400
Manufactures nec	6,486	6,315	59	59	689	691	6,567	7,598	6,567	7,598
All sectors	34,231	30,536	8,651	7,566	6,106	6,264	72,509	87,931	85,163	108,104

Table 7 Initial and Adjusted Estimates of China's Net Trade Flows, 2004, in million U.S. Dollars

	Trade Balance with All Partners Excluding Hong Kong				Trade Balance with All Partners				Trade Balance with the United States			
Sector name	China officially reported	Initial estimates	Adjusted estimates	Partner officially reported	China official reported	Initial estimates	Adjusted estimates	Partner officially reported	China official reported	Initial estimates	Adjusted estimates	U.S. official reported
Food grain	-1,481	-905	-1,495	778	-1,481	-905	-1,495	778	-648	-495	-810	495
Feed grain	69	199	119	-351	71	201	120	-353	0	-1	0	0
Vegetables fruit nuts	1,095	1,222	995	-1,550	981	1,325	1,135	-1,737	20	-1	18	-95
Oil seeds	-6,620	-4,666	-5,600	4,546	-6,623	-4,664	-5,597	4,543	-3,335	-2,315	-3,287	2,307
Plant-based fibers	-2,830	-2,057	-2,762	2,035	-2,844	-2,059	-2,762	2,038	-1,766	-1,427	-1,510	1,421
Crops nec	898	920	478	-1,184	1,006	1,030	573	-1,301	46	46	21	-120
livestock	-2,376	-2,088	-1,948	918	-2,856	-1,810	-1,630	623	-386	-419	-380	244
Forestry and Fishing	-2,087	-798	-1,892	637	-1,989	-663	-1,887	532	-65	-131	-112	73
Oil and gas	-24,368	-10,149	-17,830	10,109	-24,182	-9,962	-17,644	9,854	114	114	138	-181
Coal and Minerals nec	-15,136	-6,171	-11,618	4,142	-15,248	-6,149	-11,568	4,094	-104	15	45	-125
Meat and dairy	56	13	68	18	98	382	461	-360	-220	-183	-158	125
Processed Food	2,450	3,765	2,965	-5,220	2,875	4,416	3,563	-5,878	984	1,092	1,174	-1,676
Beverages and tobacco products	28	-87	62	7	456	349	512	-434	-4	-15	0	-30
Textiles	23,596	28,305	30,968	-26,059	27,361	32,093	33,057	-31,747	4,751	5,150	6,902	-7,201
Wearing apparel	40,695	47,645	44,783	-49,780	47,524	46,953	48,049	-60,125	5,997	8,240	9,998	-11,539
Leather products	17,201	24,896	26,376	-34,024	17,863	24,647	26,171	-41,476	7,898	11,735	13,528	-16,649
Wood and paper products	4,215	8,766	11,457	-22,954	5,429	9,525	12,121	-25,138	5,472	6,832	9,462	-15,077
Petroleum coal products	-3,282	-2,675	-1,925	3,436	-3,176	-2,332	-1,576	3,154	500	613	665	-767
Chemical rubber plastic products	-44,194	-22,528	-18,279	8,509	-51,494	-22,259	-18,669	6,876	901	3,592	4,397	-6,814
Mineral products nec	5,686	6,581	7,202	-9,762	6,369	7,321	7,591	-10,336	1,539	1,703	2,412	-3,397
metals	-23,575	-15,908	-12,174	12,743	-25,367	-13,424	-10,470	12,414	-14	-447	74	280
Metal products	12,367	15,023	13,984	-18,289	13,366	14,960	13,857	-20,260	5,162	5,954	6,502	-7,748
Motor vehicles and parts	-4,980	-4,334	-5,446	8,723	-4,951	-3,239	-3,936	8,624	3,044	2,998	1,656	-1,409
Transport equipment nec	2,205	2,069	-259	47	2,621	2,488	80	-344	-1,278	-618	-1,000	271
Electronic equipment	22,336	70,770	61,347	-135,931	31,649	80,065	54,694	-152,064	35,414	41,123	54,074	-57,796
Machinery and equipment nec	-43,915	-8,965	-27,680	-26,354	-41,761	-8,187	-29,862	-37,365	7,214	13,228	17,215	-24,173
Manufactures nec	17,698	27,318	32,881	-49,659	22,039	27,182	32,747	-58,174	9,161	12,962	16,547	-24,511
All sectors	-24,249	156,165	124,774	-324,470	-2,263	177,285	127,636	-393,563	80,396	109,345	137,570	-174,095

Appendix Table A Country aggregation in the illustration example

Aggregate Region	ISO3	Country name	Aggregate Region	ISO3	Country name
United States	USA	United States	Rest of Asia	BGD	Bangladesh
Canada	CAN	Canada		LKA	Sri Lanka
Mexico	MEX	Mexico		PAK	Pakistan
Brazil	BRA	Brazil		MAC	Macao
Japan	JPN	Japan		KAZ	Kazakhstan
Korea Rep	KOR	Korea Rep		KGZ	Kyrgyz Republic
Taiwan China	TWN	Taiwan China	Rest of Europe	ALB	Albania
India	IND	India		BGR	Bulgaria
Russia	RUS	Russian Federation		HRV	Croatia
South Africa	ZAF	South Africa		ROM	Romania
Hong Kong, China (E)	HKG	Hong Kong, China		SER	Yugoslavia
China (H)	CHN	China		UKR	Ukraine
Australia & New Zealand	AUS	Australia	Rest of Latin America	ARG	Argentina
	NZL	New Zealand		CHL	Chile
EU 15	AUT	Austria		COL	Colombia
	BEL	Belgium		ECU	Ecuador
	DEU	Germany		PER	Peru
	DNK	Denmark		PRY	Paraguay
	ESP	Spain		VEN	Venezuela
	FIN	Finland		URY	Uruguay
	FRA	France		CRI	Costa Rica
	GBR	United Kingdom		GTM	Guatemala
	GRC	Greece		PAN	Panama
	IRL	Ireland		CUB	Cuba
	ITA	Italy	Midest and North Africa	DZA	Algeria
	LUX	Luxembourg		EGY	Egypt Arab Rep
	NLD	Netherlands		IRN	Iran Islamic Rep
	PRT	Portugal		ISR	Israel
	SWE	Sweden		JOR	Jordan
European FT	CHE	Switzerland		LBN	Lebanon
	NOR	Norway		MAR	Morocco
EU 10	CYP	Cyprus		SAU	Saudi Arabia
	CZE	Czech Republic		SYR	Syrian Arab Republic
	EST	Estonia		TUN	Tunisia
	HUN	Hungary		TUR	Turkey
	LTU	Lithuania		YEM	Yemen
	LVA	Latvia	Rest of Africa	BEN	Benin
	MLT	Malta		GHA	Ghana
	POL	Poland		KEN	Kenya
	SVK	Slovak Republic		MOZ	Mozambique
	SVN	Slovenia		MWI	Malawi
ASEAN	SGP	Singapore		MDG	Madagascar
	IDN	Indonesia		NGA	Nigeria
	MYS	Malaysia		SDN	Sudan
	PHL	Philippines		TGO	Togo
	THA	Thailand		TZA	Tanzania
	VNM	Vietnam		UGA	Uganda
	KHM	Cambodia		ZMB	Zambia
Other reporting countries	OTH			ZWE	Zimbabwe
No reporting partner countries	NRP				

Appendix Table B Countries in the other reporting country block

Country number	*ISO3*	*Country name*	*Country number*	*ISO3*	*Country name*
1	ABW	Aruba	33	KNA	St. Kitts and Nevis
2	AND	Andorra	34	LBY	Libya
3	ARM	Armenia	35	LCA	St. Lucia
4	AZE	Azerbaijan	36	LSO	Lesotho
5	BDI	Burundi	37	MDA	Moldova
6	BFA	Burkina Faso	38	MDV	Maldives
7	BHR	Bahrain	39	MKD	Macedonia, FYR
8	BIH	Bosnia and Herzegovina	40	MLI	Mali
9	BLR	Belarus	41	MNG	Mongolia
10	BLZ	Belize	42	MRT	Mauritania
11	BOL	Bolivia	43	MSR	Montserrat
12	BRB	Barbados	44	MUS	Mauritius
13	BRN	Brunei	45	NAM	Namibia
14	CAF	Central African Republic	46	NCL	New Caledonia
15	CIV	Cote d'Ivoire	47	NER	Niger
16	CMR	Cameroon	48	NIC	Nicaragua
17	COK	Cook Islands	49	NPL	Nepal
18	CPV	Cape Verde	50	OMN	Oman
19	DMA	Dominica	51	PNG	Papua New Guinea
20	ERI	Eritrea	52	PYF	French Polynesia
21	ETH	Ethiopia(excludes Eritrea)	53	QAT	Qatar
22	FJI	Fiji	54	RWA	Rwanda
23	GAB	Gabon	55	SEN	Senegal
24	GEO	Georgia	56	SLE	Sierra Leone
25	GIN	Guinea	57	SLV	El Salvador
26	GMB	Gambia, The	58	STP	Sao Tome and Principe
27	GRD	Grenada	59	SUR	Suriname
28	GRL	Greenland	60	SWZ	Swaziland
29	GUY	Guyana	61	SYC	Seychelles
30	HND	Honduras	62	TTO	Trinidad and Tobago
31	ISL	Iceland	63	VCT	St. Vincent and the Grenadines
32	JAM	Jamaica	64	WSM	Samoa

Appendix Table C — Sectors in the illustration example and their GTAP-ISIC concordance

Sectors in the illustrate example	GTAP[a] 6 Sector Number and Description	ISIC[b] Rev. 3 CODE
1.Food Grains	1. Paddy rice; 2. Wheat	01111, 01301, 01401,01112, 01302, 01402,
2. Feed grains	3. Cereal grains, nec	01113, 01303, 01403
3. Oilseeds	5 Oil seeds	01307, 01407
4. Vegetables, fruits and nuts	4. Vegetables and fruit nuts	01121, 01112,, 01114
5. Plant-based fibers	7. Plant-based fibers	01116
6. Other crops	6. Sugar cane sugar beet, 8. Crops nec.	01305, 01405, 01204, 01404, 01117, 01115, 01306, 01406, 01122, 01132.
7 Live stock	9 Bovine cattle, sheep and goats, houses, 10 Animal products, n.e.c. 11 Raw milk, 12 Wool, silk-worn cocoons	01308, 01408, 01211, 01212, 01213,0122, 01309, 013010, 013011, 013012, 01409, 014010, 014011, 014012 , 15311
8. Meat and dairy products	19 Bovine cattle, sheep and goats, houses meat products, 20 Meat products, n.e.c. 22 Dairy products	151,115,141,520
9. Processed Food	21. processed rice, 23. Sugar, 24 Vegetable oils and fats, 25 Food products n.e.c.	1500 Manufacture of food products except 1511,1514,1520,1542, 1551,1552,1553,1554
10. Beverages & tobacco	26 Beverages & tobacco	1551,1552,1553,1554,1600 Manufacture of tobacco products
11. Forestry and fishery	13. Forestry, 14. Fishing	02 Forestry, logging and related service activities; 015 Hunting, trapping and game propagation including related service activities; 05 Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing
12. Crude Oil and natural gas	16 Oil, 17 Gas	111 Extraction of crude petroleum and natural gas; 112 Service activities incidental to oil and gas extraction excluding surveying
13. Coal and Minerals nec	15 Coal, 18 Minerals n.e.c	101 Mining and agglomeration of hard coal; 102 Mining and agglomeration of lignite; 103 Mining and agglomeration of peat; 12 Mining of uranium and thorium ores; 13 Mining of metal ores; 14 Other mining and quarrying ;
14. Textile	27 Textiles	17 Manufacture of textiles; 243 Manufacture of man-made fibers
15. Apparel	28 Wearing apparel.	18 Manufacture of wearing apparel; dressing and dyeing of fur
16. Leather & shoes	29 Leather products, footwear & travel goods	19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
17. Other light manufactures	42 manufactures n.e.c	36 Manufacturing n.e.c.
18. Wood & paper products	30 wood products, 31 paper products, publishing,	20 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; 361 Manufacture of furniture; 21 Manufacture of paper and paper products; 2211 Publishing of books, brochures, musical books and other publications; 2212 Publishing of newspapers, journals and periodicals; 2219 Other publishing (photos, engravings, postcards, timetables, forms, posters, art reproductions, etc.. 222 Printing and service activities related to printing.
19. Petroleum coal and mineral products	32. Petroleum coal products	241 Manufacture of coke oven products; 242 Manufacture of refined petroleum products

20. Chemical rubber plastic products	33. Chemical rubber plastic products	233 Processing of nuclear fuel； 241 Manufacture of basic chemicals; 242 Manufacture of other chemical products; 25 Manufacture of rubber and plastics products
21. Mineral products, n.e.c	34. mineral products, n.e.c	26 Manufacture of other non-metallic mineral products
22. Basic metals	35. Ferrous metals; 36. Metals n.e.c.,	271 Manufacture of basic iron and steel; 2731 Casting of iron and steel, 272 Manufacture of basic precious and non-ferrous metals; 2732 Casting of non-ferrous metals
23. Metal products	37 Metal products	28 Manufacture of fabricated metal products, except machinery and equipment
24. Motor Vehicle and other transport equipment	38 Motor vehicles and parts	34 Manufacture of motor vehicles, trailers and semi-trailers
25.Transport equipment nec	39 Transport equipment n.e.c.	35 Manufacture of other transport equipment
26. Electronic equipment	40 Electronic equipment	30 Manufacture of office, accounting and computing machinery ; 32 Manufacture of radio, television and communication equipment and apparatus
27. Machinery and equipment nec	41 Machinery and equipment n.e.c.	2213 Publishing of recorded media; 224 Reproduction of recorded media; 29 Manufacture of machinery and equipment ; 31 Manufacture of electrical machinery and apparatus n.e.c; 33 Manufacture of medical, precision and optical instruments, watches and clocks

a. Global Trade Analysis Project, version 6 (Hertel, 1997).
b. International Standard Industry Classification.

A Globally Consistent Framework for Reliability-based Trade Statistics Reconciliation in the Presence of an Entrepôt

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