



**Reconciling Trade Statistics from China, Hong Kong
and Their Major Trading Partners
-- A Mathematical Programming Approach¹**

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ABSTRACT

This paper develops a mathematical programming model to simultaneously estimate re-export markups and reconcile bilateral trade statistics between China, Hong Kong, and their trading partners. The model is applied to sector level trade flows to resolve discrepant reporting in an efficient manner. Adjustments in trade flows are based upon statistical reporters' reliability information. The program is implemented in GAMS and retains many desirable theoretical and empirical properties. Estimates are used for generating trade flows and markups for Hong Kong's re-exports used in the forthcoming version 7 GTAP database. The model's flexibility has potential for expanded use in other regions where re-exports and associated markup cause discrepant trade flows.

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I. Introduction

It has long been known that bilateral trade statistics reported by importing and exporting countries are unlikely to be the same, and in fact they often vary greatly for a variety of reasons. Economists and statistical agencies around the globe working on reconciling bilateral trade have adopted methods for choosing either the importer's or exporter's data, or some weighted average of the two, as more reliable (e.g. Gehlhar, 1996, for the GTAP model, and the documentation for Statistics Canada's *World Trade Analyzer*). However, the standard methods for data reconciliation have generally not worked well for China and its major trading partners because of the intermediary role of Hong Kong in China's external trade.

A large share of China's trade with the world passes through Hong Kong. Yet current reporting practices in China and her trading partners do not fully reflect this fact. This is in part because traders often do not know the final destination when their goods leave China. In these cases, they are recorded as exports to Hong Kong by the Chinese Customs authorities. For this reason, Chinese Customs statistics show that Hong Kong is one of China's largest export destinations, behind the United States but on a par with the EU 15 countries in recent years. In fact, Hong Kong re-exports most of its imports from China to other countries. On the other hand, 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 between the US and China invariably arise, and its increasingly large magnitude has not only caused concerns among policy makers in the two countries, but it has also motivated quite a few studies aimed at reconciling the conflicting official trade statistics between China and her major trading partners.

Key components of any effort at trade data reconciliation in the case of China and Hong Kong include both 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 part of any attempt to reconcile 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 Chinese trade flows 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 of the above-mentioned studies use an *ad hoc*, one size-fits-all estimate, though differing in value across studies. Fung, Lau and Xiong (2006) even undertake to convert the *fas* to *fob* value for US exports, and seek to include the services trade in their China-US trade data reconciliation.

These studies aim to use a large amount of trade statistics to estimate the Hong Kong re-export markups, and include a wide range of factors contributing to the discrepancies and 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 underpinning trade data discrepancies. In these studies, however, estimation of Hong Kong's re-export markups and adjustment of Chinese bilateral trade are undertaken independently, and do not take account of data adjustment with other countries. Therefore, global consistency is not ensured. In addition, these earlier studies never fully utilize all official trade statistics from China, Hong Kong and their trading partners simultaneously. Doing so requires a new approach to trade data reconciliation, which is the very motivation of this paper.

The paper has two specific goals. First, it develops and implements a formal model to simultaneously estimate Hong Kong re-export markups and to reconcile the Chinese and Hong Kong trade statistics in a globally consistent optimization framework. Second, it applies the model to 2004 bilateral world trade data to produce a set of trade estimates for the next version of the Global Trade Analysis Project (GTAP) database (version 7). To enhance its empirical quality, this paper also draws on more detailed information on trade related shipping costs to estimate *cif/fob* ratios as well as the most up-to-date research on the estimation of Hong Kong re-export markups.

The paper is organized as follows. Section two specifies the 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 *cif/fob* ratios and Hong Kong's re-export markup estimates, aggregation issues and the estimation of reliability weights for major variables in the model. Modeling results 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

2.1 Reconciling international trade statistics via optimization

Reconciling international trade statistics in an optimization framework is an application of the constrained matrix balancing procedure² (Bacharach, 1970). It involves obtaining the best estimates of conflicting data from more than one source.

²The constrained matrix balancing procedure appears as a core mathematical structure in diverse applications. These applications include the estimation of input-output tables (Bachem and Korte, 1981; Harrigan and Buchanan, 1984; Miller and Blair, 1985; Kaneko, 1988; Nagurney, 1989; Antonello, 1990) and inter-regional trade flows in regional science (Batten, 1982; Byron et al., 1993), balancing of social/national accounts in economics (Byron, 1978; Van der Ploeg, 1982, 1984, 1988; Zenios, Drud, and Mulvey, 1989;

Procedures for matrix balancing can be classified into two broad classes -- bi-proportional scaling and mathematical programming. The scaling methods involve adjusting the initial matrix by multiplying its row and column by positive constants until the matrix is balanced. It was developed by Stone and other members of the Cambridge Growth Project (Stone et al., 1963) and is usually known as RAS. The basic method was originally applied to known row and column totals but has been extended to cases where the totals themselves are not known with certainty (Senesen and Bates, 1988; Lahr, 2001). Mathematical programming methods are explicitly based on a constrained optimization framework, usually minimizing a penalty function, which measures the deviation of the balanced matrix from the initial matrix subject to a set of balance conditions.

An important advantage of mathematical programming models over scaling methods is flexibility. They allow a wide range of initial information to be used efficiently in the data adjustment process. Additional constraints can be easily imposed, such as allowing precise upper and lower bounds to be placed on unknown elements. Inequality conditions or incorporation of a penalty term in the objective function are used to minimize deviations from the initial row or column total estimates when they are not known with certainty. This flexibility results in improved information content of the balanced estimates as shown by Robinson, Cattaneo and El-said (2001).

The mathematical programming approach also permits one to routinely introduce relative degrees of reliability for initial estimates. The idea of including data reliability metrics in matrix balancing can be traced back over a half century to Richard Stone and his colleagues (1942) when they explored procedures for compiling national income accounts. Their ideas were formalized into a mathematical procedure to balance the system of accounts after assigning reliability weights to each entry in the system. The minimization of the sum of squares of the adjustments between initial and balanced entries in the system, weighted by the reliabilities or the reciprocal of the variances of the entries is carried out subject to linear (accounting) constraints. This approach was first implemented by Byron (1978) and applied to the System of National Accounts of the UK by Ploeg (1982, 1984). Zenios and his collaborators (1989) further extended this approach to balance a large social accounting matrix in a nonlinear network-programming framework. Robinson and his colleagues (2001) provided a way to handle measurement error in cross entropy minimization via an error-in-variables formulation. Although computational burden is no longer a problem today, the estimation of error variances in large data set in such approaches remains problematic.

Nagurney, Kim, and Robinson, 1990), estimating interregional migration in demography (Plane, 1982), the analysis of voting patterns in political science (Johnson, Hay, and Taylor, 1982), the treatment of census data and estimation of contingency tables in statistics (Friedlander, 1961), the estimation of transition probabilities in stochastic modeling (Theil and Rey, 1966), and the projection of traffic within telecommunication and transportation networks (Florian, 1986; Klinkiewicz, 1989). A survey of this literature can be found in Schneider and Zenios (1990).

There is a large and growing literature on the use of matrix balancing procedures to estimate input/output tables or Social Accounting Matrices (SAMs), but only a few studies have used them to adjust/estimate bilateral trade statistics³. There are some important differences in the conditions for adjusting an unbalanced SAM and reconciling bilateral trade data. First, SAMs are square matrices and their rows and columns represent the same accounts, so that all their row sums equal the corresponding column sums. In contrast, bilateral trade matrices are usually rectangular, and their row and column sum represent different types of accounts (for example, reporter and partner sums or export and import totals); therefore the row and column sums are not generally equal. Second, SAMs usually have common structure in terms of their zero and nonzero elements. However, this structure may differ significantly from region to region in the trade matrix, depending on the dominant trade pattern in the region under concern.

The final area in which SAMs and bilateral trade matrices differ is with regard to the issue of multiple, conflicting data sources. In SAMs, estimates of the same entries can often be obtained from income, expenditure or production data, and typically data gathered from one source is not consistent with that obtained from a different source. The common practice in removing the account inconsistencies is by assigning relative degrees of reliability to entries in the SAM and using constrained matrix balancing procedures with available information to adjust the data to ensure consistency in the accounts. On the other hand, international trade statistics are often obtained from two sources: reporting countries and their partner's official trade flow statistics. In most cases, even with apparently "good" data from both sides, the discrepancies can be significant. This is because the exporter and importer may have very different reporting criteria and systems for valuation of bilateral trade. For example, the initial destination of a shipment may not be sole and may be different with the actual destination of its components; and the importer may not be able to assign a unique origin. Because international trade statistics are inherently inconsistent, a systematic procedure is needed to ensure the balance between imports and exports of multiple partners.

The TESSY (trade estimation system) used by UNSTAT is the first mathematical procedure to find estimates of trade data by commodity and partner for non-reporting countries. It can calculate estimates for all the missing values in a bilateral trade matrix, including missing commodity totals, partner totals. By scaling and re-scaling estimates other than the "true reported" figures, a balanced trade matrix can be achieved. Baras and Panoutsopoulos (1993) developed a progressive elimination and quadratic programming procedure to estimate missing value in bilateral trade flows. They tested their procedure by using several selected countries. Unfortunately, they devoted most of their efforts to filling in the missing values in the trade matrix, and did not focus on the reliability of different reporters. In addition, this approach has little to offer for dealing with the increasingly important phenomena of *entrepot*

³ Waelbroeck(1964) applied the RAS procedure on trade flows for the world with the flows grouped into nine regions. Using 1938 trade flows as base, he estimated 1948, 1951-52, and 1959-60 trade flows. Mohr, Crown and Polenske (1987) discussed the problems encountered when the RAS procedure is used to adjust trade flow data. They pointed out that the special properties of interregional trade data increase the likelihood of non-convergence of the RAS procedure and proposed a linear programming approach that incorporates exogenous information to override the infeasibility of RAS problem.

trade and transshipments. To the best of our knowledge, our paper's formulation of international trade statistics reconciliation problem into an optimization framework in the context of China's trade with other nations, via Hong Kong, is the first attempt of this kind in both the international trade and the constrained matrix balancing literature. We turn now to a formal exposition of our approach.

2.2 General Assumptions and Mathematical Notation

China and Hong Kong both engage in bilateral trade with N partner countries and each other on M commodities for time period T . Hong Kong is assumed to be the only *entrepot* between China and the N partner countries engaging re-export activities to transship both China's and its N partner countries' exports to each others. Hong Kong earns a markup by conducting such *entrepot* activities. This markup is the difference between the price at which Hong Kong buys goods and the price at which it sells the same goods. Let us assume that all partner countries except one report their exports to and imports from China and Hong Kong. China and Hong Kong also report their exports to, and imports from, all their partner countries and trade flows between them. In addition, Hong Kong reports the origin and destination of all commodities it re-exports bound for, and coming from, China and other partner countries. The markup from such activities is unreported; it must be estimated. We assume that all reporting countries, including China, can correctly identify the country of origin of their imports, either the imports are directly from the partners or indirectly via Hong Kong. Reporting countries however can not determine the final destination when exports leave their ports (Schindler and Beckett, 2005).

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

DX_{it}^{sr} = Direct exports of commodity i from country s to country r at time t . When the source country, s , denotes Hong Kong, this flow comprises domestic exports, inclusive of earnings from re-exportation of that commodity. When the destination country, r denotes Hong Kong, it is the partner countries' exports that remain in Hong Kong

RX_{it}^{sr} = Indirect exports of commodity i via Hong Kong from origin country s to destination country r at time t , inclusive of Hong Kong's re-export earnings

TX_{it}^{sr} = Total exports of commodity i from country s to country r at time t . For s equals Hong Kong, this corresponds to domestic exports plus re-exports

DM_{it}^{sr} = Direct imports of commodity i by country r from country s at time t . When r corresponds to Hong Kong, it is imports for domestic use, for s equals Hong Kong it is partner's imports originated from Hong Kong

TM_{it}^{sr} = Total imports of commodity i by country s from country r at time t

RXM_{it}^{sr} = Hong Kong markup earnings by re-export commodity i originated from country s to final destination country r at time t

WEX_{it}^s = Total reported exports of commodity i to the world by country s at time t

WMX_{it}^r = Total reported imports of commodity i from the world by country r at time t

XER_{it}^r = Statistical discrepancy of commodity i in China and Hong Kong's east bound trade with partner country r at time t

MER_{it}^r = Statistical discrepancy of commodity i in China and Hong Kong's west bound trade with partner country r at time t

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

Indices i are defined over commodity set $I \in \{1, 2, \dots, M\}$, indices s and r are defined over country set $W \in \{1, 2, \dots, N, CH, HK\}$. The first superscript in any trade flow variable always indicates the source country and the second always refers to the destination country. For exports (DX and TX), source countries are the reporters, while for imports (DM and TM), destination countries are the reporters. Exports are valued on a *fob* basis and imports are valued on a *cif* basis.

This completes the notation required for our problem. We now turn to the 16 accounting identities describing bilateral trade flow statistics reported by China, Hong Kong and their partner countries. These are divided into four sections: those dealing with exports from China/Hong Kong, those dealing with imports by China/Hong Kong, those dealing with bilateral, China-Hong Kong trade, and those dealing with global consistence.

2.3 Eastbound flows: exports from China and Hong Kong

For all $r \in \{1, 2, \dots, N\}$ and all $s \in \{1, 2, \dots, N, CH\}$:

$$cif_{it}^{CH,r} TX_{it}^{CH,r} + cif_{it}^{HK,r} DX_{it}^{HK,r} + XER_{it}^r = TM_{it}^{CH,r} + DM_{it}^{HK,r} \quad (1)$$

Equation (1)⁴ states that the sum of any particular partner's imports of China and Hong Kong-originated products should equal the sum of China's total exports and Hong Kong's domestic exports to that partner adjusted for China to Hong Kong *cif/fob* margin, plus a statistical discrepancy. Left hand of this equation is actual exports from China and Hong Kong while the right hand is the imports statistics published by partner countries.

4 There is a condition for equation (1) to hold when the error term equals to zero:

$cif_{it}^{CH,r} = cif_{it}^{CH,HK} cif_{it}^{HK,r}$. 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.

$$TX_{it}^{CH,r} = DX_{it}^{CH,r} + \frac{(RX_{it}^{CH,r} - RXM_{it}^{CH,r})}{cif_{it}^{CH,HK}} \quad (2)$$

Equation (2) defines that China's total exports to a particular partner equal China's direct exports plus Hong Kong's re-exports for China to that partner minus Hong Kong's re-export makeup adjusted by China-Hong Kong *cif/fob* ratio.

$$DX_{it}^{HK,r} = TX_{it}^{HK,r} - \sum_s (RX_{it}^{sr} - RXM_{it}^{sr}) \quad (3)$$

In equation (3) Hong Kong'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.

$$TM_{it}^{HK,r} = DM_{it}^{HK,r} + cif_{it}^{HK,r} \sum_s (RX_{it}^{sr} - RXM_{it}^{sr}) \quad (4)$$

Equation (4) indicates partner's total imports from Hong Kong equals partners' imports of Hong Kong domestic products plus Hong Kong's re-exports to the partner from all sources adjusted by Hong Kong re-export markup and the *cif/fob* ratio from Hong Kong to the partner.

$$DM_{it}^{CH,r} = TM_{it}^{CH,r} - cif_{it}^{HK,r} (RX_{it}^{CH,r} - RXM_{it}^{CH,r}) \quad (5)$$

Equation (5) indicates that a partner's direct imports from China equal its total imports from China minus Hong Kong's re-exports for China to that partner adjusted by Hong Kong's re-exports markup and Hong Kong to partner *cif/fob* ratios.

2.4 Westbound flows: China and Hong Kong imports, partner exports

For all $s \in \{1, 2, \dots, N\}$ and all $r \in \{1, 2, \dots, N, CH\}$:

$$DM_{it}^{s,CH} + TM_{it}^{s,HK} - MER_{it}^s = cif_{it}^{s,CH} DX_{it}^{s,CH} + cif_{it}^{s,HK} TX_{it}^{s,HK} \quad (6)$$

Equation (6) states that the sum of China's direct and Hong Kong's total imports of products originated from any particular partner should equal to the sum of that partner's direct exports to China and its total exports to Hong Kong adjusted by *cif/fob* margin, plus a statistical discrepancy. Similar to equation (1), left hand of this equation is actual imports by China and Hong Kong while right hand is the exports statistics published by partner countries.

$$DM_{it}^{s,HK} = TM_{it}^{s,HK} - \sum_r (RX_{it}^{sr} - RXM_{it}^{sr}) \quad (7)$$

Equation (7) requires Hong Kong's domestic use of imports plus its re-exports for a particular partner minus re-exports markup equals Hong Kong's total imports from that partner country.

$$DM_{it}^{s,CH} = TM_{it}^{s,CH} - cif_{it}^{HK,CH} (RX_{it}^{s,CH} - RXM_{it}^{s,CH}) \quad (8)$$

Equation (8) states that China's direct imports from a partner equals China's total imports from that partner minus Hong Kong's re-exports to China for that partner adjusted by Hong Kong's re-export earnings, as well as Hong Kong to China *cif/fob* ratios.

$$TX_{it}^{s,CH} = DX_{it}^{s,CH} + \frac{(RX_{it}^{s,CH} - RXM_{it}^{s,CH})}{cif_{it}^{s,HK}} \quad (9)$$

Equation (9) reveals that partner's total exports to China equals partner's direct exports to China plus Hong Kong's re-exports to China for that partner, adjusted by Hong Kong's re-export markup and the *cif/fob* ratio from the partner to Hong Kong.

$$DX_{it}^{s,HK} = TX_{it}^{s,HK} - \frac{\sum_r (RX_{it}^{sr} - RXM_{it}^{sr})}{cif_{it}^{s,HK}} \quad (10)$$

From equation (10) we see that a partner's exports to Hong Kong, destined for Hong Kong domestic use, must equal its total export to Hong Kong minus its re-exports via Hong Kong to all destinations, adjusted by Hong Kong's re-export markup and the partner to Hong Kong's *cif/fob* ratio.

2.5 China-Hong Kong bilateral trade

Equation (11) states that China's actual exports to Hong Kong for Hong Kong domestic use must equal its direct exports to Hong Kong minus Hong Kong's re-exports for China to all other trading partners adjusted by the Hong Kong re-export markup and the China to Hong Kong *cif/fob* ratio.

$$TX_{it}^{CH,HK} = DX_{it}^{CH,HK} - \frac{\sum_r (RX_{it}^{CH,r} - RXM_{it}^{CH,r})}{cif_{it}^{CH,HK}} \quad (11)$$

$$DM_{it}^{CH,HK} = TM_{it}^{CH,HK} - \sum_r (RX_{it}^{CH,r} - RXM_{it}^{CH,r}) \quad (12)$$

Equation (12) defines Hong Kong's imports from China for domestic use as equaling its total imports from China minus its re-exports for China to all destinations adjusted by its markup earnings.

$$DX_{it}^{HK,CH} = TX_{it}^{HK,CH} - \sum_r (RX_{it}^{s,CH} - RXM_{it}^{s,CH}) \quad (13)$$

$$TM_{it}^{HK,CH} = DM_{it}^{HK,CH} + cif_{it}^{HK,CH} \sum_r (RX_{it}^{s,CH} - RXM_{it}^{s,CH}) \quad (14)$$

Equation (13) indicates that Hong Kong's domestic export to China equals its total exports to China minus its re-exports to China from all other partners adjusted by its markup earnings. Equation (14) states that China's total imports from Hong Kong equal its imports of goods with Hong Kong origin plus Hong Kong's re-exports to China from all sources adjusted by re-exports markup and the Hong Kong to China *cif/fob* ratio.

2.6 Global balance and objective function

For all $r \in \{1, 2, \dots, N, CH, HK\}$:

$$\sum_r DX_{it}^{CH,r} + \sum_s \sum_r (RX_{it}^{sr} - RXM_{it}^{sr}) + \sum_r DX_{it}^{HK,r} = WEX_{it}^{HK} + WEX_{it}^{CH} \quad (15)$$

$$\sum_s TM_{it}^{s,CH} + \sum_s \sum_r (RX_{it}^{sr} - RXM_{it}^{sr}) + \sum_s DM_{it}^{s,HK} = WMX_{it}^{HK} + WMX_{it}^{CH} \quad (16)$$

Equation (15) describes that the sum of after-adjustment actual exports from China and Hong Kong to all its partners should still equal the sum of their reported total exports to the world. This means that the adjustments made by the model do not change the total exports to the world reported by China and Hong Kong, it merely estimates Hong Kong's re-export markup and rearranges the destinations of China's exports to account for these re-exports. Equation (16) states that China and Hong Kong imports and Hong Kong's re-exports minus the re-export markups after adjustment should still equal the sum of China and Hong Kong's total imports from the world. The adjustments made by the model only change the markup estimates and rearrange the sources of China and Hong Kong's imports, not the total.

In addition, China and Hong Kong's total exports to, and imports from, the world should satisfy following conditions: total world exports by all trading countries equal total world imports after *cif/fob* adjustment:

$$\sum_s cif_{it}^r WEX_{it}^s = \sum_r WMX_{it}^r \quad (17)$$

Given these accounting relationships among trade flow statistics, what remains is to formulate the reconciliation problem within an optimization framework, for which we must develop a criterion for changing the reported statistics so that they conform with the linear accounting constraints. Either a cross-entropy (Harrigan & 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 reasons⁵:

$$Min \quad S = \frac{1}{2} \left\{ \begin{aligned} & \sum_t \sum_{i \in M} \sum_{s \in W} \sum_{r \in W} \frac{(DX_{it}^{sr} - DX0_{it}^{sr})^2}{wdx_{it}^{sr}} + \sum_t \sum_{i \in ms \in W} \sum_{r \in W} \frac{(DM_{it}^{sr} - DM0_{it}^{sr})^2}{wdm_{it}^{sr}} \\ & + \sum_t \sum_{i \in M} \sum_{s \in W} \sum_{r \in W} \frac{(TX_{it}^{sr} - TX0_{it}^{sr})^2}{wtx_{it}^{sr}} + \sum_t \sum_{i \in ms \in W} \sum_{r \in W} \frac{(TM_{it}^{sr} - TM0_{it}^{sr})^2}{wtm_{it}^{sr}} \\ & + \sum_t \sum_{i \in ms \in W} \sum_{r \in W} \frac{(RXM_{it}^{sr} - RXM0_{it}^{sr})^2}{wrxm_{it}^{sr}} + \sum_t \sum_{i \in M} (xer_{it}^2 + mer_{it}^2) \end{aligned} \right\} \quad (18)$$

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 is to modify a given set of bilateral trade flow statistics with equation (18) as the objective function and equations (1) - (16) as constraints.

2.7 Properties of the reconciliation model

There are several desirable analytical properties of the optimization model specified above. Firstly, the estimates of markups and trade flow adjustments are made in a consistent and simultaneous manner. The model re-directs sources and destinations of China’s and Hong Kong’s exports and imports, estimates Hong Kong’s re-export markup, allocates statistical discrepancies to trade flows among China, Hong Kong and their trading partners, and adjusts bilateral trade balances for China and all its partners simultaneously. In so doing 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 as 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

⁵ 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.

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 \mathbf{W} as the variance matrix of initial estimates $\bar{\mathbf{D}}$, \mathbf{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 $\bar{\mathbf{D}}$ to \mathbf{D} that satisfies the linear constraint, $\mathbf{R}\cdot\mathbf{D} = \mathbf{0}$ can be written as:

$$\mathbf{D} = (\mathbf{I} - \mathbf{WR}^T(\mathbf{RWR}^T)^{-1}\mathbf{R}) \bar{\mathbf{D}} \quad (19)$$

Thus,

$$\text{var}(\mathbf{D}) = (\mathbf{I} - \mathbf{WR}^T(\mathbf{RWR}^T)^{-1}\mathbf{R})\mathbf{W} = \mathbf{W} - \mathbf{WR}^T(\mathbf{RWR}^T)^{-1}\mathbf{R}\mathbf{W} \quad (20)$$

Since $\mathbf{WR}^T(\mathbf{RWR}^T)^{-1}\mathbf{R}\mathbf{W}$ 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 $\mathbf{R}\cdot\mathbf{D} = \mathbf{0}$ holds⁶. *This is the fundamental reason why such a reconciliation framework will provide improved trade statistics.* In summary, imposing equations (1) to (16) 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 ($wdx_{it}^{sr}, wtx_{it}^{sr}, wdm_{it}^{sr}, wtm_{it}^{sr}, wrxm_{it}^{sr}$) 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 can not 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

⁶ Details of the derivation of equation (19) and (20) can be found in classic textbook of econometrics, such as of *Econometric Methods, second edition* by Johnston, pp 157-158.

(2) each error variance is proportional to the corresponding initial estimates. In practice these 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 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 initial 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: Hong Kong's re-export markup rate on each country's re-exports via Hong Kong as percent of the country's total exports and imports is estimated, along with the adjusted bilateral balance of trade among China, Hong Kong 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 nonnegative. 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 China and Hong Kong 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 optimization model with actual trade statistics. First, all variables in the model need to be correctly linked with officially

reported statistics; second, Hong Kong's markup earnings from its re-exports and all bilateral *cif/fob* margins have to be computed independently or estimated based on information from other sources, so that the optimization model can be properly specified; third, an appropriate commodity and country aggregation needs to be determined based on data availability and computation capacities; and finally, a full set of reliability weights in the objective function need to be selected in order to obtain a meaningful solution from the model. We will discuss those issues one by one in five steps below.

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

In east bound trade, initial estimates can be directly obtained from existing bilateral trade statistics for four sets of variables in the model. They are: China's direct exports to partner countries ($DX0_{it}^{CH,r}$), Hong Kong's total exports to partner countries ($TX0_{it}^{HK,r}$), and partner's total imports from China ($TM0_{it}^{CH,r}$) and imports of product originated from Hong Kong ($DM0_{it}^{HK,r}$). Similarly, there are also four sets of variables for which initial estimates may be obtained directly from existing data in westbound trade. They are: partner countries total exports to Hong Kong and direct exports to China ($TX0_{it}^{s,HK}$ and $DX0_{it}^{s,CH}$), and China and Hong Kong's total imports from partner countries ($TM0_{it}^{s,CH}$ and $TM0_{it}^{s,HK}$). All China and Hong Kong reported trade statistics are obtained from Chinese Customs authorities and the Hong Kong Census and Statistical Department at the HS 8-digit level of detail. All partner countries' reported data are downloaded from UN COMTRADE at the HS 6-digit level.

We obtain initial estimates of Hong Kong's re-exports by origin and destination ($RX0_{it}^{sr}$) from Hong Kong re-exports statistics provided by the Hong Kong Census and Statistical Department at the HS 8-digit level. However, there are still nine sets of variables for which we need initial estimates before the model can be implemented. There are four sets each for eastbound and westbound trade respectively, plus the Hong Kong re-export markup ($RXM0_{it}^{sr}$). However, if we can obtain initial estimates for $RXM0_{it}^{sr}$ and if we also know the *cif/fob* margin for all bilateral routes, then the rest of the eight sets of variables all can be derived from existing trade statistics based on the accounting identities specified in the optimization model.

The four sets unobservable variables in eastbound trade are China's total exports to partner countries ($TX0_{it}^{Ch,r}$), Hong Kong's domestic exports to partner countries ($DX0_{it}^{HK,r}$),⁷ partner countries' direct imports from China ($DM0_{it}^{CH,r}$), and partner countries' total imports from Hong Kong ($TM0_{it}^{HK,r}$). Their initial estimates can be derived from observed

⁷ 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.

data according to equations (2), (3), (4) and (5) respectively (they are left hand variables in these equations). The four sets of unobservable variables in westbound trade are Hong Kong's imports from partner countries for domestic use ($DM0_{it}^{s,HK}$), China's direct imports from partner countries ($DM0_{it}^{s,CH}$), and partner countries' total exports to China and their exports for Hong Kong's domestic market ($TX0_{it}^{s,CH}$ and $DX0_{it}^{s,HK}$). Their initial estimates can be computed from observed data according to equations (7), (8), (9) and (10) respectively (they are left hand variables in these equations).

The initial estimates for bilateral trade variables between Hong Kong and China can be obtained from existing trade statistics reported by China and Hong Kong or calculated from observed trade data in the same fashion as unobserved variables in east and west bound trade according to equations (11) to (14). The observed statistics are $DX0_{it}^{CH,HK}$, $TX0_{it}^{HK,CH}$, $TM0_{it}^{CH,HK}$, and $DM0_{it}^{HK,CH}$. The only difference is that $TX0_{it}^{CH,HK}$ is China's actual exports to Hong Kong, equals its direct exports to Hong Kong minus all its re-export to other countries via Hong Kong.

In summary, there are eight sets of variables required, four of which in each direction can be obtained directly from existing reported trade statistics. The remaining four sets unobservable variables can be obtained from the four sets of equations in each trade direction. Therefore, as long as we can obtain estimates for Hong Kong's re-exports markup ($RXM0_{it}^{sr}$) and *cif/fob* margins (cif_{it}^{sr}), all variables in the optimization model specified in this paper are fully initialized.

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* (1998, 1999) only report overall markup rates for China trade with the US and a few other selected countries, Yao (2000) is able to produce markup rates at 6-digit HS commodity and individual country levels. Yao (2000) 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 2002-04 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 just 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 formulae:

$$\begin{aligned}
 RXMR &= \frac{\sum_i (PX_i QX_i - PM_i QX_i)}{\sum_j PX_j QX_j} = \sum_i \left(1 - \frac{PM_i}{PX_i} \right) \left(\frac{PX_i QX_i}{\sum_j PX_j QX_j} \right) \\
 &= \sum_i RXMR_i \left(\frac{PX_i QX_i}{\sum_j PX_j QX_j} \right) = \sum_i RXMR_i \frac{RX_i}{\sum_j RX_j}
 \end{aligned} \tag{21}$$

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:

$$Var(RXMR_i) = \frac{\sum_k RX_k (RXMR_k - \overline{RXMR_i})^2}{\sum_j RX_j}, \text{ and } STD(RXMR_i) = \sqrt{Var(RXMR_i)} \quad (22)$$

where indexes j and k represent the group of 6 digit HS codes that in GTAP sector i , and were used to estimate the GTAP sector level mean markup rates, and again, the re-export values are chosen as weights to calculate the weighted variance.

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 2002, 2003 and 2004. So the markup rates should be interpreted as the trade weighted average over the three years. Both China and Hong Kong data are in 8-digit HS codes, but only comparable at 6-digit level. 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 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.⁸ 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

⁸ 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.

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 recorded costs associated with shipping goods. These costs are generally 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 procedure to estimate *cif/fob* margins for trade between China & Hong Kong and their trading partners is similar to that used for constructing the GTAP database which incorporates transport margins for all bilateral trade flows for each GTAP merchandise sector. This approach recognizes that attempts to impute transportation costs from the same trade data that suffers from reporting inaccuracies rarely yields credible estimates of shipping margins. Accordingly, we draw our transportation margin estimates directly from shipping cost information that is recorded and compiled consistently with the traded goods. The data we use is primarily from the U.S. Census Bureau on foreign trade statistics. 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. The difference between the customs value and the *cif* value is expressed as a *cif/fob* ratio in the discussion that follows. Having the comprehensive commodity and partner coverage, this extensive dataset permits us to calculate GTAP 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. In the GTAP database (version 7) global merchandise imports valued at *cif* prices is 4 percent greater than merchandise exports valued at *fob* prices. This would imply that transport services add 4 percent to traded goods. This estimate reflects a trade-weighted average of all bilateral margins where some goods require a higher transport margin and others a lower margin depending on the characteristics of the product and the trading partner. 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 aggregate GTAP sector there are 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 margins (*cif/fob*) for 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).

Table 1. Bilateral transport margins on selected U.S. import flows for machinery and equipment sector

	<i>High unit value (HV)</i>	<i>Low unit value (LV)</i>	<i>Traded content</i>	<i>Aggregate</i>
HS category	8409-8411	8413-8415	Ratio	Machinery&Equip
	<i>cif/fob</i>	<i>cif/fob</i>	LV / HV	<i>cif/fob</i>
Canada	1.010	1.013	0.42	1.012
Mexico	1.007	1.005	1.36	1.011
Costa Rica	1.014	1.128	0.12	1.025
Brazil	1.077	1.064	1.00	1.045
United Kingdom	1.005	1.034	0.20	1.031
Germany	1.018	1.029	0.74	1.034
India	1.070	1.087	0.92	1.052
China	1.036	1.088	8.91	1.066
Hong Kong	1.017	1.088	2.93	1.052
South Korea	1.026	1.062	2.01	1.055
Taiwan	1.034	1.064	2.94	1.046
Japan	1.028	1.030	0.68	1.033
Australia	1.020	1.050	0.71	1.034
South Africa	1.060	1.116	0.29	1.040
World	1.016	1.041	0.79	

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 (LV) to high value (HV) 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.

Table 2. Bilateral transport margins on selected U.S. import flows for other manufacturers

	<i>High unit value (HV)</i>	<i>Lower unit value (LV)</i>	<i>Traded content</i>	<i>Aggregate</i>
HS category	7101-7118	9501-9508	Ratio	Other manufacturers
	<i>cif/fob</i>	<i>cif/fob</i>	LV / HV	<i>cif/fob</i>
Canada	1.006	1.056	1.27	1.034
Mexico	1.003	1.063	1.67	1.051
Costa Rica	1.002	1.000	0.67	1.043
Brazil	1.014	1.176	0.17	1.038
United Kingdom	1.004	1.044	0.50	1.014
Germany	1.008	1.045	1.43	1.034
India	1.004	1.093	0.01	1.005
China	1.039	1.088	9.63	1.086
Hong Kong	1.008	1.101	0.33	1.036
South Korea	1.027	1.037	1.37	1.049
Taiwan	1.052	1.073	17.37	1.093
Japan	1.005	1.020	5.58	1.039
Australia	1.002	1.029	0.63	1.022
South Africa	1.000	1.078	0.01	1.005
World	1.006	1.079	0.89	

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

Note: HS categories of high unit value goods consist of precious stones, metals, and jewelry categories in low unit value goods are primarily toys, sporting goods, and accessories.

Bilateral *cif/fob* margins for the other manufactures (Table 2) differ substantially more than other aggregate GTAP sectors because of the wide range goods in this sector. This sector is comprised of goods with high unit value such as precious stones, metals, and jewelry and products with low unit value such as toys and sporting goods. As a result of mixing

manufactures with precious minerals, the general pattern of higher transport margins for developing country goods does not hold. For example, India and South Africa have the lowest transport margins. The aggregate margins are driven primarily by the high proportion of precious stones such as diamonds and gold items in both countries exports of other manufacturers. Both countries have a very low LV/HV ratio as shown in Table 2. China on the other hand exports a high proportion of low value goods (toys and sporting goods) and once again this is the reason for China's high transport margin (1.086) for the other manufactures sector as a whole.

The lowest and most uniform transportation sectors margins are those of the electronic equipment sector (Table 3). This, despite the fact that computer components such as chip sets and circuit boards 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 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.

Table 3. Transport margins on selected U.S. import flows for electronic equipment sector

<i>HS</i>	<i>8471</i>	<i>8518</i>	<i>8517</i>	<i>Aggregate</i>
	Computer/parts	Microphones/parts	Telephone/parts	Electronic equip.
Canada	1.006	1.004	1.005	1.004
Mexico	1.002	1.003	1.002	1.003
Costa Rica	0.996	1.020	1.017	1.012
Brazil	1.026	1.077	1.022	1.019
United Kingdom	1.017	1.022	1.016	1.022
Germany	1.020	1.026	1.011	1.020
India	1.039	1.093	1.057	1.026
China	1.024	1.067	1.022	1.023
Hong Kong	1.029	1.078	1.018	1.022
South Korea	1.025	1.043	1.028	1.016
Taiwan	1.022	1.053	1.028	1.019
Japan	1.018	1.034	1.018	1.022
Australia	1.018	1.018	1.015	1.020
South Africa	1.023	1.029	1.015	1.031
World	1.019	1.047	1.013	

A full set estimate for transport margins between China (Hong Kong) and their trading partners is 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. Table 4 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, we can assume transport margins for the same goods would be similar as goods carried on similar vessels from China to Brazil as China's exports to the United States.

Table 4. Bilateral aggregate transport margins for China's exports to its major trading partners

	<i>Footwear</i>	<i>Chemicals, Rubber, plastics</i>	<i>Electronic equipment</i>	<i>Machinery & equip.</i>
Canada	1.076	1.085	1.024	1.065
Mexico	1.109	1.084	1.025	1.048
United States	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
United Kingdom	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
Hong Kong	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
Korea	1.072	1.092	1.024	1.039
Australia	1.079	1.091	1.024	1.064
South Africa	1.075	1.084	1.029	1.059

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

3.4 Determine appropriate country and commodity aggregation level based on the issue at hand and data availability

Because one of the objectives of this study is to produce Hong Kong re-export-adjusted trade flows as a contribution to the version 7 GTAP database, trade data reported by China, Hong Kong and their partners were aggregated from 8 and 6 digit HS to the 42 GTAP merchandise trade commodities respectively.

There are 215 countries identified in the GTAP global bilateral trade data base, while only 159 countries reported their exports to or import from China and Hong Kong during 2004.⁹ To determine the country aggregation used in our optimization model, we first aggregate all the non-reporting countries into one block to be consistent with the model assumption that only one partner country does not report their trade with China and Hong Kong. Then we use the difference between China reported imports (exports) and the sum of all partner reported exports (imports) adjusted by the associated *cif/fob* margin to approximate the partner reported data for this aggregate non reporting country block. Then we use two cut-off criteria to separate the 159 reporting country into two blocks. The first block has 95 countries outside of China and Hong Kong, including all single countries in the version 6 GTAP database, and countries not in version 6 GTAP but with total exports from China and Hong Kong greater than \$300 million in 2004 as identified either by China and Hong Kong reported data or their partner reported data. The selected model country list and initial value of corresponding model variables for eastbound and westbound trade are listed Table 5 and Table 6 respectively. The second block is consisted of 64 remaining reporting countries. Their names are listed in Appendix Table A.

⁹ There are about 120 countries reported their trade with China and Hong Kong in 2004 in current WITS with missing data for China's several important trading partners such as Viet Nam. Therefore, additional data for 2002 to 2005 pulled directly from UN COMTRADE database were also used and growth rates between 2002 and 2003 were calculated at the 6-digit HS level to project missing data in 2004 before being aggregated into GTAP sectoral classifications.

Table 5. Initial Estimates of Bilateral Trade Between China, Hong Kong and their Partner Countries, Eastbound Flows, 2004, in Millions of U.S. Dollars

Country Name	China exports to partners	China direct exports to Partners	Hong Kong total exports to partner	Hong Kong domestic export to partner	China re-exports to partner via Hong kong	Hong Kong re-export markup	Partners total re-imports from Hong Kong	Partners actual imports from China	Partner imports of Hong Kong domestic products	Partner direct import from China	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong re-export markup rate	Partners balance of trade with China after adjustment	China reported balance of trade with partners	Partner reported balance of trade with China	Partners balance of trade with Hong Kong after adjustment	Hong Kong reported balance of trade with partners	Partner reported balance of trade with Hong Kong	cif/fob ratio, China to partner	cif/fob ratio, Hong Kong to partner
Variable in the model	TX0(CH,r)	DX0(CH,r)	TX0(HK,r)	DX0(HK,r)	RX0(s,CH)	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(CH,r)-TX0(r,CH)	TX0(r,CH)-TX0(HK,r)	TX0(HK,r)-TX0(r,HK)	TX0(r,HK)-TX0(HK,r)	cif(CH,r)	cif(HK,r)	
United States	148,395	125,118	43,924	17,680	35,587	11,743	37,044	208,153	9,141	182,798	15.7	18.0	33.0	109,345	80,396	-174,095	8,745	29,467	-21,535	1.056	1.064
Canada	10,060	8,161	3,132	1,100	2,761	819	2,689	18,526	552	16,484	18.9	35.8	29.7	4,514	816	-13,460	568	1,927	-1,622	1.072	1.052
Mexico	5,658	4,973	938	219	808	110	1,158	14,003	406	13,273	12.1	56.4	13.6	4,923	2,831	-13,529	15	542	-625	1.060	1.048
Australia	10,499	8,838	3,190	1,098	2,493	798	3,126	13,064	933	11,283	15.8	10.6	32.0	3,676	-2,702	-6,755	-177	1,334	-1,109	1.068	1.049
New Zealand	1,315	1,077	413	138	355	113	393	2,180	104	1,925	18.1	30.1	31.8	113	-336	-1,080	-121	84	-20	1.074	1.053
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	21,608	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	4.8	-2.2	50.3	-26,694	-34,350	20,173	-8,694	-7,244	11,408	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	23,458	1.053	1.029
Singapore	14,969	12,684	5,588	1,908	3,456	1,140	7,411	16,139	3,627	13,752	15.3	9.8	33.0	-2,309	-1,281	-1,016	-12,577	-8,655	9,788	1.040	1.027
Macao	1,778	1,604	1,242	344	256	78	1,325	1,531	368	1,341	9.8	-14.5	30.5	1,376	1,387	-1,140	199	944	-1,015	1.074	1.067
Indonesia	6,912	6,256	1,104	281	851	184	1,134	3,770	266	3,065	9.5	-80.5	21.6	1,780	-942	668	-302	-665	260	1.070	1.059
Malaysia	9,036	8,087	2,288	1,028	1,625	662	4,072	10,100	2,766	9,103	10.5	16.6	40.8	-2,630	-10,072	-1,704	-2,357	-4,377	3,399	1.055	1.033
Philippines	5,296	4,268	2,514	1,055	1,679	633	3,347	2,841	1,823	1,748	19.4	-35.1	37.7	1,077	-4,807	-188	2	-1,821	-128	1.061	1.042
Thailand	6,808	5,786	2,639	1,085	1,838	801	2,943	8,184	1,327	7,102	15.0	10.9	43.6	-2,216	-5,757	-1,158	-1,134	-2,210	1,771	1.060	1.040
Vietnam	4,833	4,259	1,218	328	746	160	2,160	2,922	1,217	2,300	11.9	-30.6	21.5	3,418	1,777	-1,602	-15	770	-1,664	1.084	1.058
Cambodia	768	452	451	110	393	71	781	414	410	64	41.1	-11.7	18.1	754	422	-402	-505	443	-164	1.085	1.086
Bangladesh	2,195	1,895	506	173	418	111	777	1,587	419	1,258	13.7	-24.3	26.5	2,127	1,825	-1,556	119	419	-683	1.073	1.074
India	6,610	5,925	2,096	389	813	118	3,418	6,687	1,683	5,973	10.4	9.9	14.6	797	-1,776	-1,403	-1,636	-1,686	231	1.060	1.019
Sri Lanka	905	694	428	179	355	140	890	475	620	242	23.3	-6.4	39.5	878	668	-458	132	363	-822	1.084	1.081
Pakistan	2,293	2,230	126	37	84	20	188	1,486	95	1,420	2.8	-58.1	23.8	1,610	1,635	-1,186	-155	-476	402	1.068	1.052
Austria	1,122	781	583	206	513	167	589	2,609	199	2,250	30.4	46.8	32.5	-142	-731	-1,454	-126	71	-120	1.051	1.039
Belgium	6,577	5,860	1,610	504	1,047	315	1,933	8,286	798	7,528	10.9	15.8	30.1	3,549	2,327	-5,548	-779	-187	-10	1.070	1.026
Germany	28,633	23,753	8,071	2,753	6,905	1,942	7,959	40,261	2,420	35,091	17.0	21.0	28.1	1,177	-6,624	-15,415	569	2,940	-2,706	1.052	1.045
Denmark	2,304	1,946	807	392	578	214	788	2,677	354	2,296	15.5	4.6	37.0	920	392	-1,890	158	39	50	1.073	1.044
Spain	6,669	5,477	1,880	561	1,637	421	1,740	10,609	358	9,335	17.9	27.7	25.7	5,155	3,715	-9,256	243	1,411	-1,230	1.075	1.049
Finland	2,971	2,495	907	392	818	336	679	2,444	146	1,947	16.0	-30.3	41.1	315	-602	-14	209	460	-175	1.040	1.033
France	12,080	9,922	3,409	1,062	2,981	782	3,199	20,367	743	18,066	17.9	32.5	26.2	5,227	2,252	-14,025	-689	1,016	-596	1.056	1.048
United Kingdom	19,438	14,952	8,450	3,503	6,849	2,271	8,550	26,206	3,371	21,406	23.1	15.6	33.2	14,500	10,141	-22,087	578	4,385	-3,635	1.068	1.049
Greece	1,557	1,381	262	72	228	47	283	1,765	84	1,575	11.3	4.7	20.8	1,479	1,293	-1,692	20	215	-221	1.080	1.050
Ireland	2,343	2,138	419	190	328	119	845	3,518	605	3,299	8.8	35.5	36.2	1,316	946	-2,748	-501	-596	186	1.038	1.043
Italy	11,042	9,224	3,001	993	2,654	798	2,783	14,696	695	12,764	16.5	15.4	30.1	4,297	2,731	-9,246	-1,151	-336	874	1.071	1.042
Luxembourg	945	918	73	13	35	8	120	76	58	47	2.9	-458.3	21.4	818	788	40	2	45	-95	1.036	1.028
Netherlands	20,893	18,519	4,253	1,652	3,555	1,149	4,687	17,826	1,981	15,322	11.4	-17.9	32.3	17,874	15,534	-15,077	916	2,702	-3,628	1.048	1.041
Portugal	685	588	150	46	135	36	146	570	37	466	14.2	-27.0	26.5	552	307	-453	-3	83	-70	1.075	1.052
Sweden	2,303	1,860	767	304	652	201	1,433	2,396	944	1,920	19.2	15.4	30.9	-426	-1,481	105	-14	260	-852	1.070	1.057
Switzerland	1,851	1,506	1,199	663	812	459	1,214	2,274	661	1,909	18.7	8.7	56.6	-1,079	-1,663	200	-1,477	-2,298	2,063	1.060	1.031
Norway	1,214	1,029	338	145	319	130	433	2,406	229	2,206	15.3	44.1	40.8	393	-371	-1,630	-111	158	-125	1.072	1.059
Cyprus	207	185	31	7	27	5	62	233	36	209	10.5	14.0	17.7	203	183	-230	1	24	-55	1.077	1.053
Czech Republic	1,512	1,351	274	103	252	88	340	3,512	162	3,341	10.7	53.9	34.9	1,193	909	-3,241	-4	128	-158	1.046	1.041
Estonia	246	202	73	26	64	20	83	379	34	333	17.8	29.0	31.2	209	181	-344	20	67	-75	1.051	1.041
Hungary	3,156	2,652	775	253	747	237	1,199	2,871	660	2,345	16.0	0.0	31.7	2,698	2,174	-2,484	246	625	-1,055	1.036	1.031
Lithuania	290	274	26	7	22	5	27	294	8	277	5.5	-4.6	24.6	278	260	-283	3	23	-24	1.065	1.050
Latvia	196	179	28	9	26	8	28	92	9	73	8.8	-109.8	31.5	185	159	-80	7	28	-26	1.081	1.052
Malta	288	273	21	5	20	5	32	77	15	61	5.2	-208.9	23.0	225	21	-58	-25	-61	48	1.045	1.061
Poland	2,033	1,844	290	88	264	72	264	4,065	53	3,863	9.3	45.4	27.2	1,463	1,353	-3,509	62	250	-222	1.068	1.045
Slovak Republic	195	160	44	8	43	7	81	797	43	760	18.1	75.2	16.8	115	31	-719	-9	32	-61	1.059	1.046
Slovenia	235	207	39	10	36	8	40	186	9	157	11.8	-31.0	22.0	195	165	-152	-2	25	-23	1.070	1.055
Albania	64	63	1	0	1	0	1	101	1	100	0.9	34.8	38.1	63	57	-100	0	1	-1	1.065	1.042
Bulgaria	370	338	45	8	38	6	60	464	22	431	8.6	16.9	14.9	330	270	-427	5	37	-53	1.066	1.036
Croatia	365	345	35	12	30	9	53	636	28	614	5.6	40.3	30.1	357	323	-628	9	33	-50	1.069	1.052
Romania	1,087	1,057	43	10	37	7	57	1,060	23	1,028	2.8	-9.1	18.1	884	730	-865	-9	19	-20	1.074	1.038
Yugoslavia	172	163	13	3	12	3	14	541	4	532	5.0	68.8	26.5	170	150	-540	3	10	-11	1.075	1.048

Country Name	China actual exports to partners	China direct exports to partners	Hong Kong exports to partner	Hong Kong domestic export to partner	China re-exports to partner via Hong Kong	Hong Kong re-export markup	Partners total re-imports from Hong Kong	Partners actual imports from China	Partner imports of Hong Kong domestic products	Partner direct import from China	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong re-export markup rate	balance of trade with China after adjustment	China reported balance of trade with partners	Partner reported balance of trade with China	Partners balance of trade with Hong Kong after adjustment	Hong Kong reported balance of trade with partners	Partner reported balance of trade with Hong Kong	cif/fob ratio, China to partner	cif/fob ratio, Hong Kong to partner
Ukraine	1,488	1,444	62	13	57	12	56	731	6	685	3.0	-119.1	20.8	812	403	-69	-89	42	61	1.073	1.049
Russian Federation	9,371	9,103	427	113	361	88	337	4,734	10	4,450	2.9	-117.5	24.3	828	-3,009	3,635	14	-125	8	1.078	1.041
Kazakhstan	2,217	2,212	10	5	10	5	7	758	2	753	0.2	-232.3	51.3	449	-74	1,006	5	7	-4	1.078	1.082
Kyrgyz Republic	492	492	1	0	1	0	0	80	0	80	0.1	-608.5	16.3	451	381	-41	0	-1	1	1.075	1.077
Argentina	982	852	174	32	151	19	176	1,401	28	1,263	13.2	23.8	12.9	-1,774	-2,407	1,229	-2	-50	-11	1.057	1.045
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	-329	1.061	1.041
Chile	1,956	1,689	313	35	303	30	293	1,847	0	1,558	13.7	-13.8	9.8	-1,354	-1,989	1,363	-6	121	-155	1.067	1.057
Colombia	702	629	91	15	86	13	103	1,234	23	1,156	10.3	39.0	14.6	559	453	-1,096	6	71	-83	1.068	1.054
Ecuador	370	344	36	8	34	7	36	704	7	675	7.1	44.0	21.9	318	250	-654	3	24	-29	1.072	1.064
Peru	464	418	61	12	55	8	74	768	22	718	9.9	35.4	14.7	-786	-1,108	468	-3	24	-42	1.069	1.064
Paraguay	340	235	132	18	124	17	145	486	27	375	31.0	22.9	13.4	291	175	-442	12	112	-135	1.047	1.041
Venezuela	652	596	76	16	73	14	123	423	59	361	8.7	-46.1	19.9	423	-146	-199	15	61	-112	1.071	1.065
Uruguay	228	210	25	4	22	3	31	173	10	153	8.2	-32.7	15.3	106	99	-61	-4	-5	-12	1.056	1.051
Costa Rica	172	154	26	8	25	7	77	270	57	251	10.2	41.2	28.2	-74	-489	-107	-1	-246	60	1.079	1.069
Guatemala	479	393	116	27	110	22	158	204	62	109	18.0	-83.2	20.1	459	349	-185	26	113	-157	1.079	1.078
Panama	2,656	2,187	582	88	548	70	540	520	21	18	17.7	-238.2	12.8	2,644	2,171	-509	82	567	-532	1.068	1.051
Cuba	335	330	6	1	5	1	13	590	7	585	1.4	41.9	9.7	254	135	-510	-2	-6	-3	1.076	1.037
Algeria	976	971	8	3	7	2	32	916	26	911	0.5	-12.9	28.6	727	711	-667	3	8	-32	1.078	1.047
Egypt Arab Rep	1,435	1,345	131	32	112	21	136	686	30	588	6.2	-111.7	18.7	1,309	1,151	-569	21	67	-115	1.071	1.068
Iran Islamic Rep	2,507	2,476	50	9	36	5	82	1,614	40	1,581	1.2	-64.2	13.5	2,270	-2,021	-1,404	-65	-79	26	1.065	1.044
Israel	1,878	1,540	873	235	495	147	1,828	1,476	1,178	1,117	18.0	12.7	29.7	918	558	-695	-1,145	-252	82	1.071	1.021
Jordan	766	623	201	51	185	39	209	681	47	523	18.7	-19.1	21.1	727	534	-642	50	196	-207	1.081	1.078
Lebanon	509	484	46	14	38	12	43	718	9	690	5.0	23.0	32.4	493	471	-705	6	38	-31	1.077	1.059
Morocco	955	935	30	10	26	6	52	745	30	724	2.0	-34.6	23.8	837	720	-695	8	-84	36	1.071	1.064
Nigeria	1,791	1,719	120	33	99	27	205	752	113	675	4.0	-121.4	26.8	1,708	1,253	-676	33	100	-197	1.066	1.061
Saudi Arabia	2,993	2,776	295	56	266	45	289	2,969	39	2,738	7.3	-10.6	16.8	-4,624	-4,749	4,477	-144	-76	82	1.089	1.046
Syrian Arab Republic	720	690	42	8	37	7	35	455	0	424	4.1	-71.4	17.7	698	662	-434	8	41	-34	1.071	1.031
Tunisia	255	245	15	4	13	3	33	291	22	281	3.7	11.8	25.2	225	211	-266	3	7	-26	1.071	1.046
Turkey	3,154	2,804	513	94	422	66	564	4,476	128	4,105	11.1	24.2	15.6	2,792	2,205	-4,152	-6	358	-420	1.062	1.042
Yemen	455	452	6	3	3	1	6	233	3	230	0.6	-118.4	18.4	-716	-1,007	936	-3	-10	4	1.083	1.061
Benin	580	577	6	1	4	0	6	60	1	56	0.5	-930.6	13.4	487	466	33	1	6	-6	1.080	1.051
Ghana	525	510	24	7	18	4	43	365	25	349	2.8	-48.3	19.6	505	430	-345	6	-86	40	1.077	1.071
Kenya	397	347	67	14	60	9	69	187	13	132	12.6	-101.6	14.9	364	313	-176	13	16	-45	1.073	1.072
Mozambique	78	75	5	1	4	1	20	40	17	37	4.2	-54.8	22.1	51	31	-19	1	-8	-14	1.094	1.058
Malawi	20	19	2	1	2	0	6	25	4	24	6.9	25.2	22.5	20	19	-25	0	2	-5	1.077	1.064
Madagascar	227	152	103	22	91	15	90	180	3	97	33.1	-34.5	16.0	214	134	-171	18	94	-82	1.079	1.083
Sudan	732	730	7	3	2	0	26	551	22	549	0.2	-40.5	15.8	-1,586	-980	1,761	1	-1	-19	1.076	1.045
Togo	424	399	29	4	29	4	41	57	14	30	5.9	-422.1	13.1	406	352	-40	4	26	-40	1.074	1.062
Tanzania	228	215	17	3	16	3	22	176	7	161	5.9	-36.9	15.7	142	134	-104	-1	-14	5	1.082	1.070
Uganda	74	71	4	1	4	1	17	102	13	99	4.2	32.5	20.8	53	44	-98	-7	-14	7	1.065	1.063
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	-497	1.069	1.048
Zambia	52	51	2	0	2	0	9	44	7	42	2.8	-10.4	20.1	22	-120	-15	-1	-10	3	1.055	1.054
Zimbabwe	80	78	3	1	2	1	11	58	8	56	2.4	-29.1	21.1	-33	-63	52	-2	-8	-2	1.057	1.070
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	-928	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	63.5	17.2	12,191	-5,312	-1,179	-7,287	535	-31,799	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	6.1	30.9	156,164	-24,256	-324,470	-50,243	-9,997	-4,829	1.186	1.711
Hong Kong, China	34,433	100,215	0	0	0	0	0	12,650	0	82,410	0.0	-27.7	0.0	21,121	21,980	-3,422	0	0	0	1.017	na
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	6.4	30.9	177,285	-2,276	-327,891	-71,364	-13,419	17,151	1.139	1.538

Table 6. Initial Estimates of Bilateral Trade Between China, Hong Kong and their Partner Countries, Westbound Flows, 2004, in Millions of U.S. Dollars

Country Name	Partner actual exports to China	Partner direct exports to China	Partner total exports to Hong Kong	Partner exports remain in Hong Kong	Partner re-exports to China via Hong Kong	Hong Kong re-export markup	Hong Kong total imports from partners	China actual imports from partners	Hong Kong retained imports from partner	China direct import from partner	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong re-export markup rate	Partners balance of trade with China after adjustment	Partners balance of trade with Hong Kong after adjustment	cif/fob ratio, partner to China	cif/fob ratio, Hong Kong
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	17.3	13.3	-4,514	-568	1.089	1.054
Mexico	734	474	533	203	309	39	396	2,142	52	1,869	36.4	49.8	12.7	-4,923	-15	1.046	1.059
Australia	6,823	6,309	2,017	1,276	581	31	1,856	11,540	1,061	10,979	7.9	30.4	5.3	-3,676	177	1.090	1.082
New Zealand	1,202	1,100	373	259	131	19	329	1,413	203	1,298	9.0	2.6	14.6	-113	121	1.069	1.089
Japan	88,122	70,608	32,981	12,064	20,625	2,459	32,925	94,258	11,235	75,851	20.4	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
Singapore	17,277	15,122	17,199	14,485	2,471	233	14,243	13,965	11,428	11,693	12.8	-27.8	9.4	2,309	12,577	1.039	1.033
Macao	402	391	310	145	12	1	299	216	122	205	2.7	-48.8	10.2	-1,376	-199	1.062	1.050
Indonesia	5,132	4,438	1,394	582	826	77	1,769	7,198	890	6,433	14.3	21.0	9.3	-1,780	302	1.113	1.083
Malaysia	11,667	8,395	7,471	3,385	4,169	797	6,666	18,159	2,463	14,754	28.6	20.0	19.1	2,630	2,357	1.050	1.033
Philippines	4,219	2,653	3,219	1,053	1,879	284	4,335	9,075	2,126	7,469	37.5	44.0	15.1	-1,077	-2	1.019	1.023
Thailand	9,024	7,025	4,715	2,218	2,447	299	4,849	11,543	2,186	9,353	23.4	9.5	12.2	2,216	1,134	1.086	1.066
Vietnam	1,414	1,320	496	343	111	11	448	2,482	284	2,380	6.9	28.5	10.1	-3,418	15	1.117	1.112
Cambodia	14	13	616	615	1	0	8	30	6	29	8.2	-1784.6	10.4	-754	505	1.094	1.010
Bangladesh	68	31	94	53	45	7	88	70	45	31	54.3	-11.7	15.4	-2,127	-119	1.094	1.046
India	5,813	5,285	3,649	2,025	621	66	3,782	7,701	2,116	7,128	9.2	12.0	10.7	-797	1,636	1.113	1.015
Sri Lanka	27	17	68	46	12	1	65	27	41	16	38.0	-12.5	9.9	-878	-132	1.133	1.053
Pakistan	684	300	590	192	428	15	602	595	173	171	59.1	-17.0	3.4	-1,610	155	1.081	1.077
Austria	1,264	1,155	469	332	134	20	511	1,511	367	1,395	8.9	10.7	15.1	142	126	1.037	1.068
Belgium	3,028	2,739	1,922	1,283	387	84	1,796	3,533	1,122	3,223	9.8	2.2	21.8	-3,549	779	1.053	1.051
Germany	27,456	24,847	5,253	2,184	2,923	228	5,131	30,378	1,962	27,643	9.7	4.9	7.8	-1,177	-569	1.033	1.034
Denmark	1,383	787	837	233	677	59	767	1,554	127	925	43.9	0.2	8.8	-920	-158	1.040	1.041
Spain	1,513	1,353	510	318	180	12	469	1,762	267	1,590	10.9	5.1	6.7	-5,155	-243	1.044	1.052
Finland	2,655	2,430	504	183	253	19	448	3,097	113	2,858	8.6	7.9	7.5	-315	-209	1.034	1.042
France	6,852	6,342	2,603	1,752	592	61	2,393	7,670	1,504	7,128	7.6	2.7	10.2	-5,227	689	1.033	1.040
United Kingdom	4,938	4,119	4,916	2,925	970	118	4,065	4,812	1,994	3,943	17.0	-15.6	12.1	-14,500	-578	1.036	1.033
Greece	78	73	61	52	11	5	47	87	37	81	7.1	-10.0	48.9	-1,479	-20	1.057	1.043
Ireland	1,027	770	1,031	691	484	222	1,015	1,192	662	928	25.3	4.6	45.8	-1,316	501	1.025	1.021
Italy	6,745	5,450	3,657	2,144	1,537	173	3,337	6,493	1,745	5,098	19.8	-11.4	11.3	-4,297	1,151	1.042	1.051
Luxembourg	127	115	25	11	13	1	28	129	13	117	9.3	-1.2	9.1	-818	-2	1.044	1.033
Netherlands	3,019	2,749	1,059	736	301	21	1,550	2,985	1,214	2,699	9.1	6.8	7.0	-17,874	-916	1.038	1.038
Portugal	133	117	75	49	21	4	66	281	39	263	12.9	38.2	17.2	-552	3	1.055	1.042
Sweden	2,728	2,501	581	318	286	52	507	3,341	236	3,103	8.5	11.4	18.1	426	14	1.033	1.033
Switzerland	2,931	2,473	3,277	2,140	516	42	3,497	3,169	2,318	2,686	15.9	3.7	8.1	1,079	1,477	1.035	1.034
Norway	821	775	308	256	70	23	180	1,400	126	1,352	5.7	26.9	32.3	-393	111	1.042	1.028
Cyprus	4	3	7	6	1	0	7	2	5	1	28.0	-37.1	24.9	-203	-1	1.062	1.127
Czech Republic	320	270	182	107	56	5	146	442	68	391	15.7	11.5	9.1	-1,193	4	1.037	1.050
Estonia	37	36	7	6	2	0	5	21	4	19	3.5	-86.0	15.0	-209	-20	1.065	1.066
Hungary	459	387	144	6	94	20	150	477	9	404	15.8	1.7	21.8	-2,698	-246	1.023	1.019
Lithuania	12	12	4	3	0	0	3	14	2	13	1.6	-4.8	31.6	-278	-3	1.089	1.086
Latvia	11	11	2	2	0	0	0	20	0	20	0.9	31.5	12.2	-185	-7	1.057	1.031
Malta	63	19	80	30	53	9	82	252	31	208	69.6	57.0	16.6	-225	25	1.010	1.013
Poland	570	556	41	27	17	2	40	490	24	476	2.5	-20.0	14.6	-1,463	-62	1.034	1.044
Slovak Republic	81	78	20	17	3	1	12	129	9	126	3.6	25.8	14.6	-115	9	1.053	1.048
Slovenia	39	34	17	12	6	1	13	42	8	37	12.9	-7.7	17.1	-195	2	1.054	1.050
Albania	1	1	0	0	0	0	0	6	0	6	5.1	96.8	7.9	-63	0	1.089	1.021
Bulgaria	40	37	7	3	4	1	8	68	3	65	7.7	35.5	14.5	-330	-5	1.072	1.040
Croatia	7	7	3	2	0	0	2	22	2	22	3.8	58.8	32.4	-357	-9	1.087	1.048
Romania	203	195	37	19	21	12	24	327	5	318	3.9	28.1	60.3	-884	9	1.086	1.056
Yugoslavia	2	1	3	1	1	0	3	13	0	12	56.6	71.7	10.5	-170	-3	1.051	1.051

Country Name	Partner actual exports to China	Partner direct exports to China	Partner total exports to Hong Kong	Partner exports remain in Hong Kong	Partner re-exports to China via Hong Kong	Hong Kong re-export markup	Hong Kong total imports from partners	China actual imports from partners	Hong Kong retained imports from partner	China direct import from partner	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong re-export markup rate	Partners balance of trade with China after adjustment	Partners balance of trade with Hong Kong after adjustment	cif/fob ratio, partner to Hong Kong	cif/fob ratio, partner to Hong Kong
Ukraine	676	663	117	102	16	1	20	1,041	4	1,026	2.1	20.8	8.9	-812	89	1.085	1.058
Russian Federation	8,543	8,369	345	99	195	8	552	12,111	286	11,917	2.1	26.2	4.0	-828	-14	1.077	1.068
Kazakhstan	1,767	1,764	3	0	4	0	4	2,286	0	2,282	0.2	19.2	2.5	-449	-5	1.058	1.067
Kyrgyz Republic	41	39	1	0	1	0	1	111	0	110	2.9	64.1	16.6	-451	0	1.051	1.020
Argentina	2,755	2,630	165	34	149	20	224	3,259	88	3,126	4.6	3.3	13.2	1,774	2	1.148	1.046
Brazil	5,758	5,437	773	392	352	13	894	8,704	489	8,357	5.7	24.9	3.8	1,420	263	1.150	1.058
Chile	3,309	3,210	138	41	108	3	191	3,677	84	3,570	3.1	7.1	2.9	1,354	6	1.043	1.087
Colombia	143	138	20	9	7	1	20	177	9	171	3.9	14.6	14.5	-559	-6	1.035	1.055
Ecuador	51	50	7	5	2	0	12	93	9	91	3.6	43.0	10.1	-318	-3	1.065	1.083
Peru	1,250	1,236	31	15	18	1	37	1,527	19	1,510	1.3	12.2	6.7	786	3	1.079	1.134
Paraguay	49	44	10	5	6	0	19	60	14	54	10.8	18.8	1.5	-291	-12	1.084	1.133
Venezuela	230	224	10	1	6	0	15	742	5	736	2.3	72.4	8.3	-423	-15	1.075	1.076
Uruguay	122	112	19	8	11	0	30	110	18	99	8.7	-6.5	3.9	-106	4	1.047	1.058
Costa Rica	246	163	137	9	118	33	273	644	142	558	34.3	58.1	28.0	74	1	1.010	1.024
Guatemala	20	19	1	0	1	0	3	43	2	43	2.8	54.1	3.6	-459	-26	1.105	1.051
Panama	12	11	8	7	1	0	16	15	14	14	8.4	33.7	9.2	-2,644	-82	1.072	1.065
Cuba	81	80	10	3	1	0	12	195	4	194	0.9	55.8	31.7	-254	2	1.070	1.029
Algeria	249	249	0	0	0	0	0	259	0	259	0.0	-0.7	9.8	-727	-3	1.050	1.066
Egypt Arab Rep	126	117	20	11	10	1	64	194	55	185	7.1	39.9	10.4	-1,309	-21	1.157	1.052
Iran Islamic Rep	238	210	108	74	31	2	128	4,497	92	4,467	11.9	97.4	6.2	-2,270	65	1.116	1.049
Israel	960	780	1,911	1,380	216	34	1,125	982	591	794	18.4	-39.2	15.7	-918	1,145	1.031	1.005
Jordan	40	39	2	1	1	0	6	89	5	88	1.9	60.0	13.7	-727	-50	1.054	1.059
Lebanon	16	12	12	8	4	0	8	13	4	9	22.9	-40.8	6.7	-493	-6	1.072	1.034
Morocco	118	50	88	1	82	13	115	215	26	146	58.3	36.1	16.1	-837	-8	1.054	1.017
Nigeria	83	76	7	0	8	1	20	466	12	459	8.0	84.5	8.8	-1,708	-33	1.050	1.047
Saudi Arabia	7,617	7,447	371	200	195	9	371	7,525	184	7,334	2.4	-8.9	4.8	4,624	144	1.068	1.086
Syrian Arab Republic	22	21	1	0	1	0	1	28	0	28	2.5	17.0	2.2	-698	-8	1.099	1.068
Tunisia	30	26	7	1	6	1	8	34	1	29	16.7	-2.1	11.4	-225	-3	1.160	1.093
Turkey	363	323	144	100	47	5	155	599	107	555	11.4	28.1	10.6	-2,792	6	1.110	1.085
Yemen	1,171	1,169	9	6	2	0	16	1,459	12	1,457	0.2	16.6	6.4	716	3	1.051	1.086
Benin	93	93	0	0	0	0	0	111	0	111	0.0	10.1	9.7	-487	-1	1.086	1.058
Ghana	20	20	83	1	0	0	110	80	0	80	1.7	40.4	6.4	-505	-6	1.111	1.271
Kenya	33	11	25	2	24	1	51	34	26	10	68.1	30.1	4.0	-364	-13	1.073	1.074
Mozambique	27	21	6	0	7	1	13	45	6	38	21.9	37.6	12.5	-51	-1	1.157	1.113
Malawi	0	0	0	0	0	0	0	0	0	0	42.8	-83.9	9.9	-20	0	1.103	1.064
Madagascar	13	9	8	4	4	0	9	18	4	14	30.3	12.8	8.5	-214	-18	1.114	1.080
Sudan	2,317	2,312	7	2	5	0	8	1,710	3	1,705	0.2	-43.4	5.9	1,586	-1	1.045	1.078
Togo	18	17	1	0	1	0	4	47	3	46	3.9	64.3	1.0	-406	-4	1.104	1.057
Tanzania	86	71	27	4	16	1	31	80	5	65	17.4	-6.4	4.6	-142	1	1.037	1.077
Uganda	20	5	24	8	17	1	18	26	0	10	78.2	-8.2	6.6	-53	7	1.071	1.076
South Africa	1,221	1,054	564	282	184	10	696	2,541	397	2,363	13.8	43.8	5.6	-2,202	150	1.076	1.053
Zambia	31	29	11	1	1	0	12	171	1	170	4.5	78.3	0.4	-22	1	1.021	1.017
Zimbabwe	113	110	9	3	3	0	10	141	4	138	2.2	15.0	0.6	33	2	1.071	1.048
Other reporting countries	2,039	1,944	265	105	111	10	274	7,827	102	7,724	4.8	73.6	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	97.3	58.3	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

Although the initial estimates listed in Tables 5 and 6 still suffer from some unsolved data problems,¹⁰ they do show several interesting features of the data. First, reported westbound trade seems 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, 14 of the 98 reported bilateral routes in the model have more than 100 percent statistical discrepancies in the eastbound trade, while only one route in the westbound trade shows such large discrepancies. On the other hand, there are only eight bilateral routes in eastbound trade with less than five percent discrepancies, while more than 17 routes in the westbound trade have small discrepancies. Second, trade flows with developing country partners show greater discrepancies than developed countries in general, reflecting the poor quality of data reported from those nations. Finally, extremely large discrepancies usually are associated with partners that have small trade values with China and Hong Kong, such as Benin, Nigeria, Togo and Kyrgyz Republic in eastbound trade and Cambodia in westbound trade. The combined exports reported by China and Hong Kong are small in the 14 bilateral routes with more than 100 percent discrepancies in eastbound trade, and in all those countries their reported imports are less significantly than what China and Hong Kong reported exports to them.

There are three types of trade balances reported in Table 5. They include: 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), 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 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.

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

¹⁰ For example, the no reporting partners block has a very large discrepancy in west bound trade, because the difference between China and Hong reported total exports with the sum of all their reported exports to reporting partner is too small, therefore will underestimate what these non- reporting countries actually import from them. This implies that China and Hong Kong reported total exports to and imports from the world also subject to reporting errors which should be reconciled at global level with all importing and exporting countries.

¹¹ Note that only the adjusted trade balances are listed in Table 6 and they are calculated in an opposite direction, i.e. they should have a same absolute value with what reported in Table 5, but with an opposite sign.

objective function (wdx_{it}^{sr} , wtx_{it}^{sr} , wdm_{it}^{sr} , wtm_{it}^{sr} , $wrxm_{it}^{sr}$ in equation 18) 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.

3.5 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),¹² 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 reporting discrepancies of bilateral trade data to derive those variances associated with international trade statistics.

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 analysis of discrepancies between two "reported" trade flows for the same trade route may provide a means of determining data reliability and historical mirror trade statistics could be used as a major data source to estimate the variance of reported bilateral trade statistics.

Auto regression with dummy variables

Assuming the discrepancies in any pair of mirror trade statistics are a function of a systematic bias, last period's discrepancies and N dummy variables plus an error term as follows:

$$e_{it} = a_i e_{it-1} + b_i^0 + \sum_{k=1}^n b_i^k D^k + \mu_{it} \quad (25)$$

where e_{it} is the mirror trade statistical discrepancies at year t, b_i^0 is the symmetric bias, and μ_{it} is the random error term, D^k 's are dummy variables represent events have a significant impact on the reporting practice in the two data reporting countries such as change of commodity classifications, implementing better custom information systems or enforcing effective anti-smuggling programs. The autocorrelation coefficient a_i and the variance

$\text{Var}(\mu_{it})$ can be taken as indicators of magnitude of the measurement errors. The variance of initial trade statistics thus may be derived as follows: since e_{it-1} and μ_{it} are independent,

¹² Stone proposed to estimate the variance of x_{ij}^0 as $\text{var}(x_{ij}^0) = (\theta_{ij} x_{ij}^0)^2$, where θ_{ij} is a subjective determined reliability rating, expressing the percentage ratio of the standard error to the initial estimates of x_{ij}^0 .

$$V(e_{it}) = V(a_i e_{it-1} + b_i^0 + \sum_{k=1}^n b_i^k D^k + \mu_{it}) = V(a_i e_{it-1}) + V(\mu_{it}) = a_i^2 V(e_{it-1}) + V(\mu) \quad (26)$$

At stationary assumption in long run, $V(e_{it}) = V(e_{it-1})$

$$V(e_{it}) - a_i^2 V(e_{it}) = V(\mu) \quad (27)$$

Therefore

$$V(e_{it}) = \frac{V(\mu)}{(1 - a_i^2)} \quad (28)$$

As long as we have enough historical mirror trade statistics and sufficient knowledge on the change in related country's trade reporting system to estimate $V(e_{it})$ for each pair of mirrored trade variables in our optimization model, then they can be assigned as weights in equation (18), the objective function. Although theoretically elegant and doable, the historical data and knowledge of the changes in related country's trade reporting system are too demanding and make such a method less attractable in large empirical applications like ours. Therefore, we adopted the following two types of reliability indexes as a practical alternative.

Route Reliability Indexes

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 east bound and westbound trade 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:

$$PDX_{it}^{cs} = PDM_{it}^{cs} = 2 \times \frac{|cif_{it}^{cs} DM 0_{it}^{cs} - DX 0_{it}^{cs}|}{DX 0_{it}^{cs} + cif_{it}^{cs} DM 0_{it}^{cs}} \quad (29)$$

$$PTX_{it}^{cs} = PTM_{it}^{cs} = 2 \times \frac{|cif_{it}^{cs} TM 0_{it}^{cs} - TX 0_{it}^{cs}|}{TX 0_{it}^{cs} + cif_{it}^{cs} TM 0_{it}^{cs}} \quad (30)$$

$$PDX_{it}^{sc} = PDM_{it}^{sc} = 2 \times \frac{|cif_{it}^{sc} DM 0_{it}^{sc} - DX 0_{it}^{sc}|}{DX 0_{it}^{sc} + cif_{it}^{sc} DM 0_{it}^{sc}} \quad (31)$$

$$PTX_{it}^{sc} = PTM_{it}^{sc} = 2 \times \frac{|cif_{it}^{sc} TM 0_{it}^{sc} - TX 0_{it}^{sc}|}{TX 0_{it}^{sc} + cif_{it}^{sc} TM 0_{it}^{sc}} \quad (32)$$

Where indexes “c” is indexed over set {CH, HK} and variable with a prefix “P” are reliability index for that variables.

All these reliability indexes defined above 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 18) of the model can be assigned by multiplying these indexes by their corresponding initial values, e.g., $wtx_{it}^{sr} = PTX_{it}^{sr} \times TX 0_{it}^{sr}$. 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.

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 are defined as:

$$RIM_{it}^r = \frac{MA_{it}^r}{\sum_s M_{it}^{sr}} \quad \text{where} \quad MA_{it}^r = \sum_{s \in AL_{it}^{sr} \leq 0.20} M_{it}^{sr} \quad AL_{it}^{sr} = \frac{|M_{it}^{sr} - X_{it}^{sr}|}{M_{it}^{sr}} \quad (33)$$

$$RIX_{it}^r = \frac{XA_{it}^r}{\sum_s X_{it}^{rs}} \quad \text{where} \quad XA_{it}^r = \sum_{s \in AL_{it}^{rs} \leq 0.20} X_{it}^{rs} \quad AL_{it}^{rs} = \frac{|M_{it}^{rs} - X_{it}^{rs}|}{M_{it}^{rs}} \quad (34)$$

where M_{it}^{sr} and X_{it}^{sr} are sector i imports and exports reported by country r and s in year t 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 of the 99 countries including China and Hong Kong in the model for each GTAP sectors, the weights in the objective function (equation 18) of the model can be assigned by multiplying one minus these indexes by their corresponding initial values for each variable in the model. The complete set of weights in equation 18 is defined as follows:

$$wtx_{it}^{sr} = (1 - RIX_{it}^s) PTX_{it}^{sr} \times TX 0_{it}^{sr} \quad (35)$$

$$wtm_{it}^{sr} = (1 - RIM_{it}^r) PTX_{it}^{sr} \times TM 0_{it}^{sr} \quad (36)$$

$$wdx_{it}^{sr} = (1 - RIX_{it}^s) PDX_{it}^{sr} \times DX 0_{it}^{sr} \quad (37)$$

$$wdm_{it}^{sr} = (1 - RIM_{it}^r) PDX_{it}^{sr} \times DM 0_{it}^{sr} \quad (38)$$

$$wrxm_{it}^{sr} = \lambda_{it}^{sr} \frac{STD(RXMR_{it}^{sr})}{RXMR_{it}^{sr}} RXM 0_{it}^{sr} \quad (39)$$

Where λ_{it}^{sr} are scale parameters to transfer $wrxm_{it}^{sr}$ into numerical value between zero and two, $STD(RXMR_{it}^{sr})$ is defined by equation (22).

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 current aggregation. It was solved using barrier method of the Cplex solver (GAMS Development Corporation, 2005) in a 32 bit dell computer with 3 GB memory. There are 13 input data files, all automatically produced by three SAS programs.

Adjusted estimates for the sum of all sectors aggregated into 24 regions are listed in Tables 7 and 8 for eastbound and westbound trade respectively. To facilitate comparison of trade flows before and after model adjustment, the corresponding initial data is presented in the same tables. Results for the 99-country details are listed in appendix tables B and C. More detailed initial and model adjusted trade flows by countries and GTAP sectors are available from the author upon request.

Table 7. Initial and Adjusted Estimates of Bilateral Trade Between China, Hong Kong and their Partner Countries, Eastbound Flows, 2004, in Millions of U.S. Dollars

Country Name	China actual exports to partners	China direct exports to Partners	Hong Kong total exports to partner	Hong Kong domestic export to partner	China re-exports to partner via Hong kong	Hong Kong re-export markup	Partners total imports from Hong Kong	Partners actual imports from China	Partner imports of Hong Kong domestic products	Partner direct import from China	Re-exports as percent of partner exports to China	Statistical discrepancies	Hong Kong re-export markup rate	Partners balance of trade with China after adjustment	China reported balance of trade with partners	Partner reported balance of trade with China	Partners balance of trade with Hong Kong after adjustment	Hong Kong reported balance of trade with partners	Partner reported balance of trade with Hong Kong	cif/fob ratio, China to partner	cif/fob ratio, Hong Kong to partner
	TX0(CH,r)	DX0(CH,r)	TX0(HK,r)	DX0(HK,r)	RX0(s,CH)	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)	H, r)/RX0(CH,r)	TX0(CH,r)-TX0(r,CH)	TX0(CH,r)-TX0(r,CH)	TX0(r,CH)-TX0(CH,r)	TX0(HK,r)-TX0(r,HK)	TX0(HK,r)-TX0(r,HK)	TX0(r,HK)-TX0(HK,r)	cif(CH,r)	cif(HK,r)
Variable in the model	TX0(CH,r)	DX0(CH,r)	TX0(HK,r)	DX0(HK,r)	RX0(s,CH)	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)	H, r)/RX0(CH,r)	TX0(CH,r)-TX0(r,CH)	TX0(CH,r)-TX0(r,CH)	TX0(r,CH)-TX0(CH,r)	TX0(HK,r)-TX0(r,HK)	TX0(HK,r)-TX0(r,HK)	TX0(r,HK)-TX0(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</																					

Table 8. Initial and Adjusted Estimates of Bilateral Trade Between China, Hong Kong and their Partner Countries, Westbound Flows, 2004, in Millions of U.S. Dollars

Country Name	Partner actual exports to China	Partner direct exports to China	Partner total exports to Hong Kong	Partner exports remain in Hong Kong	Partner re-exports to China via Hong Kong	Hong Kong re-export markup	Hong Kong total imports from partners	China actual imports from partners	Hong Kong retained imports from partner	China direct import from partner	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong export markup rate	Partners balance of trade with China after adjustment	Partners balance of trade with Hong Kong after adjustment	cif/fob ratio, partner to China	fob/cif ratio, partner to Hong Kong
Variable in the model	TX0(s,CH)	DX0(s,CH)	TX0(s,Hk)	DX0(s,Hk)	RX0(s,CH)	RXM0(s,C)	TM0(s,HK)	TM0(s,CH)	DM0(s,HK)	DM0(s,CH)	TX0(r,CH)	SDX(s)	(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	7,885	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	0.0	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

4.1 Adjusted trade flow and balance of trade between China and its major trading partners

Table 7 reports model 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. 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.¹³ 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.¹⁴ 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.¹⁵

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. 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

¹³ Changes of this nature were been 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.

¹⁴ 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.

¹⁵ 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.

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's 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 surplus¹⁶, 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 7).

4.2 Adjusted Hong Kong re-export markup rates

An important output of the modeling approach is the adjustments to the Hong Kong re-export markup rates. For eastbound re-exports, the differences are bigger, while for westbound re-exports, the differences are smaller. Specifically, 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 of some data issues are still unresolved in the model, the accuracy of these adjustments is subject to further investigation which will be elaborated upon in future work.

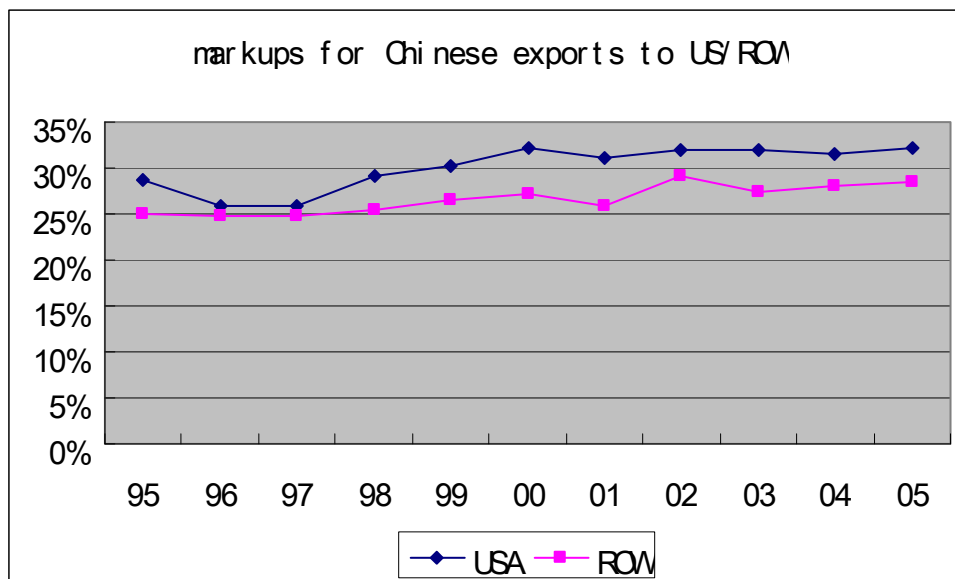
In terms of country breakdowns, the model adjusts the markup rates for all destination countries in eastbound trade downwards. Among them, the China-US markup rate is reduced from 33% to 29.4%. In comparison, for westbound trade, the adjustment are made in different directions, Some of China's top deficit 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

¹⁶ 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.

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.

To better understand our model results for eastbound trade, which experiences relatively significant adjustments, we seek to put the markup rates in perspective. Using the approach described in Section 3.2, we also calculate the markup rates for the past 11 years (1995-2005), and as shown in Figure 1, 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.

Figure 1. Hong Kong markup rates for re-export Chinese goods to the US and to the rest of the world, 1995 ~ 2005



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).¹⁷ 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.

¹⁷ This may be quite true in real world trade. For example, shipments of forest products from northwest port of Dalian to Hong Kong by sea first, then transport to factories use these products in Shenzhen by truck may be a lot cheaper than direct transport the products from inland China to Shenzhen. However, the data show that the majority of these round tripping commodities are electronic equipment (17.8 billion), Other machineries (7.3 billion) and textiles (5.0 billion), there must be some incentive reasons to encourage exporters to do so.

In terms of sectoral breakdown, in eastbound trade, significant upward adjustments occurs in the lightly traded primary sectors such as fishing, plant-based fibers, dairy products, processed rice and food products, vegetable oils, and ferrous metals, while negative adjustments are made for most manufacturing products. In westbound trade, there is a similar pattern, but the biggest rise in markup rates go to wearing apparel.

Table 9. Initial and Adjusted Estimates of Hong Kong's Re-export Rate by GTAP sectors, 2004, in percent

GTAP Sector name	Eastbound Trade						West Bound Trade					
	Initial Estimates			Adjusted Estimates			Initial Estimates			Adjusted Estimates		
	Hong Kong re-exports as percent of China's total exports	Hong Kong re-exports markup rate	Standard deviation of markup rate	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	re-exports as percent of China's total imports	Hong Kong re-exports markup rate	Standard deviation of markup rate
1 Paddy rice,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 Wheat,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 Cereal grains nec,	0.0	61.5	18.9	0.0	68.5	33.6	0.1	10.0	0.0	0.0	0.0	0.0
4 Vegetables fruit nuts,	0.3	24.4	16.9	0.4	23.7	17.2	24.5	1.6	0.8	24.2	0.6	5.9
5 Oil seeds,	0.1	32.7	15.3	0.1	11.4	16.5	0.1	4.6	1.1	0.1	0.0	0.0
6 Sugar cane and sugar beet,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 Plant-based fibers,	0.9	7.4	0.0	0.4	53.7	31.6	0.5	16.2	10.1	0.3	38.7	42.5
8 Crops nec,	2.4	52.4	9.8	3.0	58.7	7.3	7.6	9.9	12.0	7.0	14.5	15.0
9 Bovine cattle sheep and goats horses,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 Animal products nec,	0.6	40.6	28.7	0.7	38.8	15.6	37.3	6.2	2.8	39.2	7.4	19.0
12 Wool silk-worm cocoons,	10.0	0.0	0.0	8.9	1.6	0.3	0.1	19.7	0.0	0.0	29.4	1.7
13 Forestry,	3.5	38.1	11.6	2.0	39.0	12.4	3.2	5.0	6.0	2.3	12.5	31.5
14 Fishing,	2.6	31.6	16.7	0.0	100.0	0.0	4.0	4.6	4.6	0.0	100.0	0.0
15 Coal,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16 Oil,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 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
18 Minerals nec,	0.5	36.9	34.6	0.4	32.4	36.5	1.9	28.8	25.8	1.1	39.1	33.1
19 Bovine cattle sheep and goat horse meat prods,	0.5	0.7	0.0	0.3	10.6	3.2	36.9	3.0	1.7	33.6	35.2	42.2
20 Meat products nec,	0.3	20.9	6.2	0.3	24.9	12.0	45.1	2.6	3.0	60.5	4.2	7.5
21 Vegetable oils and fats,	1.1	32.0	14.1	0.9	42.6	25.0	1.7	2.3	2.0	1.7	2.4	5.9
22 Dairy products,	4.0	31.4	8.4	2.4	77.1	7.3	6.7	30.4	11.2	6.0	44.5	33.7
23 Processed rice,	0.1	15.7	0.0	0.1	32.7	30.4	0.3	11.6	0.0	0.4	13.9	0.0
24 Sugar,	0.8	20.8	0.0	1.2	16.5	0.0	4.8	6.5	3.3	3.7	7.4	21.4
25 Food products nec,	1.3	25.6	9.6	1.1	41.3	11.5	8.1	5.8	4.5	8.0	9.4	18.9
26 Beverages and tobacco products,	14.1	35.7	16.3	13.8	41.7	14.5	25.4	28.6	20.0	36.4	31.7	27.9
27 Textiles,	11.2	30.8	12.4	10.8	29.1	12.9	29.4	8.4	3.0	29.6	7.2	12.2
28 Wearing apparel,	14.5	39.3	9.6	15.9	37.3	10.4	45.7	7.5	6.5	16.3	64.7	44.8
29 Leather products,	27.9	15.3	5.7	26.8	14.8	5.7	44.2	11.7	6.2	45.4	11.1	16.9
30 Wood products,	4.1	31.0	10.6	3.3	32.6	9.9	12.3	5.0	3.8	12.7	8.2	16.9
31 Paper products publishing,	25.4	50.4	7.1	23.4	49.7	7.2	8.3	6.0	3.7	7.0	5.4	8.1
32 Petroleum, coal products,	0.1	6.4	7.7	0.1	3.5	2.8	2.0	3.9	4.9	2.3	1.6	4.1
33 Chemical rubber plastic products,	6.0	34.8	8.7	5.7	34.3	8.7	14.9	7.9	3.9	15.4	7.9	7.8
34 Mineral products nec,	2.9	32.9	12.6	2.6	34.3	12.5	10.1	9.1	3.0	10.0	9.5	3.6
35 Ferrous metals,	0.2	36.7	19.8	0.2	55.6	22.2	9.6	5.1	3.2	11.6	15.1	13.1
36 Metals nec,	2.5	17.8	13.0	1.9	11.8	13.7	11.8	4.2	5.4	11.1	2.5	13.0
37 Metal products,	8.4	33.7	9.4	8.9	31.0	9.4	8.6	5.4	3.9	8.0	1.8	7.5
38 Motor vehicles and parts,	0.2	49.6	18.5	0.3	41.9	21.7	7.6	5.2	3.8	8.1	0.9	9.4
39 Transport equipment nec,	1.6	19.1	14.1	2.1	20.1	14.2	1.9	2.8	5.2	1.5	24.4	42.7
40 Electronic equipment,	15.9	24.1	15.1	13.5	22.9	15.1	30.1	16.1	7.0	21.6	12.6	11.5
41 Machinery and equipment nec,	15.5	34.3	9.4	17.1	21.7	11.3	11.7	8.7	6.7	9.6	5.2	9.4
42 Manufactures nec,	30.0	40.8	8.3	25.9	39.7	8.2	22.9	10.1	5.2	25.6	10.0	16.2
All sectors	13.3	30.9	6.8	12.9	27.5	7.0	15.8	11.6	4.5	13.5	10.2	8.8

Table 9 presents the initial and model adjusted Hong Kong re-exports as percentage of China's total exports. For eastbound trade, the model reduces the overall share of re-exports via Hong Kong in total Chinese exports by only 0.4% (from 13.3% to 12.9%). The sectors that are mostly affected are GTAP sector 42 (manufactures nec, -4.1%), sector 14 (fishery, -2.6%), sector 40 (electronic equipment, -2.4%) and sector 31 (paper products publishing, -2.0%). For westbound trade, the overall share of Chinese imports via Hong Kong in total Chinese imports declines by 2.3% (from 15.8% to 13.5%). Noteworthy impacts occur in four sectors: sector 28 (wearing apparel, -29.4%), sector 20 (meat products nec, 15.4%), sector 26 (beverages and tobacco products, 10.9%), and sector 40 (electronic equipment, -8.5%).

4.3 Hong Kong re-exports earnings and retained imports

Another key output used in the GTAP database is the estimates for retained imports and domestic exports for Hong Kong. The first panel of table 10 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 GTAP 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 4.2 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.

Across sectors, 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 GTAP 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 GTAP 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 make good economic sense.

Table 10. Initial and Adjusted Estimates of Hong Kong's Re-export Earnings and Retained Imports, 2004, in million U.S. Dollars

GTAP Sector name	Re-export Earnings						Retained Imports			
	Re-export for China		Re-export to China		Others		Excluding China		Including China	
	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
1 Paddy rice,	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0
2 Wheat,	0.0	0.0	0.0	0.0	0.0	0.0	1.8	9.1	1.8	9.1
3 Cereal grains nec,	0.1	0.2	0.0	0.0	0.0	0.0	12.5	12.5	14.4	14.5
4 Vegetables fruit nuts,	2.3	2.2	3.6	1.4	1.9	1.9	649.7	720.9	834.5	869.7
5 Oil seeds,	0.4	0.1	0.3	0.0	0.0	0.0	10.8	28.8	13.5	32.5
6 Sugar cane and sugar beet,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 Plant-based fibers,	0.0	0.1	2.3	5.6	0.0	0.0	71.1	95.9	71.1	95.9
8 Crops nec,	38.8	43.4	4.2	6.2	9.0	13.3	167.2	205.8	253.8	304.2
9 Bovine cattle sheep and goats horses,	0.0	0.0	0.0	0.0	0.0	0.1	59.0	116.2	73.6	128.7
10 Animal products nec,	5.1	4.9	53.0	63.3	4.7	4.7	455.3	342.6	780.5	657.9
12 Wool silk-worm cocoons,	0.0	0.0	0.1	0.2	0.0	0.0	0.6	0.3	0.6	0.3
13 Forestry,	1.4	1.4	2.7	6.7	0.2	0.3	4.7	38.8	10.4	44.2
14 Fishing,	11.5	36.3	0.6	11.9	20.7	77.0	481.2	601.9	557.4	601.9
15 Coal,	0.0	0.0	0.0	0.0	0.0	0.0	309.0	258.3	368.0	298.4
16 Oil,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	4.5
17 Gas,	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254.8	186.6
18 Minerals nec,	6.3	5.5	88.7	120.7	142.4	142.5	524.9	422.5	593.1	494.0
19 Bovine cattle sheep and goat horse meat prods,	0.0	0.0	5.7	66.8	4.1	14.8	239.8	62.1	267.4	88.1
20 Meat products nec,	0.8	1.0	3.6	5.9	3.3	3.8	548.2	399.4	880.7	730.6
21 Vegetable oils and fats	1.7	2.2	1.5	1.6	0.3	0.3	207.4	216.9	244.1	258.0
22 Dairy products,	1.0	2.5	15.4	22.6	6.5	6.8	226.9	140.0	267.6	182.3
23 Processed rice,	0.0	0.1	0.1	0.1	0.6	0.7	143.7	141.6	150.1	148.1
24 Sugar,	0.0	0.0	0.6	0.7	0.2	0.2	26.9	38.0	38.3	49.3
25 Food products nec,	51.5	83.3	19.7	31.7	41.9	44.2	1,706.9	1,659.2	2,192.9	2,237.6
26 Beverages and tobacco products,	39.2	45.9	59.0	65.3	135.3	135.3	467.2	348.2	918.9	865.8
27 Textiles,	2,177.7	2,062.4	404.0	345.3	236.1	236.1	1,882.0	2,252.2	3,929.1	5,902.7
28 Wearing apparel,	4,620.8	4,387.7	35.7	308.9	125.5	125.4	542.0	883.6	5,083.0	6,393.7
29 Leather products,	1,489.1	1,442.1	243.7	230.3	209.4	209.6	1,347.9	1,740.7	1,347.9	1,740.7
30 Wood products,	322.9	339.5	19.1	31.0	2.0	2.2	264.1	319.4	724.7	828.5
31 Paper products publishing,	939.9	926.9	41.9	37.7	16.3	16.8	952.1	1,558.6	1,412.2	2,202.5
32 Petroleum, coal products,	0.7	0.4	9.0	3.7	26.7	26.7	4,476.1	5,255.0	4,766.5	5,656.7
33 Chemical rubber plastic products,	1,309.8	1,293.3	827.3	824.5	368.8	368.8	5,958.4	6,010.2	6,729.6	7,244.0
34 Mineral products nec,	135.6	141.2	28.1	29.2	13.7	14.1	973.9	865.3	1,307.4	1,325.4
35 Ferrous metals,	12.7	19.2	117.7	350.0	17.5	46.9	1,083.0	646.4	1,406.0	646.4
36 Metals nec,	41.2	27.4	77.5	45.9	8.9	8.9	1,760.0	2,825.6	2,011.5	6,190.6
37 Metal products,	865.7	796.6	24.8	8.4	29.6	29.7	515.6	1,587.0	846.3	1,587.0
38 Motor vehicles and parts,	25.2	21.3	62.3	11.1	25.9	25.9	1,275.1	1,019.7	1,411.5	2,598.7
39 Transport equipment nec,	37.6	39.4	4.1	35.7	139.7	139.7	1,441.2	1,981.7	1,677.0	2,363.3
40 Electronic equipment,	8,239.1	7,831.0	5,317.6	4,171.6	2,942.5	2,942.4	29,349.7	30,124.1	29,349.7	30,124.1
41 Machinery and equipment nec,	7,367.3	4,663.3	1,118.0	663.2	883.4	933.7	7,806.1	17,399.6	7,806.1	17,399.6
42 Manufactures nec,	6,485.7	6,315.3	59.2	58.9	689.2	691.4	6,566.7	7,598.0	6,566.7	7,598.0
All sectors	#####	30,536.1	8,650.9	7,565.6	6,106.1	6,264.1	72,508.8	87,930.7	85,163.0	108,103.9

The second panel of table 10 lists initial and adjusted estimates of Hong Kong's retained imports from all its trading partners excluding and including China by GTAP 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 misreported 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 trip trade flows properly in the model will improve the accuracy of the final estimates.

4.4 Adjusted China's balance of trade at sector level

The first and second panels of table 11 presents initial and model adjusted net exports of China with all its trading partners, with and without Hong Kong, by GTAP sectors. 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 three GTAP sectors (fishery, beverages and tobacco products and other transport equipment). Furthermore, when trade with Hong Kong is included, two of the three sectors are consistent to the net direction of the partner officially reported trade balances, the only exception is GTAP sector 14, fisheries, which is more problematic from an inherent data quality issue.¹⁸ 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 certain technology-capital intensive goods such as 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.

¹⁸ 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 consistence 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.

Table 11. Initial and Adjusted Estimates of China's Net Trade Flows, 2004, in million U.S. Dollars

GTAP Sector name	Trade Balance with All Partners Excluding Hong Kong				Trade Balance with All Partners				Trade Balance with the United States			
	China		Partner		China		Partner		China		U.S.	
	officially reported	Initial estimates	Adjusted estimates	officially reported	officially reported	Initial estimates	Adjusted estimates	officially reported	officially reported	Initial estimates	Adjusted estimates	officially reported
1 Paddy rice,	47.5	47.6	45.9	-101.7	47.5	47.6	45.9	-101.7	0.0	0.0	0.0	0.0
2 Wheat,	-1,528.4	-952.1	-1,541.1	880.2	-1,528.4	-952.1	-1,541.1	880.2	-648.2	-495.1	-810.4	495.1
3 Cereal grains nec,	69.0	199.3	118.6	-350.9	70.7	201.0	120.4	-352.8	0.1	-0.6	-0.2	0.2
4 Vegetables fruit nuts,	1,095.1	1,222.0	994.6	-1,549.6	981.2	1,324.8	1,135.3	-1,737.5	20.0	-0.7	18.2	-95.0
5 Oil seeds,	-6,620.1	-4,665.6	-5,600.3	4,545.8	-6,623.1	-4,663.6	-5,596.7	4,542.6	-3,334.8	-2,314.9	-3,286.7	2,306.9
6 Sugar cane and sugar beet,	-0.4	0.0	-0.3	0.0	-0.4	0.0	-0.3	0.0	0.0	0.0	0.0	0.0
7 Plant-based fibers,	-2,829.9	-2,057.0	-2,761.9	2,035.5	-2,843.5	-2,059.4	-2,762.1	2,037.7	-1,766.1	-1,426.8	-1,510.1	1,421.0
8 Crops nec,	898.0	920.4	477.9	-1,183.9	1,006.7	1,030.3	573.7	-1,301.1	45.9	46.3	21.1	-120.3
9 Bovine cattle sheep and goats horses,	-184.3	-154.3	-180.6	158.7	-154.3	-124.3	-168.1	144.2	0.0	-0.1	-0.2	0.1
10 Animal products nec,	-1,216.1	-955.0	-826.9	92.9	-1,725.1	-706.9	-520.8	-186.2	-380.0	-414.9	-375.7	243.1
12 Wool silk-worm cocoons,	-976.0	-978.2	-941.0	666.0	-976.1	-978.4	-941.0	665.2	-6.3	-4.0	-4.0	0.5
13 Forestry,	-2,816.1	-1,421.5	-1,767.9	1,252.5	-2,864.4	-1,420.5	-1,763.4	1,247.6	-69.4	-133.3	-103.3	94.1
14 Fishing,	729.5	623.9	-123.7	-615.7	875.5	757.5	-123.7	-716.0	4.6	2.6	-8.4	-21.4
15 Coal,	2,927.2	3,208.6	2,688.7	-4,155.3	2,975.6	3,257.0	2,726.5	-4,214.3	8.6	-24.5	6.3	17.9
16 Oil,	-24,368.3	-10,008.7	-17,763.5	9,968.3	-24,368.3	-10,008.7	-17,763.5	9,968.3	114.5	114.0	137.6	-181.2
17 Gas,	-0.1	-140.5	-66.6	140.4	186.8	46.5	120.0	-114.4	0.0	0.0	0.0	0.0
18 Minerals nec,	-18,063.6	-9,379.2	-14,306.8	8,297.6	-18,223.7	-9,405.6	-14,294.7	8,308.6	-112.6	39.9	39.1	-142.8
19 Bovine cattle sheep and goat horse meat prods	-441.3	-432.5	-283.7	275.7	-600.8	-411.7	-258.7	253.7	-97.3	-60.2	-29.9	28.0
20 Meat products nec,	923.1	901.9	779.5	-688.9	1,117.7	1,224.3	1,107.8	-1,017.9	-76.8	-77.7	-81.2	50.6
21 Vegetable oils and fats,	-3,775.6	-3,330.1	-3,471.0	3,205.0	-3,794.9	-3,289.8	-3,430.9	3,166.5	-12.3	-11.2	-9.1	3.9
22 Dairy products,	-425.8	-456.0	-428.3	431.5	-419.3	-430.8	-388.0	404.1	-45.9	-44.9	-47.4	46.4
23 Processed rice,	-73.5	-46.2	-61.0	-10.8	-68.3	-40.6	-54.7	-17.4	11.8	11.8	15.9	-20.8
24 Sugar,	-276.0	-166.2	-222.3	93.6	-275.7	-157.2	-212.1	82.8	0.4	0.4	0.5	-0.9
25 Food products nec,	6,575.6	7,307.3	6,719.0	-8,507.9	7,013.9	7,903.7	7,261.1	-9,109.5	984.6	1,090.6	1,166.9	-1,658.2
26 Beverages and tobacco products,	27.5	-86.7	61.9	7.2	456.2	348.8	512.4	-434.1	-4.0	-14.7	-0.1	-30.4
27 Textiles,	23,596.4	28,304.8	30,968.1	-26,059.3	27,361.0	32,093.4	33,056.6	-31,747.0	4,750.7	5,149.9	6,901.7	-7,201.0
28 Wearing apparel,	40,695.1	47,645.2	44,783.2	-49,780.4	47,523.7	46,953.5	48,048.7	-60,124.8	5,996.6	8,239.7	9,998.1	-11,539.5
29 Leather products,	17,201.4	24,896.2	26,376.1	-34,024.2	17,862.8	24,647.0	26,171.1	-41,476.4	7,897.9	11,735.0	13,528.1	-16,648.9
30 Wood products,	11,559.4	12,772.9	16,653.9	-24,214.6	12,689.1	13,622.4	17,086.4	-25,370.6	6,507.7	6,860.5	9,421.5	-13,910.6
31 Paper products publishing,	-7,344.8	-4,006.7	-5,196.5	1,260.9	-7,259.7	-4,097.1	-4,965.3	232.6	-1,036.1	-28.9	40.1	-1,166.3
32 Petroleum, coal products,	-3,282.4	-2,674.7	-1,925.4	3,435.5	-3,176.2	-2,332.5	-1,576.2	3,154.0	499.7	612.5	665.2	-767.5
33 Chemical rubber plastic products,	-44,194.3	-22,527.9	-18,279.5	8,508.8	-51,494.2	-22,259.1	-18,669.5	6,875.9	901.3	3,592.0	4,397.2	-6,814.2
34 Mineral products nec,	5,686.2	6,581.1	7,201.7	-9,761.6	6,369.0	7,321.1	7,591.3	-10,335.7	1,539.0	1,703.3	2,412.0	-3,396.9
35 Ferrous metals,	-11,957.5	-8,561.7	-6,788.0	7,376.4	-13,881.6	-8,146.0	-7,031.8	7,305.4	669.9	456.7	889.3	-556.9
36 Metals nec,	-11,617.4	-7,345.9	-5,385.8	5,366.5	-11,485.0	-5,277.9	-3,438.3	5,108.7	-684.2	-903.7	-815.4	836.6
37 Metal products,	12,367.4	15,022.7	13,984.1	-18,289.3	13,365.5	14,960.1	13,856.6	-20,260.3	5,161.5	5,953.6	6,502.2	-7,748.3
38 Motor vehicles and parts,	-4,980.3	-4,333.7	-5,445.7	8,723.0	-4,950.9	-3,239.1	-3,935.6	8,623.8	3,044.4	2,998.1	1,655.7	-1,409.3
39 Transport equipment nec,	2,205.4	2,069.0	-259.4	46.7	2,621.0	2,487.8	80.4	-343.8	-1,277.8	-618.1	-1,000.3	270.6
40 Electronic equipment,	22,336.5	70,769.5	61,346.6	-135,930.9	31,648.9	80,064.8	54,694.0	-152,064.1	35,413.8	41,123.0	54,073.8	-57,796.1
41 Machinery and equipment nec,	-43,914.9	-8,964.7	-27,680.4	-26,354.3	-41,761.2	-8,187.3	-29,862.1	-37,365.2	7,214.0	13,227.7	17,215.0	-24,172.9
42 Manufactures nec,	17,698.2	27,317.8	32,881.3	-49,659.0	22,039.5	27,181.6	32,746.6	-58,173.7	9,160.5	12,962.0	16,547.1	-24,511.0
All sectors	-24,248.6	156,164.8	124,774.0	-324,469.7	-2,263.1	177,284.6	127,636.3	-393,562.8	80,395.7	109,345.1	137,570.3	-174,095.3

China's trade balance with the United States by GTAP sector is presented (second panel of table 11) as an example to illustrate the features of model adjusted bilateral net trade flows at sector level. It also shows that most model adjusted sector net trade flows lie between China and the U.S. officially reported statistics except few sectors, which are associated with either very small trade balance or China and US both reported surplus or deficit with each other. It is also interesting to note there are four GTAP sectors where the initial estimates of the sector balance of trade were adjusted out of the range reported by the two trading partners. Yet the model is able to correctly realign the final estimates back to (or closer to) an acceptable range (vegetable and fruits, other animal products, forestry, fishing). This further demonstrates some desirable attributes of the model not only as a tool for statistical reconciliation but preserving consistency in global trade flow data where economic soundness of data must be respected.

V. Concluding Remarks

This study constructed a mathematical programming model to estimate re-export markups and reconcile detailed bilateral trade statistics from China, Hong Kong and their trading partners. Five key steps are required to link the model with actual trade statistics. The model was applied to 2004 bilateral world trade data in GTAP sector classifications to produce Hong Kong re-exports adjusted trade flows to be contributed to the version 7 GTAP database. Preliminary results show that the model is able to eliminate statistical discrepancies efficiently and at the same time provides positive re-export markup estimates in both directions for all covered commodities. Hong Kong's re-export mark-up, each trading partner's exports and imports via Hong Kong as percent of the country's total exports to and import from China, and adjusted bilateral trade balances among China, Hong Kong and their partner countries by commodity are all part of the model solution.

In conclusion, the model provides a flexible tool to reconcile trade statistics from China, Hong Kong and their trading partners simultaneously. Advantages of the model are its flexibility in data requirements and its desirable theoretical and empirical properties. It can also be applied to reconcile direct and indirect trade for other regions of the world where re-export activities create major discrepancies. It not only provides a tool for the preparation of global trade data in future versions of GTAP database, but also contributes to the methodological development to estimate and reconcile discrepancies in international trade statistics when re-export activities diminish the ability of a country to identify its partner countries correctly.

However, there are several caveats that need mentioning. First, we keep re-export statistics reported by the Hong Kong Census and Statistics Department unchanged in the model during the adjustment process, because it is the most reliable source to provide both origins and destinations of re-exports through Hong Kong. In reality, such statistics also subject to errors as other reported trade statistics.

Second, the model assumes both China and Hong Kong correctly report their total exports to and imports from the world. Therefore, these totals enter the model as controlled constants. However, in the real world, the sum of partner countries reported trade with

China and Hong Kong in some sectors may well exceed what China and Hong Kong reported as illustrated by the huge negative discrepancies in derived trade statistics for the no reporting country block in our model. Therefore, there is an inconsistency at the global level which can not be eliminated by the current model alone. To solve this issue, a global commodity equilibrium adjustment model is needed. Such a model would treat each country as both supplies and demanders for each commodity and reconciles each countries' total exports and imports statistics using equation (17) as its constraint to solve a set of global consistent total exports and imports (no bilateral trade data needed) for each commodity and every country, which then can be used as input to our current model to solve the bilateral details.

Third, we made our estimates on bilateral transport margins primarily from trade-related shipping cost information from the United States and these estimates enter the model as constant parameters. The associated errors with these parameters may transmit through the model thus impact the accuracy of the re-export markup and bilateral trade flow estimates. Therefore, the numeric estimates reported in the paper should be interpreted with caution and sensitivity analysis should be conducted in future studies to check how changes in these fixed parameters of the model may impact results from its solutions.

Finally, the current model only reconciles one year's bilateral trade data, to be consistent with the 2004 base year of version 7 GTAP database. However, a three year average may be more desirable. This would smooth any unusual annual variation of the bilateral trade data, reducing time differences in record keeping which might cause discrepancies, and it would also provide more non-zero entries in the trade flow matrix. This would have a positive impact on the development of CGE-based trade policy analysis using future versions of GTAP database.

References

- Antonello, Paola, 1990, "Simultaneous Balancing of Input-Output Tables at Current and Constant Prices with First Order Vector Autocorrelated Errors," *Economic Systems Research*, Vol. 2, No. 2, pp. 157-171
- Bacharach, M, 1970, *Bi-proportional Scaling and Input-output Change*, Cambridge University Press, Cambridge
- Bachem, Achim and Bernhard Korte (1981) Mathematical Programming and Estimation of Input-Output Matrices, Report WP78102, University of Bonn
- Baras, J S and Panoutsopoulos, 1993, "World Trade Data Estimation: A Methodology Using Progressive Elimination and Constrained Quadratic Optimization," The World Bank (unpublished report), March.
- Batten, F. David, 1982, "The Interregional Linkages between National and Regional Input-Output Models," *International Regional Science Review*, Vol. 7, pp. 53-67.
- Bohatyretz, Sandra and Bruna Santarossa, 2005, "Merchandise Trade Reconciliation Study: Canada-China, 2002 and 2003," *Canadian Trade Review*, No 3, International Trade Division, Statistics Canada, Ottawa, <http://www.statcan.ca/english/research/65-507-MIE/65-507-MIE2005003.htm>
- Brooke, Kendrick, Meeraus, and Raman, 2005, "GAMS -- User's Guide" GAMS Development Cooperation, Washington, DC.
- Byron, Ray P. 1978. "The Estimation of Large Social Account Matrix," *Journal of Royal Statistical Society, A*, 141 (Part 3), 359-367.
- Canning, Patrick and Zhi Wang, 2005, "A Flexible Mathematical Programming Model to Estimate Interregional Input-Output Accounts." *Journal of Regional Sciences* 45(3):539-563, August.
- Deardorff, Alan V. 1998, "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?" In J. A. Frankel, ed., *The Regionalization of the World Economy*, pp. 7-22. Chicago: University of Chicago Press.
- Jonathan, Eaton and Samuel Kortum, 2002, "Technology, Geography, and Trade," *Econometrica*, Vol. 70: 1741-1779, September.
- Feenstra, Robert, Wen Hai, Wing Woo and Shunli Yao, 1998, "The U.S.-China Bilateral Trade Balance: Its Size and Determinants," *NBER Working Paper #6598*, June, National Bureau of Economic Research (NBER), Cambridge, MA

Feenstra, Robert, Wen Hai, Wing Woo and Shunli Yao, 1999, "Discrepancies in International Data: An Application to China-Hong Kong Entrepôt Trade," *American Economic Review*, vol. 89, no. 2, 338-343, May.

Feenstra, Robert C., James R. Markusen and Andrew K. Rose, 2001, "Using the Gravity Equation to Differentiate Among Alternative Theories of Trade," *Canadian Journal of Economics*, Vol. 34: 430-447, May.

Feenstra and Robert C. and Gordon H. Hanson, 2004, "Intermediaries in Entrepôt Trade: Hong Kong Re-Exports of Chinese Goods," *Journal of Economics and Management Strategy*, Vol. 13, No. 1, pp. 3-35.

Feenstra, Robert and Gordon Hanson, 2005, "Ownership and Control in Outsourcing to China: Estimating the Property-Rights Theory of the Firm," *Quarterly Journal of Economics*, p729-761, May

Ferrantino Michael J and Zhi Wang, 2007, "Accounting for Discrepancies in Bilateral Trade: The Case of China, Hong Kong, and the United States" ITC staff working paper, 07-04-A.

Fung, K C, 1996, "Accounting for Chinese Trade: Some National and Regional Considerations," *NBER Working Papers 5595*, National Bureau of Economic Research (NBER), Cambridge, MA

Fung, K C and Lawrence Lau, 1998, "The China-United States Bilateral Trade Balances: How Big Is It Really?" *Pacific Economic Review*, No. 3, October, pp. 33-47

Fung, K C and Lawrence Lau, 2001, "New Estimates of U.S.-China Bilateral Trade Balances," *Journal of the Japanese and International Economics*, Vol. 15, pp. 102-130

Fung, K C and Lawrence Lau, 2003, "Adjusted Estimates of United States-China Bilateral Trade Balances: 1995-2002," *Asian Economic Journal*, Vol. 14, May/June, pp. 489-496.

Fung, K C, Lawrence Lau, and Yanyan Xiong, 2006 "Adjusted Estimates of United States-China Bilateral Trade Balances—An Update," *Pacific Economic Review*, vol 11(3), pages 299-314, October

Florian, M, 1986, "Nonlinear Cost Network Models in Transportation Analysis," *Mathematical Programming Study*, Vol. 26, pp. 167-196

Friedlander, D, 1961, "A Technique for Estimating Contingency Table, Given the Marginal Totals and Some Supplementary Data," *Journal of the Royal Statistical Society, A*. Vol.124, Part 3, pp. 412-420

- Gehlhar, Mark, 1996, "Reconciling Bilateral Trade Data for Use in GTAP" GTAP Technical Paper No. 10, Purdue University.
- Harrigan, J. Frank 1990, "The Reconciliation of Inconsistent Economic Data: the Information Gain," *Economic System Research*, Vol.2, No.1, pp. 17-25
- Harrigan, J. Frank and Iain Buchanan. 1984. "A Quadratic Programming Approach to Input-Output Estimation and Simulation," *Journal of Regional Science*, 24(3), 339-358.
- Hong Kong Census and Statistical Department (HKCSD), *Hong Kong Monthly Digest of Statistics*, various issues, Hong Kong
- Johnston, R.J., A.M. Hay, and P. J. Taylor, 1982, "Estimating the Sources of Spatial Change in Election Results: A Multiproportional Matrix Approach," *Environment and Planning, A*, Vol. 14 pp. 951-962
- Joint Commission on Commerce and Trade (JCCT), 1995, "Report of the 'Trade Statistics Subgroup'," Trade and Investment Working Group, Washington DC, October 17, <http://www.census.gov/foreign-trade/reconcile/china.html>
- Kaneko, Yukio, 1988, "An Empirical Study on Non-survey Forecasting of the Input Coefficient Matrix in a Leontief Model," *Economic Modelling*, No.1, pp. 41-48
- Klincewicz, J G, 1989, "Implementing an Exact Newton Method for Separable Convex Transportation Problems," *Networks*, Vol.19, pp. 95-105
- Lahr, Michael L, 2001, "A Strategy for Producing Hybrid Regional Input-output Tables," in Lahr, Michael and Erik Dietzenbacher (eds.), *Input-Output Analysis: Frontiers and Extensions*. Basingstoke, U.K: Palgrave, pp. 211-242.
- Miller, R. E. and P.D. Bliar, 1985, *Input-Output Analysis: Foundations and Extensions*, Prentice Hall, Englewood Cliffs, New Jersey
- Mohr, Malte, William H. Crown and Karen R Polenske, 1987, "A Linear Programming Approach to Solving Infeasible RAS Problems," *Journal of Regional Sciences*, 27(4), 587-603
- Nagurney, A., Dae-Shik Kim and A.G. Robinson, 1990, "Serial and Parallel Equilibration of Large-Scale Constrained Matrix Problems with Application to the Social and Economic Sciences," *The International Journal of Supercomputer Applications*, Vol. 4, No. 1, pp. 49-71.
- Plane, D.A., 1982, "An information theoretic approach to the estimation of migration flows," *Journal of Regional Science*, 22: 441-456.

Ploeg, van der F, 1982, "Reliability and the Adjustment of Sequences of Large Economic Accounting Matrices," *Journal of the Royal Statistical Society*, A. 145, 169-194

Ploeg, van der F, 1984, "General Least Squares Methods for Balancing Large Systems and Tables of National Accounts," *Review of Public Data Use*, 12, 17-33

Ploeg, van der F, 1988, "Balancing Large Systems of national Accounts," *Computer Science in Economics and Management* 1, 31-39

Robinson, Sherman, Andrea Cattaneo and Moataz El-Said, 2001, "Updating and Estimating a Social Accounting Matrix Using Cross Entropy Methods," *Economic System Research*, 13(1), 47-64

Schindler, W. John and Dustin Beckett, 2005, "Adjusting Chinese Bilateral Trade Data: How Big China's Trade Surplus?" *International Journal of Applied Economics*, 2(2):27-55, September.

Schneider, Michael H., and Stavros A. Zenios, (1990) "A Comparative Study of Algorithms for Matrix Balancing." *Operations Research*, Vol. 38, No. 3, pp. 439-455.

Senesen, Gulay and John M. Bates, 1988, "Some Experiments with Methods of Adjusting Unbalanced Data Matrices," *Journal of the Royal Statistical Society*, A. 151 (Part 3), 473-490.

Stone, Richard, 1984, "Balancing the National Accounts: The Adjustment of Initial Estimates: a Neglected Stage in Measurement," in A. Ingham and A.M. Ulph (eds.), *Demand, Equilibrium and Trade*. London: Macmillan

Stone, Richard, John M. Bates and Michael Bacharach, 1963, *A Program for Growth, Vol. 3 Input-Output Relationship 1954-1966*, London: Chapman and Hall

Stone, Richard, David G. Champernowne and James E. Meade, 1942, "The Precision of National Income Estimates," *Review of Economic Studies*, 9(2), 110-125.

Theil, Henri and G. Ray (1966) "A quadratic Programming Approach to the Estimation of Transition Probabilities." *Management Sciences*, No. 12, 714-721.

van Leeuwen, Nico and Arjan Lejour, 2006, "Bilateral FDI Stocks by Sector", CPB Memorandum No. 164, Netherlands Bureau for Economic Policy Analysis.

Waelbroeck, J. (1964) "Use non-survey methods to analyze International Trade Matrix." *Cahiers Economiques de Bruxelles*, Vol. 21, pp.93-114.

Weale, Martin R, 1985, "Testing Linear Hypotheses on National Account Data," *Review of Economics and Statistics*, 67, 685-689.

Weale, Martin R, 1989, "Asymptotic Maximum-Likelihood Estimation of National Income and Expenditure," Cambridge, mimeo.

Yao, Shunli, 2000, *Three Essays on China's Foreign Trade*, unpublished PhD dissertation, University of California, Davis.

Zenios, Stavros A., Arne Drud and John M. Mulvey, 1989, "Balancing Large Social Accounting Matrices with Nonlinear Network Programming," *NETWORKS*, 19, 569-585.

Appendix Table A. Countries in the other reporting country block of the model

<i>Country number</i>	<i>ISO3</i>	<i>Country name</i>	<i>Country number</i>	<i>ISO3</i>	<i>Country name</i>
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

Country Name	China actual exports to partners	China direct exports to partners	Hong Kong total exports to partner	Hong Kong domestic export to partner	China re-exports to partner via Hong Kong	Hong Kong re-export markup	Partners total imports from Hong Kong	Partners actual imports from China	Partner imports of Hong Kong domestic products	Partner direct import from China	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong re-export markup rate	Partners balance of trade with China after adjustment	China reported balance of trade with partners	Partner reported balance of trade with China	Partners balance of trade with Hong Kong after adjustment	Hong Kong reported balance of trade with partners	Partner reported balance of trade with Hong Kong	cif/fob ratio, China to partner	cif/fob ratio, Hong Kong to partner
Croatia	443	422	39	15	30	8	41	472	16	449	4.8	0.0	27.2	415	323	-628	12	33	-50	1.069	1.052
Romania	873	843	46	13	37	6	48	936	14	903	3.5	0.0	16.8	723	730	-865	5	19	-20	1.074	1.038
Yugoslavia	281	272	12	3	12	3	13	301	3	292	3.1	0.0	25.6	261	150	-540	1	10	-11	1.075	1.048
Ukraine	839	793	56	7	56	10	59	901	7	853	5.4	0.0	17.8	577	403	-69	-433	42	61	1.073	1.049
Russian Federation	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	8	1.078	1.041
Kazakhstan	997	991	6	1	10	5	6	1,081	1	1,075	0.5	0.0	48.2	-354	-74	1,006	1	7	-4	1.078	1.082
Kyrgyz Republic	199	199	1	0	0	0	1	215	0	215	0.2	0.0	8.5	153	381	-41	0	-1	1	1.075	1.077
Argentina	1,235	1,103	172	27	151	16	181	1,301	30	1,161	10.7	0.0	10.9	-1,550	-2,407	1,229	-1	-50	-11	1.057	1.045
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	-328	1.061	1.041
Chile	1,841	1,572	302	24	303	28	325	1,957	30	1,667	14.6	0.0	9.3	-1,503	-1,989	1,363	-28	122	-155	1.067	1.057
Colombia	950	874	94	15	86	9	100	1,010	17	929	7.9	0.0	10.8	807	453	-1,096	5	72	-83	1.068	1.054
Ecuador	528	501	34	6	34	7	36	564	7	535	5.0	0.0	20.0	462	250	-654	-2	24	-29	1.072	1.064
Peru	628	581	65	15	55	6	70	668	17	617	7.5	0.0	11.7	-668	-1,108	468	-3	24	-42	1.069	1.064
Paraguay	388	280	131	14	124	14	138	405	17	290	27.9	0.0	11.3	321	175	-442	7	112	-135	1.047	1.041
Venezuela	448	388	95	32	73	11	103	479	36	414	13.4	0.0	15.6	-381	-146	-199	30	61	-112	1.071	1.065
Uruguay	199	180	27	6	22	3	29	209	7	189	9.6	0.0	13.0	93	99	-61	-3	-5	-12	1.056	1.051
Costa Rica	230	212	40	21	25	6	43	247	23	227	8.0	0.0	25.2	-653	-489	-107	-17	-246	61	1.079	1.069
Guatemala	517	429	125	34	110	21	137	556	39	459	17.0	0.0	18.7	495	349	-185	32	113	-157	1.079	1.078
Panama	1,301	810	538	23	548	49	570	1,378	29	854	37.7	0.0	8.9	1,289	2,171	-509	5	567	-531	1.068	1.051
Cuba	443	438	8	2	5	0	8	475	2	470	1.1	0.0	7.9	220	135	-510	-1	-6	-3	1.076	1.037
Algeria	991	985	24	19	7	2	26	1,064	20	1,059	0.5	0.0	24.8	712	667	18	8	-32	1.078	1.047	
Egypt Arab Rep	1,154	1,061	136	34	112	17	147	1,235	38	1,134	8.1	0.0	15.5	1,008	1,151	-569	15	67	-115	1.071	1.068
Iran Islamic Rep	1,926	1,894	78	37	36	4	84	2,035	41	2,001	1.6	0.0	11.8	-2,972	-2,021	-1,404	-45	-79	26	1.065	1.044
Israel	1,547	1,197	1,134	485	495	134	1,160	1,661	497	1,289	22.6	0.0	27.1	537	558	-695	-606	-252	83	1.071	1.021
Jordan	682	536	197	45	185	37	217	730	52	570	21.4	0.0	19.7	649	534	-642	40	196	-207	1.081	1.078
Lebanon	597	572	42	10	38	12	45	642	11	615	4.3	0.0	30.7	583	471	-705	6	38	-30	1.077	1.059
Morocco	744	723	39	17	26	5	42	794	19	772	2.8	0.0	18.7	594	720	-695	-10	-84	35	1.071	1.064
Nigeria	1,108	1,032	140	48	99	21	150	1,184	53	1,101	6.9	0.0	21.5	924	1,253	-676	37	100	-197	1.066	1.061
Saudi Arabia	3,183	2,949	304	48	266	27	317	3,463	49	3,213	7.4	0.0	10.2	-3,822	-4,749	4,477	-118	-76	83	1.089	1.046
Syrian Arab Republic	611	581	42	8	37	5	44	658	8	625	5.0	0.0	14.8	583	662	-434	6	41	-34	1.071	1.031
Tunisia	241	231	20	9	13	3	21	256	9	246	4.1	0.0	20.5	212	211	-266	7	7	-26	1.071	1.046
Turkey	3,825	3,461	535	102	422	52	561	4,046	112	3,660	9.5	0.0	12.3	3,442	2,205	-4,152	16	358	-420	1.062	1.042
Yemen	373	370	5	2	3	1	6	403	3	401	0.7	0.0	16.5	-906	-1,007	936	-7	-10	4	1.083	1.061
Benin	237	234	6	1	4	0	6	257	1	254	1.3	0.0	12.0	129	466	33	0	6	-6	1.080	1.051
Ghana	497	482	26	9	18	3	28	533	10	516	3.0	0.0	16.3	446	430	-345	4	-86	40	1.077	1.071
Kenya	385	334	70	17	60	8	76	410	19	355	13.2	0.0	13.6	356	313	-176	8	17	-44	1.073	1.072
Mozambique	58	55	10	6	4	1	10	64	6	60	5.8	0.0	19.0	20	31	-19	5	-8	-14	1.094	1.058
Malawi	21	20	3	2	2	1	3	23	2	22	4.8	0.0	39.9	20	19	-25	1	2	-5	1.077	1.064
Madagascar	315	236	87	2	91	10	96	337	4	250	25.2	0.0	11.3	301	134	-171	-2	94	-82	1.079	1.083
Sudan	512	510	11	7	2	0	11	546	7	544	0.4	0.0	7.4	-1,664	-980	1,761	-11	-1	-19	1.076	1.045
Togo	168	142	32	6	29	3	35	180	7	153	15.2	0.0	11.0	83	352	-40	5	26	-40	1.074	1.062
Tanzania	207	193	19	4	16	2	20	223	5	208	6.7	0.0	12.8	114	134	-104	-1	-14	5	1.082	1.070
Uganda	79	76	6	2	4	1	6	85	2	81	4.2	0.0	15.0	23	44	-98	-33	-14	7	1.065	1.063
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	-496	1.069	1.048
Zambia	52	51	6	5	2	0	7	55	5	54	2.9	0.0	12.4	-24	-120	-15	4	-10	3	1.055	1.054
Zimbabwe	54	52	5	3	2	0	5	57	3	55	3.6	0.0	18.3	-86	-63	52	-3	-8	-2	1.057	1.070
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	-928	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	0.0	12.5	5,770	-5,307	-1,179	-330	535	-31,799	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	0.0	27.5	124,774	-24,249	-324,470	-40,312	-9,984	-4,763	1.058	1.080
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	39,208	1.057	1.061

Appendix Table C. Adjusted Estimates of Bilateral Trade Between China, Hong Kong and their Partner Countries, Westbound Flows, 2004, in Millions of U.S. Dollars

Country Name	Partner actual exports to China	Partner direct exports to China	Partner exports to Hong Kong	Partner exports remain in Hong Kong	Partner re-exports to China via Hong Kong	Hong Kong re-export markup	Hong Kong re-imports from partners	Hong Kong total imports from partners	Hong Kong actual imports from partners	Hong Kong retained imports from partner	China direct import from partner	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong re-export markup rate	Partners balance of trade with China after adjustment	Partners balance of trade with Hong Kong after adjustment	cif/fob ratio, partner to China	cif/fob ratio, partner to Hong Kong
	TX(s,CH)	DX(s,CH)	TX(s,Hk)	DX(s,Hk)	RX(s,CH)	RXM(s,CH)	TM(s,HK)	TM(s,CH)	DM(s,HK)	DM(s,CH)	TX(r,CH)	(RX(r,CH)-RXM(r,CH))/TX(r,CH)	SDX(s)	RXM(CH,r)/TX(CH)	TX(CH,r)-TX(r,HK)	TX(HK,r)-TX(r,HK)	cif(s,CH)	cif(s,HK)
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	2.5	0.0	87.7	-7,096	-208	1.046	1.059	
Australia	8,562	8,153	1,818	1,190	581	142	2,005	9,383	1,336	8,935	5.0	0.0	24.4	-3,171	267	1.090	1.082	
New Zealand	1,158	1,085	332	249	131	50	370	1,243	277	1,160	6.8	0.0	38.2	-517	141	1.069	1.089	
Japan	91,099	72,899	34,044	12,459	20,625	1,755	35,918	94,958	13,547	75,841	20.5	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	
Singapore	20,102	17,782	15,796	12,918	2,471	64	16,371	20,768	13,390	18,326	11.8	0.0	2.6	3,947	10,543	1.039	1.033	
Macao	228	219	285	122	12	2	302	242	129	232	4.2	0.0	19.2	-1,473	-219	1.062	1.050	
Indonesia	6,748	6,076	1,409	632	826	103	1,537	7,428	703	6,691	10.5	0.0	12.4	1,791	349	1.113	1.083	
Malaysia	20,183	16,714	6,792	2,510	4,169	594	7,129	20,864	2,726	17,255	17.6	0.0	14.3	10,268	1,189	1.050	1.033	
Philippines	11,068	9,237	4,453	2,024	1,879	16	4,594	11,226	2,119	9,350	16.7	0.0	0.9	7,115	814	1.019	1.023	
Thailand	10,585	8,519	4,776	2,217	2,447	230	5,188	11,376	2,460	9,116	20.6	0.0	9.4	3,113	743	1.086	1.066	
Vietnam	1,036	938	442	287	111	6	482	1,156	316	1,050	9.9	0.0	5.8	-2,306	-363	1.117	1.112	
Cambodia	15	14	6	5	1	0	7	17	6	16	7.4	0.0	2.7	-643	-228	1.095	1.010	
Bangladesh	69	33	96	56	45	7	103	76	61	37	53.2	0.0	15.3	-2,219	-146	1.094	1.046	
India	6,751	6,222	3,657	2,035	621	66	3,746	7,558	2,090	6,985	8.0	0.0	10.6	-189	1,173	1.113	1.015	
Sri Lanka	26	23	71	58	11	8	74	30	60	26	13.4	0.0	68.7	-914	-283	1.133	1.053	
Pakistan	639	253	571	171	428	11	638	680	206	253	63.7	0.0	2.7	-1,119	121	1.081	1.077	
Austria	1,457	1,351	471	337	134	23	508	1,506	367	1,393	7.5	0.0	17.3	-224	127	1.037	1.068	
Belgium	3,122	2,828	1,848	1,206	387	80	1,957	3,278	1,280	2,963	9.6	0.0	20.6	-4,116	678	1.053	1.051	
Germany	28,130	25,421	5,039	1,879	2,923	126	5,293	29,019	2,032	26,180	9.8	0.0	4.3	-6,970	-267	1.033	1.034	
Denmark	1,364	915	599	140	677	210	641	1,408	163	932	33.6	0.0	31.0	-1,041	-208	1.040	1.041	
Spain	1,582	1,419	465	272	180	10	497	1,646	294	1,472	10.6	0.0	5.3	-6,894	-98	1.044	1.052	
Finland	2,907	2,713	414	124	253	51	441	2,997	140	2,789	6.8	0.0	20.0	-21	-180	1.034	1.042	
France	7,455	6,935	2,565	1,706	592	50	2,691	7,690	1,794	7,137	7.1	0.0	8.5	-8,832	1,052	1.033	1.040	
United Kingdom	5,128	4,309	4,547	2,560	970	119	4,731	5,297	2,681	4,429	16.3	0.0	12.2	-17,245	-529	1.036	1.033	
Greece	83	77	57	48	11	5	60	87	50	81	7.0	0.0	46.2	-1,487	-20	1.057	1.043	
Ireland	1,145	892	1,010	676	484	226	1,035	1,171	693	912	22.4	0.0	46.7	-2,035	408	1.025	1.021	
Italy	6,572	5,201	3,616	2,030	1,537	93	3,869	6,811	2,200	5,334	21.5	0.0	6.1	-6,157	1,450	1.042	1.051	
Luxembourg	131	130	18	15	13	13	18	137	16	136	0.5	0.0	94.8	-24	-8	1.044	1.033	
Netherlands	3,039	2,753	1,316	978	301	4	1,375	3,147	1,025	2,844	9.6	0.0	1.5	-16,426	-622	1.038	1.038	
Portugal	210	196	68	45	21	6	71	218	47	203	7.0	0.0	29.3	-356	12	1.055	1.042	
Sweden	2,945	2,687	573	282	286	21	598	3,041	299	2,772	8.9	0.0	7.3	662	-258	1.033	1.033	
Switzerland	3,135	2,666	3,406	2,271	516	29	3,536	3,233	2,360	2,738	15.3	0.0	5.7	1,127	1,782	1.035	1.034	
Norway	1,006	958	186	132	70	21	194	1,048	139	998	4.8	0.0	29.4	-507	-4	1.042	1.028	
Cyprus	2	2	7	6	1	1	8	2	7	2	25.7	0.0	60.4	-199	-10	1.062	1.127	
Czech Republic	429	379	151	76	55	4	160	443	82	391	11.9	0.0	6.9	-2,129	-27	1.037	1.050	
Estonia	30	30	5	5	1	1	6	33	5	32	1.7	0.0	63.2	-253	-22	1.065	1.066	
Hungary	424	414	81	6	93	83	83	434	6	423	2.5	0.0	88.3	-2,545	-335	1.023	1.019	
Lithuania	9	9	2	2	0	0	3	10	2	10	1.2	0.0	42.9	-302	-4	1.090	1.087	
Latvia	10	10	1	1	0	0	1	11	1	11	0.0	0.0	100.0	-100	-6	1.057	1.031	
Malta	132	88	80	30	53	8	82	132	31	88	33.6	0.0	15.5	50	21	1.010	1.013	
Poland	501	491	34	24	17	6	36	518	25	508	2.0	0.0	37.9	-2,376	-43	1.033	1.044	
Slovak Republic	93	91	16	13	3	2	16	97	14	96	1.8	0.0	50.3	-275	2	1.053	1.048	
Slovenia	42	37	13	8	6	1	14	44	9	39	11.8	0.0	17.6	-144	2	1.054	1.050	
Albania	3	3	0	0	0	0	0	3	0	3	0.0	0.0	0.0	-61	0	1.092	1.017	

Country Name	Partner actual exports to China	Partner direct exports to China	Partner total exports to Hong Kong	Partner re-exports remain in Hong Kong	Partner re-exports to China via Hong Kong	Hong Kong export markup	Hong Kong re-imports from partners	China actual imports from partners	Hong Kong retained imports from partner	China direct import from partner	Re-exports as percent of partner total exports to China	Statistical discrepancies	Hong Kong re-export markup rate	Partners balance of trade with China after adjustment	Partners balance of trade with Hong Kong after adjustment	cif/fob ratio, partner to China	cif/fob ratio, partner to Hong Kong
Bulgaria	35	34	6	4	4	3	6	38	4	37	2.9	0.0	70.9	-371	-8	1.072	1.038
Croatia	28	28	3	2	0	0	3	30	3	29	0.9	0.0	27.2	-415	-12	1.087	1.046
Romania	151	144	24	7	21	13	26	162	8	154	4.7	0.0	64.9	-723	-5	1.086	1.056
Yugoslavia	19	19	4	2	1	1	4	20	3	20	0.5	0.0	88.9	-261	-1	1.051	1.047
Ukraine	261	251	451	440	16	4	478	281	466	269	4.2	0.0	28.1	-577	433	1.085	1.058
Russian Federation	9,428	9,281	308	103	195	35	344	10,131	125	9,965	1.6	0.0	17.9	3,688	63	1.077	1.068
Kazakhstan	1,351	1,351	0	0	4	4	0	1,425	0	1,425	0.0	0.0	100.0	354	-1	1.058	1.067
Kyrgyz Republic	46	46	0	0	1	1	0	49	0	49	0.0	0.0	100.0	-153	0	1.051	1.018
Argentina	2,786	2,661	158	28	149	20	170	3,240	36	3,107	4.5	0.0	13.4	1,550	1	1.148	1.046
Brazil	7,099	6,780	695	324	352	14	756	8,231	363	7,885	4.6	0.0	4.1	2,999	72	1.150	1.058
Chile	3,344	3,248	149	52	108	2	176	3,490	68	3,381	3.1	0.0	1.7	1,503	28	1.043	1.087
Colombia	143	137	20	10	7	1	21	148	11	142	3.9	0.0	14.0	-807	-5	1.035	1.055
Ecuador	66	65	9	8	2	1	9	71	9	70	1.1	0.0	64.3	-462	2	1.065	1.083
Peru	1,296	1,281	33	17	18	1	40	1,397	23	1,380	1.3	0.0	6.2	668	3	1.079	1.134
Paraguay	67	62	12	8	6	0	15	72	9	67	7.9	0.0	0.9	-321	-7	1.084	1.134
Venezuela	829	824	11	2	6	0	13	936	3	931	0.6	0.0	7.9	381	-30	1.075	1.076
Uruguay	106	95	20	9	11	0	21	111	10	100	9.9	0.0	4.2	-93	3	1.047	1.058
Costa Rica	883	783	183	38	118	16	191	887	43	784	11.5	0.0	13.5	653	17	1.010	1.024
Guatemala	22	22	2	2	1	1	2	25	2	25	0.0	0.0	100.0	-495	-32	1.105	1.050
Panama	12	11	19	18	1	0	21	13	19	12	6.5	0.0	20.2	-1,289	-5	1.072	1.065
Cuba	223	223	11	3	1	0	11	232	4	232	0.3	0.0	32.9	-220	1	1.070	1.028
Algeria	248	248	1	1	0	0	1	261	1	261	0.0	0.0	0.0	-742	-18	1.050	1.000
Egypt Arab Rep	146	138	27	19	10	1	28	171	19	162	5.8	0.0	14.4	-1,008	-15	1.157	1.052
Iran Islamic Rep	4,898	4,873	114	83	31	4	121	5,176	88	5,148	0.5	0.0	14.0	2,972	45	1.116	1.049
Israel	1,010	822	1,629	1,091	216	25	1,648	1,037	1,106	840	18.3	0.0	11.8	-537	606	1.031	1.005
Jordan	32	32	5	4	1	1	5	35	5	35	0.6	0.0	75.6	-649	-40	1.054	1.057
Lebanon	14	11	8	4	4	0	8	15	4	12	25.2	0.0	6.0	-583	-6	1.072	1.034
Morocco	149	79	116	27	82	11	119	157	29	85	47.6	0.0	13.0	-594	10	1.054	1.017
Nigeria	184	177	18	10	8	1	19	193	11	186	3.5	0.0	10.9	-924	-37	1.050	1.047
Saudi Arabia	7,005	6,836	336	166	195	10	371	7,470	185	7,280	2.6	0.0	5.2	3,822	118	1.068	1.086
Syrian Arab Republic	29	28	3	2	0	0	3	32	2	31	1.2	0.0	27.9	-583	-6	1.100	1.069
Tunisia	29	26	5	2	6	3	6	33	2	31	8.6	0.0	55.6	-212	-7	1.160	1.095
Turkey	382	343	130	87	47	4	143	427	97	383	10.9	0.0	9.1	-3,442	-16	1.110	1.085
Yemen	1,279	1,277	12	9	2	1	13	1,343	10	1,342	0.1	0.0	23.7	906	7	1.051	1.086
Benin	108	108	0	0	0	0	0	117	0	117	0.0	0.0	0.0	-129	0	1.086	1.064
Ghana	52	51	87	5	0	0	110	58	5	57	0.7	0.0	6.1	-446	-4	1.111	1.272
Kenya	29	9	30	9	24	3	33	30	11	9	71.6	0.0	11.4	-356	-8	1.073	1.074
Mozambique	38	34	5	1	7	3	7	43	2	38	11.0	0.0	36.6	-20	-5	1.157	1.113
Malawi	1	1	1	1	0	0	1	1	1	1	0.0	0.0	100.0	-20	-1	1.103	1.064
Madagascar	14	11	8	4	4	1	8	16	4	12	26.3	0.0	13.9	-301	2	1.114	1.080
Sudan	2,176	2,176	18	18	5	5	20	2,285	20	2,285	0.0	0.0	100.0	1,664	11	1.045	1.078
Togo	85	85	2	1	1	0	2	93	2	93	0.3	0.0	62.8	-83	-5	1.104	1.057
Tanzania	93	87	21	5	16	9	23	97	7	90	7.6	0.0	54.7	-114	1	1.037	1.077
Uganda	57	57	37	35	17	17	39	61	37	61	0.1	0.0	99.6	-23	33	1.071	1.076
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
Zambia	76	76	10	1	1	1	10	77	1	77	0.0	0.0	100.0	24	-4	1.020	1.017
Zimbabwe	139	139	9	6	3	2	10	149	6	149	0.3	0.0	79.2	86	3	1.071	1.048
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	12.9	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	0.0	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	11.9	0.0	13.0	-127,636	43,174	1.047	1.053