The Methodology and Compilation of 2012 China Multi-regional Input-output Model[1]

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Abstract: This paper introduces the method and procedures on how to build the China's multi-regional input-output (CMRIO) models of 2012, with highlighting the new features on the 2012 model compilation. The entire development work for CMRIO is based on 31-province classification, with relying on each province's IO table and using the national table as the control totals. We propose a specific model based on entropy maximizing and gravity models to estimate the interregional trade coefficients. The entrepot trade is taken into account in order to compile the import-inflow non-competitive provincial tables. At the same time, the discrepancies of the CMRIO is discussed and the suggestions on future improvement are given.

Keywords: CMRIO, inter-regional trade coefficient, entropy maximizing and gravity model, regional inter-dependency

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1. Introduction

In recent years, as the gaps on economic development, industrial structure and technology level in regions in China expand, it's difficult to study regional economic characteristic and future development if only from a overall country perspective. Moreover, as marketization of China's economy deepens, interregional economic link and cooperation become closer, and influence of economic development on each other region strengthens. Thus, it's urgent to conduct research from regional economic and interrelation perspective when conducting economic research and designing policy in China. Especially, since "thirteenth five-year plan" period, to serve major national development strategy and promote coordinated development and harmonious society, many regional economic development plans are made. However, in China, quantitative research on regional economy and interregional economic interdependency is still relatively immature, one main reason of which is lacking analysis tool and data, especially systematic quantitative research—Interregional Input-Output (IRIO) model. Therefore, to strengthen research on IRIO model becomes one of the most urgent tasks, and undoubtedly it has practical significance and profound policy implication.

IRIO model is one important basic research tool on spatial economy. After Isard (1951) proposed IRIO model and applied it on regional economic interdependency study, Chenery (1953), Moses(1955), Polenske (1970), Miller (1985,1998) and Oosterhaven (1994) were successively devoted to research on IRIO model methods and applications. Due to their promotion and participation, IRIO model is developed regularly in Japan, Netherlands and EU. In recent years, IRIO model plays an important role in many countries and famous international research projects, such as EU-KLEMS and WIOD project in EU, GTAP model and database in USA, and multiregional CGE model—MMRF and TERM developed by Monash University in Australia.

In contrast, China has less experience in IRIO research. Combining survey data method and non-survey method, State Information Centre (SIC) (2005,2012) developed 1997,2002 and 2007 China's 8-region, 30-sector/17-sector multi-regional input-output (MRIO) models, which was widely applied in domestic and overseas. In mathematics calculation method, Ichimura and Wang (2007) developed China's year 1987 7-region, 9-sector model. However, since 2007, as China's interregional trade and economic link strengthens, it's more urgent to update and develop 2012 IRIO model according to the compiling year of IO table in China. To do this, we propose one new estimation model after we summarize the experience on our 1997 China's MRIO model development and systematically study various international-frontier estimation methods on interregional trade coefficient. We further study and improve the development methods and steps on China's MRIO model, then 2002,2007 and 2012 MRIO model are successively developed based on more normative theory and method. There are several characteristics in our 2002,2007 and 2012 MRIO model development: first, the entire development is based on all feasiable provinces (municipalities, autonomous regions)[2], various regional versions of MRIO model can be made after aggregating different province groups, according to needs of regional plan and policy design; second, in MRIO core work — estimating interregional trade coefficient, we propose specific models and estimation methods, based on entropy maximizing and gravity models; third, in cooperation with Department of National Accounts of National Bureau of Statistics (NBS), we modify interregional transaction matrix, adopting the basic survey data reflecting inter-province inflow and outflow in "National Input-Output Survey 2007" in 2007 MRIO model and referencing the structure in 2012 MRIO model; fourth, when conducting balance adjustment, each province's table are fully used in total control that the sum of all provinces' tables equals national table.

This paper has five sections: the first section is introduction; in the second section, theory on interregional trade flow estimation using spatial interaction model is briefly elaborated, and methods on estimating interregional trade coefficient in China's MRIO model are proposed; in the third section, methods of adjustment on each province's IO table, and problems and treatments in adjustment process are explained; in the fourth section, development and balance adjustment of China's MRIO model are described; the fifth section is conclusion.

2. Method on interregional trade coefficient estimation

IRIO model links each region's IO table according to the same sector classification that by using interregional trade data and endogenizing interregional inflow and outflow of goods and services. Therefore, IRIO model can reflect regional economic development and linkage in a country more comprehensive and systematically. Due to too much work in IRIO model development and that the requirement of basic data are often beyond the scope of regional statistic data in most countries, many scholars proposed some models that require less data. For example, Chenery-Moses model (Multiregional IO model, MRIO) and Leontief-Strout model (Pool model), and they were both widely applied[3]. However, whether MRIO or Pool model are adopted in developing China's model, the key difficulties are both estimating interregional trade coefficients. Due to the difficulty to obtain directly the coefficients through comprehensive survey in reality, it's a common calculation method on estimating interregional trade flow and calculating coefficient matrix via spatial interaction model.

Carey (1958) first used models to study human flow in society. Referring to Newton's gravity formula, he defined "gravitation principle" of spatial flow and thought that people in society as molecule in substance, the more people located in a region, the more gravity it has. Therefore, the gravity is proportional to population density, and inversely proportional to distance. Following Carey, researchers including Young

[2] In 2002 and 2007 China MRIO molde, due to IO table of Tibet province is not compiled, Tibet is not included in provinces described in this paper. Also, economic structure of Tibet is not considered in the development of China's MRIO model. And in 2012 China MRIO, Tibet provides the province table and is included in our model.

[3] More detailed description on IRIO, MRIO and pool models can be referred to "Interregional Input-Output analysis" by Zhang Yaxiong and Zhao Kun (2006).

(1924), Zipf (1947) and Anderson (1955) extended the principle and gradually extended it to calculating interregional trade coefficients in application, including Harris (1954) and Isard (1951). As gravity model was applied widely, extensive researches were conducted on specific forms of equation, weight selection, determination on economic distance and so on. Meanwhile, as transportation costs were introduced into, researches gradually extended to the choice of transport route and mode.

At the same time, some new theories were also applied in spatial interaction model, such as entropy theory and individual behavior decision theory, which have more similarity than difference contrast to gravity model (Smith, 1975). Meng Bo (2005) thought existing estimation methods can be considered from two aspects: first, whether the economic theory based on is from macro statistics level or from micro decision of individual behavior level; second, whether the principle adopted is deterministic or probabilistic.

In 1955, Anderson proposed the equation form of classic gravity model without constraint, and then he extended two single-constraint and one dual-constraint gravity models, which formed a model group. Due to lack in describing micro individual behavior, the results of gravity model were unconvincing until that the form of interregional flow estimation model deduced from entropy maximizing theory is similar with gravity model, which provides better theoretical explanation for gravity model. Wilson (1967) first adopted entropy maximizing theory to deduce the most probable distribution of interregional trade, and then he deduced calculation formula of interregional trade flow. Calculation formula deduced from entropy maximizing theory was similar with dual-constraint gravity model, which aroused discussion on consistency of various final equation forms deduced from different theories, including later polynomial logic model (McFaden,1973), and these discussion finally got confirmed.

Methods on constructing interregional trade flow matrix rose in 1970s, which were based on choice theory of individual behavior in goods trade, and these methods aimed to seek more reasonable economic theory basis for calculation results of gravity model and entropy maximizing model. The main idea is that considering individual behavioral choice in trade flow, set up function on individual's profits and preference, and make descriptive model on spatial interaction based on individual economic behavior. Decision theory based on deterministic behavior is used to analysis based on individual and group continuous behavior assumption, however, in reality individual behavioral decision is often discrete, for example, on the choice of travel mode and route. McFadden (1973) made great contribution in the field, based on predecessors' researches, and he proposed polynomial logic model in calculating interregional flow according to random utility maximization theory.

In fact, although the theories based on in making model are different, amounts of research shows that estimation equations on interregional flow that finally obtained are very similar in form. Due to the theories based on are different, the specific forms of "distance" function, the understandings of coefficients in equations, and the methods on calibration are all different. More importantly, availability of basic data required in estimating interregional trade coefficients determines future application in practical. Thus, model forms that finally used in practical return to basic forms of gravity model and entropy maximizing model, meanwhile, adopt data on interregional transport and "distance" as more as possible and treat the data accordingly.

Based on in-depth study on above estimation methods on interregional trade coefficients, methods are further modified and improved in the development of 2002,2007 and 2012 China MRIO model. According to the Wilson's ideas on entropy maximizing model and dual-constraint gravity model, below models are used in core work in non-survey method —estimation of interregional trade coefficients:

$$T_i^{rs} = A_i^r B_i^s X_i^{ro} X_i^{os} f({}^k D_i^{rs}) \quad (1)$$

and

$$A_i^r = [\sum_s B_i^s X_i^{os} f({}^k D_i^{rs})]^{-1} \quad (2)$$

$$B_i^s = [\sum_r A_i^r X_i^{ro} f({}^k D_i^{rs})]^{-1} \quad (3)$$

where T_i^{rs} is interregional trade transaction on each commodity, X_i^{ro} is total commodity i outflow from region r to all other regions, X_i^{os} is total commodity i inflow from all other regions to region s[4], $f({}^k D_i^{rs})$ is trade barrier and it is described in below equation:

$$f({}^k D_i^{rs}) = \sum_k {}^k M_i ({}^k D_i^{rs})^{-{}^k \alpha_i^s} \quad (4)$$

where ${}^k M_i$ is the quantity of commodity i delivered by transport mode k[5], ${}^k D_i^{rs}$ is spatial economic distance on delivering commodity i from region r to s by transport mode k[6], ${}^k \alpha_i^s$ is decay coefficient of distance on delivering commodity i to region s by transport mode k, which reflects the resistance extent of spatial economic distance

[4] The data is from adjusted 2002,2007 and 2012 IO tables of each province, and they are introduced in detail in section 3.

[5] Transport modes mainly include road, railway, water, air and pipeline in interregional goods trade. In estimating interregional trade coefficients, transport volume used data are mainly on road, railway and water, because the ratios of air and pipeline in all transport modes are small, and only several commodities are delivered by air and pipeline. Of course, the estimated results are adjusted by transport data on commodities delivered by air (e.g. live and fresh food) and pipeline (e.g. petrol and gas).

[6] The ideal spatial economic distance is minimum transport time among different provinces. Therefore, in practical calculation, minimum time cost distance is as approximately substituted for interregional spatial economic distance, and the distance between two provinces are represented by distance between two provincial capitals. However, due to treatment on basic data, in 2002 and 2007 MRIO model only railway distance between two provincial capitals is calculated, where we assume that spatial economic distance of road and water is equal to that of railway, and in 2012 MRIO model road distance is also calculated and we assue that spatial economic distance of water is equal to that of average of railway and road.

on trade activity. In the condition that other conditions remain unchanged, a larger ${}^{k}\alpha_i^s$ means smaller trade quantity between two regions, and vice versa.

${}^{k}\alpha_i^s$ can be solved in linear programming via average distance of some transport modes. For each transport mode, average distance of commodity i in region s delivered from other regions can be calculated by following formula:

$$\frac{\sum_{i,r} {}^{k}C_i^{rs}\, {}^{k}d_i^{rs}}{\sum_{i,r} {}^{k}C_i^{rs}} = {}^{k}\bar{d}^{s} \qquad (5)$$

$$\text{s.t.} \quad C_i^{rs} \geq 0$$

where ${}^{k}C_i^{rs}$ is the quantity of commodity i delivered from region r to s by transport mode k, ${}^{k}\bar{d}^{s}$ is average distance on delivering commodity from other regions to region s by transport mode k, which equals to goods turnover divided by inflow. ${}^{k}C_i^{rs}$ can be described by following gravity model:

$${}^{k}C_i^{rs} = {}^{k}K^{s} \cdot {}^{k}C_i^{ro} \cdot {}^{k}C_i^{os} \cdot ({}^{k}d_{\mathrm{i}}^{rs})^{-{}^{k}\alpha_{\mathrm{i}}^{s}} \qquad (6)$$

where ${}^{k}C_i^{ro}$ is outflow of commodity i from region r, ${}^{k}C_i^{os}$ is inflow of commodity i in region s, ${}^{k}d_{\mathrm{i}}^{rs}$ is distance from region r to s, ${}^{k}K^{s}$ is ratio coefficient.

Substituting equation (5) into (6), the most suitable ${}^{k}\alpha_i^s$ that satisfy equation (6) can be solved by linear programming[7].

3. Adjustment to Provincial Input-Output Tables

One feature of the method for compiling China's MRIO models for 2012 is that it takes full advantage of the information in all provincial tables. Although the IO tables for provinces are improving continuously in term of the details of trade data, they still need to be further divided and be converted to import-inflow non-competitive input-output tables.

3.1. Adjustment to trade data in the input-output tables for provinces

According to the completeness of included data on the trade with other provinces and countries, we divided provincial tables into three categories: four-column tables,

[7] Due to the limitation of basic data, we made some simplifications in the estimation. One simplification is to only use the aggregated railway transport data of each commodity, because the most suitable ${}^{k}\alpha_i^s$ are always the same. Another simplification is for ${}^{k}\bar{d}^{s}$, we only use the average of the distances between each two provincial capitals, but not the average distance on delivering commodity from other regions to region s by different transport modes.

two-column tables and one-column tables. Four-column tables have four data columns – “inflow”, “outflow”[8], “import” and “export”. Two-column tables have only two columns – “inflow + import” and “outflow + export”. One-column tables have only one column – “net outflow” (outflow + export – inflow - import) or “net inflow” (inflow + import – outflow - export). Provinces using these different types of forms are shown in Table 1. Compared with 2002 and 2007, provincial input-output tables in 2012 have improved gradually in term of the level of details of trade data.

Table 1: Comparison between trade data in provincial input-output tables for 2002 , 2007 and 2012

	2002	2007	2012
Four-column tables	**12 tables:** Liaoning, Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Guangdong, Hainan, Anhui, Guangxi and Xinjiang	**20 tables:** Liaoning, Beijing, Tianjin, Hebei, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Hainan, Anhui, Jiangxi, Guangxi, Chongqing, Yunnan, Gansu, Ningxia, Qinghai and Xinjiang	**28 tables:** Liaoning, Beijing, Tianjin, Hebei, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Hainan, Anhui, Jiangxi, Guangxi, Chongqing, Yunnan, Gansu, Ningxia, Jilin, Henan, Shanxi, Hunan, Shaanxi, Guizhou and Sichuan , Heilongjiang, Xizang and Xinjiang
Two-column tables	**13 tables:** Jilin, Fujian, Henan, Shanxi, Hunan, Hubei, Jiangxi, Inner Mongolia, Qinghai[9], Gansu, Ningxia, Shaanxi and Yunnan	**9 tables:** Jilin, Henan, Shanxi, Hunan, Hubei, Inner Mongolia, Shaanxi, Guizhou and Sichuan	**3 tables:** Inner Mongolia, Hubei and Qinghai
One-column tables	**5 tables:** Heilongjiang, Shandong, Sichuan, Chongqing and Guizhou	**1 table:** Heilongjiang	

Four-column tables have already contained the basic trade data information we need, and such information can be directly used without adjustment. Thus, the adjustment to provincial tables starts with two-column tables. In the process of expanding two-column tables into four-column tables, we need to introduce provincial foreign trade data for the corresponding years. Firstly, we need to set up a converter between the Customs 8-digit (or 10-digit) HS coding classification[10] and the input-output industry classification. Then, we need to collect, merge and classify the provincial

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[8] “Inflow” and “outflow” refer to the domestic trade between the province and other provinces.

[9] The table for Qinghai province for 2002 is actually a three-column table – “outflow + export”, “inflow” and “import”.

[10] China’s Customs organizes provincial import and export data in two ways — by place of destination of import and by place of origin of export and by location of the importer or exporter. As far as the needs from input-output models are concerned, the first method meets the needs better.

import and export data (previously classified by goods) from the Customs by input-output industries, and then estimate the value of imports and exports in service trade, and implement corresponding price treatment[11] to produce an import column and an export column for provincial tables. Lastly, we use the "inflow + import" column and the "outflow + export" column of the provincial tables to deduct the import and export columns respectively to obtain an inflow column and an outflow column.

One-column tables have only one column of "net outflow" or "net inflow" data and do not have data on the total value of each industry or control totals. In addition, this column may contain error adjustment items. As a result, data in this column cannot be used to distinguish between inflow, outflow, import and export columns, or as aggregate control. In this case, we can only use Customs import and export data to estimate the import and export columns respectively. Meanwhile, we can use the structure of four-column tables of neighboring provinces in the same economic region to estimate the inflow and outflow columns. Then we can make some adjustments using the "net outflow" or "net inflow" data already in the provincial tables as control.

3.2. Adjustment to provincial non-competitive input-output tables

So far, all the input-output tables prepared and published by the National Bureau of Statistics have been the import competitive type, and the same is true with those for individual provinces. However, in order to develop interregional input-output models, we not only need to convert provincial tables to non-competitive import forms, but also need to convert them further to import-inflow non-competitive ones.

To simplify the conversion, we assumed that the distribution structures of the products imported or flowing into individual provinces are the same as that of the local products, so that we can establish provincial import and inflow matrixes based on the import and inflow values of products, and then develop non-competitive import-inflow tables for individual provinces by deducting the import and inflow values from the intermediate and final demand of provincial tables.

3.3. Problems arising in the adjustment process and solutions

(1) Input-output trade data inconsistent with Customs trade data

During the adjustment of two-column tables, the Customs trade data for individual provinces are used to produce data for the “import” and “export” columns, and the “inflow + import" and “outflow + export” columns of provincial tables are used to generate the “inflow” and “outflow” columns. However, it is noted in the actual calculation process that the values in the “inflow” and “outflow” columns for some sectors may be negative after the deduction of import or export data, which means the

[11] The export prices of commodities listed in the national and provincial input-output tables are FOBs minus trade and transport margins (TTM) in China and the import prices are CIFs plus tariffs. In contrast, the Customs calculates the value of exports using FOBs and the value of imports CIFs. For this reason, the TTM in China should be deducted when calculating the values of exports for provinces using Customs data and the parts deducted should be merged and used as the export data for the trade industry and the transportation industry. Likewise, tariffs should be added when calculating the values of imports for provinces using Customs data.

Customs trade data do not match the input-output trade data. Taking for example provinces in 2007 adopting four-column tables (Table 2), the Customs data for some provinces are far less than their input-output data (e.g., export data of Beijing and Hainan and import data of Yunnan and Gansu), while on the other hand the Customs data for other provinces are far greater than their input-output data (e.g., export data of Shandong, Yunnan and Xinjiang and import data of Tianjin, Shandong, Xinjiang and Hainan).

Certain differences are expected between Customs trade data and input-output data. This may result from: (a) the variances arising in the process of merging and classifying Customs import and export data originally classified under the HS coding system by input and output sectors; (b) the inclusion of service trade data as well as commodity import and export data in the input-output data. In contrast, Customs data contains only commodity import and export data; (c) price differences between the two sets of data[12]. However, these factors are not sufficient to cause such large differences between the Customs trade data and the input-output data for provinces.

Table 2: Comparison between total Customs import and export value and input-output data for provinces adopting four-column tables for 2007[13]

	Customs data (100 million RMB)		Input-output table data (100 million RMB)		Customs data/input-output data	
	Export	Import	Export	Import	Export	Import
Beijing	2,300	3,939	4,363	3,676	0.53	1.07
Tianjin	2,908	2,845	2,240	1,647	1.30	1.73
Shandong	5,949	4,760	2,207	2,345	2.70	2.03
Guangdong	28,388	21,215	17,835	21,453	1.59	0.99
Hainan	126	412	290	16	0.44	25.99
Yunnan	324	344	182	657	1.78	0.52
Gansu	128	316	121	2,023	1.06	0.16
Xinjiang	818	357	278	150	2.94	2.38

Note: Data for the service industry is not included in the input-output table data here.

When looking for solutions to this problem, we retained the data provided in the provincial input-output tables wherever possible. Namely, we deducted the import and export data calculated using Customs trade data from the “inflow + import” and “outflow + export” columns of two-column tables for individual provinces to generate the “inflow" and “outflow" columns. When the “inflow” or “outflow” values are negative, we adjust the corresponding import figures to make them equal to “inflow + import” or the “export” figures to make them equal to "outflow + export”, and set the

[12] If only price difference is considered, the Customs import data should be smaller than the input-output import data, while the Customs export data should be greater than the input-output export data.

[13] The provincial import and export data are respectively classified by by place of destination of import and by place of origin of export, and the RMB central parity in 2007 is used (1 USD=7.6044RMB).

corresponding “inflow” or “outflow" values as zero. We used this method also because two-column tables are mainly compiled by inland provinces, where the shares of inflows and outflows are relatively small.

(2) Adjustment to provincial processing trade and “re-export” data

When estimating data for provincial import-inflow non-competitive input-output tables, we found that if import and inflow data are respectively deducted from the intermediate and final demands, some elements of the intermediate or final demand matrix or even the sum of the intermediate demand or final demand for some industries may be negative. This means that even if all products used in a province are imported or inflow products, it is impossible to use up all the products, and this is obviously inconsistent with the facts. As for four-column tables, as we directly used the data in the import and inflow columns of provincial tables, we believe that there is no data inconsistency due to the use of different data sources. After carefully checking the provincial input-output tables, we noted two major issues in 2002,2007 and 2012 MRIO models:

Firstly, in some coastal provinces with big sizes of economy and trade such as Guangdong, Jiangsu and Fujian, some sectors have engaged in large amounts of external and inter-provincial trade activities although they already have large production capacities (e.g. the manufacture of communication equipment, computer and other electronic equipment in Jiangsu province, the manufacture of measuring instrument and machinery for cultural activity & office work in Fujian and Guangdong provinces, and the manufacture of textile wearing apparel, footwear, caps, leather, fur, feather (down) and its products and manufacture of general purpose and special purpose machinery industries in Guangdong province). The product use in these provinces (intermediate use + final use) is less than the aggregate of imports and inflows, and the total output is less than the aggregate of exports and outflows. Secondly, in some inland provinces, such as Chongqing, Yunnan and Qinghai, as some sectors’ production capacities are very small, products needed by these provinces mainly come from imports and inflows, but these provinces also export or ship out to other provinces some products. Therefore, the product use in these provinces (intermediate use + final use) is also less than the aggregate of their imports and inflows and their total output is also less than the aggregate of their exports and outflows. The causes of the above phenomena may be: Firstly, different from national tables, provincial tables did not exclude processing and assembling trade figures in their import and export data, and the differences in data sources have resulted in excessively large values of foreign trade; secondly, part of the products imported or flowing from other countries or provinces to these provinces may be exported or may flow to other provinces through the so-called “re-export” trade[14]. That is to say, we have deducted the imports or inflows not used in the provinces from the intermediate use and final use.

[14] The “re-export” trade refers to the trade in which products imported from other countries or coming in from other provinces are directly exported or directly flow to a third province instead of being consumed within the province.

Table 3: Provinces and sectors having processing and "re-export" trade (100 million RMB)

Province	Input-output sector	Import + Inflow (1)	Export + Outflow (2)	In-province intermediate use + final use (3)	Total output (4)	(3)/(1)	(4)/(2)
Jiangsu	Manufacture of communication equipment, computer and other electronic equipment	6,540.5	8,995.8	6,001.7	8,456.8	0.9	0.9
Fujian	Manufacture of measuring instrument and machinery for cultural activity & office work	267.9	239.7	193.0	164.9	0.7	0.7
Guangdong	Manufacture of textile wearing apparel, footwear, caps, leather, fur, feather (down) and its products	1,798.2	3,828.7	1,299.0	3,329.5	0.7	0.9
	Manufacture of general purpose and special purpose machinery	4,118.6	4,413.4	2,499.2	2,794.0	0.6	0.6
	Manufacture of measuring instrument and machinery for cultural activity & office work	2,823.6	2,988.6	1,377.6	1,542.6	0.5	0.5
Chongqing	Manufacture of artwork, other manufacture	68.8	39.9	38.3	9.5	0.6	0.2
Yunnan	Manufacture of artwork, other manufacture	26.0	14.0	18.4	6.4	0.7	0.5
Qinghai	Processing of petroleum, coking, processing of nuclear fuel	14.5	9.0	9.5	4.0	0.7	0.4

To solve this problem once and for all, we need Customs processing trade data and "re-export" trade data classified by province and product as well as data on "re-export" trade between domestic provinces. As we have little or even no such statistics, we used the following method and achieved good results. No negative value occurred again concerning the intermediate use and final use in any sector. Our method is based on the assumption that part of the imports and inflows is used for exports and outflows and is thus deducted. The share of this part of imports and inflows is the ratio of exports and outflows to intermediate use and final use.

4. Construction of MRIO Models for China and Balance Adjustment

In construction of 2002 , 2007 and 2012 China MRIO models, we adopted the classification methodology used by the National Bureau of Statistics for input-output sectors. We aggregated some of the service industries, so that the models are classified at 29-industry level (see appendix table for detail). This sector classification methodology is basically comparable to that used for the MRIO model for China for

1997, allowing for the establishment of a series of China MRIO models. The regional division for the 2002 ,2007 and 2012 models are identical to that for the 1997 model. All research and development work for the MRIO models, however, is based on separate information on all feasible provinces, allowing for different combinations in regional division and thus the establishment of MRIO models for different regions.

4.1. Construction of preliminary MRIO models

As per the technical route shown in Figure 1 for the construction of the MRIO models for China and based on the adjusted import-inflow non-competitive input-output tables for individual provinces as well as estimated interregional trade coefficients, the Chenery-Moses Model can be used to develop a preliminary MRIO model via the formula described as follows:

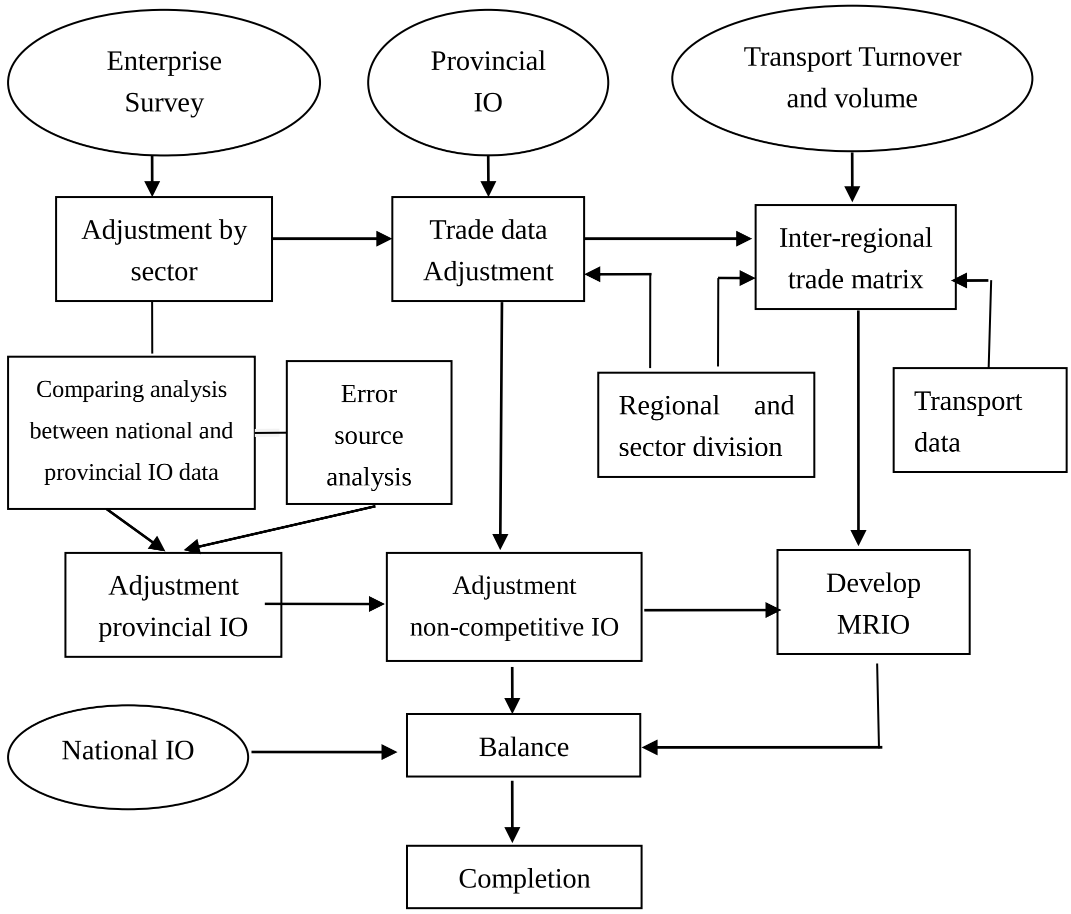
$$T*\left[x_{ij}^{d}\right]+T*F^{d}+E=X \quad (8)$$

where, F^{d} is each region's final demand, E is each region's export vector, X is the gross output, $\left[x_{ij}^{d}\right]$ is the matrix for each region's direct input of domestic products, and T is the matrix for the coefficient of interregional trade, consisting of diagonal matrix $\widehat{T}^{rs}$, where the diagonal elements t_{i}^{rs} are the shares of products produced by industry *i* flowing to region *s* from region *r* to all products produced by that industry flowing to region *s*, representing in the formula below.

$$t_{i}^{rs}=\frac{T_{i}^{rs}}{\sum_{r}T_{i}^{rs}} \quad (9)$$

where, t_{i}^{rs} is the elements in the interregional trade matrix.

Figure 1: Technical route for construction of MRIO models for China



Based on formulas (8) and (9), a preliminary interregional intermediate and final use flow matrix can be developed. Then, by consolidating the calculation results from the above formulas with each province's data on intermediate and final use in inflow-import non-competitive input-output tables, we could obtain a preliminary MRIO model for China.

4.2. Balance adjustment

Since China uses a multi-level accounting system in its national economic account, there are often big differences between the aggregate of data in provincial input-output tables and the data in the national input-output tables. The result of simply adding together the data in the input-output tables for all provinces does not match the national input-output table in terms of both the control totals and the structures. China's MRIO model should reflect not only structural information of all regions, but also basic information on national aggregate. Thus, we need to conduct balance adjustment to preliminary estimates using the RAS method, with the national table being used as the control. In addition, we need to revise the interregional intermediate and final use flow matrix inferred from trade coefficients against the results of inflows and outflows between provinces available from the "National Input-Output Survey 2007". We have also adjusted trade data during the development of the model. Therefore, it is a very important and technically challenging job to find the appropriate method to consider the various balance relations in the MRIO models, to calculate various control data, and to minimize errors during the development of models.

For an input-output model, there are two kinds of basic balances: row-wise balance ("intermediate demand" + "final demand" = "total output") and column-wise balance ("intermediate input" + "primary input (value added)" = "total input"). These two basic balances are interrelated, not independent of each other. Therefore, we have two ways to implement balance adjustment to MRIO models: the first method is to calculate "intermediate demand", "intermediate input", "final demand", "primary input (value added)" and "total output" ("total input") for each industry of each province separately, and to conduct adjustment in row-wise by means of the "error term", thus achieving row-wise balance; the other method is to calculate "intermediate input" and "primary input (value added)" separately and then add them together to produce the "total input", thus achieving column-wise balance. Then we can achieve row-wise balance by adjusting "intermediate demand", "final demand" and the "error term".

As the "primary input (value added)" is actually the income side GDP, which is more reliable than "total input", we adopt the latter method to implement balance adjustment to China's MRIO model, based on the primary inputs of industries of provinces. The result turns out to be good, and errors are effectively controlled.

We also have two methods to separately calculate control totals for the MRIO model with the national table being used as the control and provincial tables as the structure. Take for example the calculation of " value added ". In the first method, we use the national " value added " of a certain sector as the control and the "value added" of each provincial of this sector as the share to calculate, this sector’s "value added" of each province in the MRIO models, namely, splitting the " value added " of a sector in the national table into the " value added" of the same sector in all feasible provinces. The other method is first to work out each province’s aggregate "value added" based on the share of each province’s aggregate "value added" in the aggregate "value added" of all provinces with the national aggregate "value added" being used as the control. Then using each province’s aggregate “value added” as the control, we calculate each sector’s “value added” based on the share of the value added of each sector of each province. The difference between the two methods is that in the former method, the national figure is equal to the aggregate of sector figures of all provinces of one certain sector, but the structure of sectors in a provincial table is not retained; in contrast, the latter method retains the structure of sectors in a provincial table, but the sector figures of all provinces do not add up to the figure in the national table. To ensure the conformity of the aggregate of sectoral figures in the MRIO model with the figure in the national table, we adopted the first method.

As the MRIO model for China incorporates a huge amount of data including national input-output data, provincial input-output data, Customs data and transportation data, errors are unavoidable. Errors are primarily from the following sources: ① the processes of converting provincial tables to "four-column" tables and estimating data for non-competitive import-inflow tables; ② the calculation of control totals of sectors of provinces; ③ When we use the national input-output table as the control, the total inputs are calculated by adding together the intermediate inputs and the primary inputs (value added), so discrepancies with the intermediate uses and the final uses[15] are unavoidable; ④ original errors in provincial input-output tables. After passing through all the steps in the development of the model, all these errors are finally reflected in the error term. As we carefully considered and repeatedly tried a lot of methods during the development of the model, we have brought errors under effective control. As a result, we have made only minor adjustment to the error term using the expertise, and completed the development of MRIO models for China.

5. Conclusion

This paper has proposed a new model for estimating interregional trade coefficients, systematically summarized our research methodology and the development of MRIO models in recent years, and tried to standardize the process of model development. The structure of the interregional input-output model makes it difficult to have relatively complete and accurate statistical data base, thus to develop the model, the survey of statistical data must be supported by scientific estimating methods. The questions that this paper attempts to answer include how to reasonably calculate data without statistical base, how to establish technical routes for model development and a set of reasonable methods for tackling problems, how to control errors during estimation, and how to conduct balance adjustment. Certainly, these problems differ from each other in nature. For instance, the method for estimating interregional trade coefficients is more theoretical, while those methods for addressing some specific problems and balance adjustment require an enormous amount of experience in compiling tables. In particular, the development of interregional input-output models is a very labor-, fund- and resource-consuming task, thus entailing close cooperation between specialists of different technical backgrounds. Also, strong and continuous in-depth research and support are needed for this work.

Luckily, we have a cooperative team, and have received great support from the Department of National Accounts in NBS. These factors have contributed greatly to the successful completion of the current work. Although we have used best endeavors in the course of methodology research and model development, obviously many things still need to be improved and refined. Such imperfections relate to the determination of interregional spatial and economic distance, the methods to better use transportation statistical data, the adjustment to provincial non-competitive import-inflow tables, the treatment of processing trade and "re-export" trade data as well as the service trade.

National and provincial input-output tables are the basis and necessity for the development of interregional input-output models. In the process of using national and provincial input-output tables, a thought came to our mind that, if more work could be done to reconcile the works of development of national and provincial input-output tables, or if more help could be offered to aid the development of

[15] The method of separately adjusting balance for “public consumption” and “inventory” can also produce errors.

provincial tables, our work should become easier.

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Appendix Table：Sector Classification of China MRIO Tables

1	Agriculture, Forestry, Animal Husbandry & Fishery
2	Mining and Washing of Coal
3	Extraction of Petroleum and Natural Gas
4	Mining of Metal Ores
5	Mining and Processing of Nonmetal Ores and Other Ores
6	Manufacture of Foods and Tobacco
7	Manufacture of Textile
8	Manufacture of Textile Wearing Apparel, Footwear, Caps, Leather, Fur, Feather(Down) and Its products
9	Processing of Timbers and Manufacture of Furniture
10	Papermaking, Printing and Manufacture of Articles for Culture, Education and Sports Activities
11	Processing of Petroleum, Coking, Processing of Nuclear Fuel
12	Chemical Industry
13	Manufacture of Nonmetallic Mineral Products
14	Smelting and Rolling of Metals
15	Manufacture of Metal Products
16	Manufacture of General Purpose and Special Purpose Machinery
17	Manufacture of Transport Equipment
18	Manufacture of Electrical Machinery and Equipment
19	Manufacture of Communication Equipment, Computer and Other Electronic Equipment
20	Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work
21	Manufacture of Artwork, Other Manufacture
22	Scrap and Waste
23	Production and Supply of Electric Power and Heat Power
24	Production and Distribution of Gas
25	Production and Distribution of Water
26	Construction
27	Traffic, Transport and Storage
28	Wholesale and Retail Trades
29	Other service sector