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THE COMPILATION OF CHINA'S INTERREGIONAL INPUT–OUTPUT MODEL 2002

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The increasing economic interaction among various regions in China makes the construction of an interregional input–output table relevant for economic studies. This paper elaborates the model compilation procedure of the China Interregional Input–output model 2002. The key features of the model compilation include: (1) using representative commodities to estimate the interregional commodity flows of the primary industries; (2) adopting functions to estimate the decreasing interregional transportation of manufacturing sectors in relation to distance and (3) selecting appropriate indicators to estimate the interregional commodity flows of non-material sectors. This study is an initial attempt in interregional input–output modelling and might be helpful for economic studies at the levels of micro-regions.

Keywords: Economic modeling; Interregional input–output model; Interregional trade; China IRIO

1. INTRODUCTION

The deepening interdependence between regions in China stresses the role of economic interaction as one of the essential factors affecting regional economic development. Hence, the Interregional Input–Output (IRIO) model has become a useful quantitative technique for interregional economic studies and the compilation of a Chinese IRIO table is therefore of great significance in enhancing the development of interregional economic studies in China.

The main approaches to estimate interregional trade data include the survey approach, the non-survey approach and hybrid approaches. Although the data obtained by means of the survey approach are generally of high reliability, its high requirement on manpower, financial cost and time constrains its application. There are only a few studies that applied the survey approach to build IRIO tables (Kauppila, 1999; Genereux and Langen, 2002).

The emergence of the non-survey approach using economic models to estimate interregional trade effectively remedied the drawbacks of the survey approach. These methods have been widely applied (Oosterhaven et al., 2008; Bonfiglio and Chelli, 2008; Miyagawa et al., 2008). The representative interregional trade estimating models include the Isard

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model (Isard, 1951), the Chenery–Moses model (Chenery, 1953; Moses, 1955), the pool-approach model (Leontief and Strout, 1963) and the gravity model (Leontief and Strout, 1963). Compared with the other models, the Chenery–Moses model has the advantage of low data requirements and high precision (Polenske, 1970; Liu and Okamoto, 2002; Zhang and Li, 2004), and thus effectively facilitated the development of IRIO tables.

Although the non-survey approach can be conveniently applied, it is usually weak in accuracy and reliability. To overcome this shortcoming, at the late phase of model development using the non-survey approach, the model developers often incorporate some non-model information, such as data from a small-scale survey targeting at a specific issue, or subtle adjustments based on experts' judgements. This approach is often called the hybrid approach (also known as the partial survey approach or semi-survey approach). Since the hybrid approach has advantages related to both the survey approach and the non-survey approach, many studies have applied a hybrid approach to estimate interregional trade in recent years (Verdura, 1995; Okamoto and Zhang, 2003; Ichimura and Wang, 2003; Meng and Ando, 2005; Okamoto and Ihara, 2005; Kuwamori and Meng, 2006; Zhang and Zhao, 2006; Li et al., 2010; Escobedo and Oosterhaven, 2011). Hitherto, the only three IRIO tables for China (constructed by ICSEAD/DRC in 2003; by IDE-JETRO, 2003; and by IDE-JETRO/SIC in 2006) all adopted hybrid approaches.¹ In our view, the information provided by these models is becoming insufficient, because of the following reasons.

- (1) The existing China IRIO models are merely at the 'economic region' (or 'zone') level. For a very large country like China, in which the spatial distribution of activity and resources is very uneven, the zonal division (see Figure 1) is too coarse to obtain a comprehensive picture of interregional economic connections. Such IRIO models might overlook internal economic interactions and disparities within 'zones'. Since provinces are the most basic and active units in economic activities in China, a province-level model is more pertinent to reflect the actual interregional economic conditions in China.
- (2) Most existing IRIO tables focus on 'material' sectors (primary and manufacturing industries) rather than 'non-material' sectors (services). In recent years tertiary industries have developed rapidly. According to the *China Statistical Yearbook, 2014* (National Bureau of Statistics of China, 2014), the contribution of the tertiary industries to GDP increased from 32.4% in 1990 to 46.9% in 2013. With the service sectors becoming very important components in the national economic system, the increasing interregional trade by these sectors should be fully taken into account in the compilation of the IRIO table.

This study aims at filling these gaps by compiling a province-level IRIO model, including more detail for non-material sectors. There were three major obstacles hindering the compilation of such IRIO models. First, we faced a lack of sufficient basic data to support the model compilation. A lot of investigations were required to obtain such data, partly

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¹ ICSEAD: The International Centre for the Study of East Asian Development, Japan; DRC: Development Research Center of State Council, China; SIC: State Information Center, China; IDE-JETRO: Institute of Developing Economies of the Japan External Trade Organization, Japan.

FIGURE 1. The geographic distribution of the ‘zones’ in China and the economic heterogeneity within ‘zones’ in 2002.

Note: GDP in mln Yuan.
Source for provincial GDP: *China Statistical Yearbook, 2003*.

due to the complexity of China interregional economic structure. Second, we had to deal with difficulties in appropriately recognizing and differentiating between sectoral trade characteristics and, third, we had to solve problems in measuring interregional trade of non-material sectors. Trade data of non-material sectors are notoriously difficult to obtain since the interregional trade of non-material happens ‘invisibly’. The selection of proper indicators for this type of trade was an inevitable challenge.

The contribution of this study is to provide valuable technological references to overcome the above obstacles in the IRIO model compilation for the scholars doing similar studies. Our Chinese IRIO model for 2002 (China IRIO-2002, see Table 1) is a province-level IRIO model with non-material sectors representing a relatively low level of aggregation. In its compilation, the framework of the Chenery–Moses model was used, following a hybrid approach.

TABLE 1. Layout of China IRIO-2002.

Output Input			Intermediate Use						Domestic Final Use			Export	Import	Error	Total Output	
			Region 1			...	Region m			Region 1	...					Region m
			Sector1...Sector n				Sector1...Sector n									
Intermediate Input	Region 1		Sector1 ... Sector n			$x_{11}^{11} \quad \cdots \quad x_{1n}^{11}$ $\vdots \quad \cdots \quad \vdots$ $x_{n1}^{11} \quad \cdots \quad x_{nn}^{11}$	$\cdots$	$x_{11}^{1m} \quad \cdots \quad x_{1n}^{1m}$ $\vdots \quad \cdots \quad \vdots$ $x_{n1}^{1m} \quad \cdots \quad x_{nn}^{1m}$	F_1^{11} $\cdots$ F_n^{11}	$\cdots$	F_1^{1m} $\cdots$ F_n^{1m}	E_1^1 $\cdots$ E_n^1	M_1^1 $\cdots$ M_n^1	$error_1^1$ $\cdots$ $error_n^1$	X_1^1 $\cdots$ X_n^1	
	$\vdots$	$\vdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	
	Region m		Sector1 ... Sector n			$x_{11}^{m1} \quad \cdots \quad x_{1n}^{m1}$ $\vdots \quad \cdots \quad \vdots$ $x_{n1}^{m1} \quad \cdots \quad x_{nn}^{m1}$	$\cdots$	$x_{11}^{mm} \quad \cdots \quad x_{1n}^{mm}$ $\vdots \quad \cdots \quad \vdots$ $x_{n1}^{mm} \quad \cdots \quad x_{nn}^{mm}$	F_1^{m1} $\cdots$ F_n^{m1}	$\cdots$	F_1^{mm} $\cdots$ F_n^{mm}	E_1^m $\cdots$ E_n^m	M_1^m $\cdots$ M_n^m	$error_1^m$ $\cdots$ $error_n^m$	X_1^m $\cdots$ X_n^m	
	Value Added			$V_1^1 \quad \cdots \quad V_n^1$	$\cdots$	$V_1^m \quad \cdots \quad V_n^m$										
Total Input			$X_1^1 \quad \cdots \quad X_n^1$	$\cdots$	$X_1^m \quad \cdots \quad X_n^m$											

This paper is structured as follows. Section 2 briefly introduces the relevant data sources, the basic presumptions and the estimation methodology. The model compilation procedure is explicitly described in Section 3. A sensitivity analysis is conducted in Section 4 to test how much deviations from the ‘manually preset’ choices will affect the results. Section 5 concludes.

2. DATA AND METHODOLOGY

2.1. Data

The main data source of this study is the set of 2002 input–output tables for the 30 provinces in China (National Bureau of Statistics of China, 2008). The 30 provinces include 22 ‘true’ provinces, 4 municipalities and 4 autonomous regions. For simplicity, these 30 administrative entities are all called ‘provinces’ in this study. Hong Kong, Macao, Taiwan and Tibet are not included due to data unavailability. The spatial distribution and the Gross Regional Product levels of the provinces are shown in Figure 1. The 60 sectors include 31 material sectors and 29 non-material sectors (Appendix 1). The interregional commodity flows of primary industries are estimated using interregional transportation data (by railway, water and air) of eight commodities (grain, timber, coal, petroleum, metal ore, salt, non-metal minerals, phosphorite) which are considered to be representative commodities.

For the non-material sectors, the interregional trade of electricity is based on *Electric Industry Statistic Information Compilation 2002* (China Electricity Council, 2002) and *China Statistical Yearbook 2003* (National Bureau of Statistics of China, 2003a). The interregional trade of transportation sectors is based on interregional transportation data of via railway, water and air. We presume that most service sectors are not engaged in interregional trade, except for sector 48 (Wholesale and Retail Trades), sector 49 (Hotels and Catering Services), sector 53 (Tourism), sector 54 (Scientific Research) and sector 57 (Education). Considering the high correlation between inward interregional passenger transportation and the level of accommodation provision, catering services as well as tourism, interregional passenger transportation (including railway and air) data are used to estimate interregional trade of sector 49 (Hotels and Catering Services) and sector 53 (Tourism). The interregional trade of sector 54 (Scientific Research) is based on the data of the transaction value in the markets for technology in each province, as taken from the National Bureau of Statistics of China (2003a). The interregional trade of sector 57 (Education) is based on the number of students who matriculated through the National Matriculation Test in each province.

2.2. Methodology

The compilation of China IRIO-2002 is based on the Chenery–Moses model. In the Chenery–Moses approach, the technical input structure of production in each region and the interregional trade structure of various products are separately built into the model. Suppose there are m regions, with n sectors in each region. The basic mathematical

structure of the Chenery–Moses system can then be expressed as follows:

$$\mathbf{C} \cdot \mathbf{A}\mathbf{X} + \mathbf{C} \cdot \mathbf{F} + \mathbf{E} - \mathbf{M} = \mathbf{X}, \quad (1)$$

$$\text{where } \mathbf{A}\mathbf{X} = \begin{bmatrix} \mathbf{A}^1 \mathbf{X}^1 & 0 & \dots & 0 \\ 0 & \mathbf{A}^r \mathbf{X}^r & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \mathbf{A}^m \mathbf{X}^m \end{bmatrix}, \quad (2)$$

$\mathbf{X}^r$ denotes the total output matrix of region r and has dimensions $n \times n$. Its typical element x_i^r denotes the gross output of sector i in region r ; $\mathbf{A}^r$ denotes the $n \times n$ technology matrix of region r , with a_{ij}^r being the direct input of sector i to sector j per unit of output of sector j in region r . $\mathbf{A}^r \mathbf{X}^r$ is actually the intermediate use matrix of region r .

The interregional trade coefficient matrix $\mathbf{C}$ consists of the diagonal matrix $\hat{\mathbf{C}}^{rs}$:

$$\mathbf{C} = \begin{bmatrix} \hat{\mathbf{C}}^{11} & \dots & \hat{\mathbf{C}}^{1m} \\ \vdots & \hat{\mathbf{C}}^{rs} & \vdots \\ \hat{\mathbf{C}}^{m1} & \dots & \hat{\mathbf{C}}^{mm} \end{bmatrix}, \quad (3)$$

$$\text{with } \hat{\mathbf{C}}^{rs} = \begin{bmatrix} c_1^{rs} & 0 & \dots & 0 \\ 0 & c_i^{rs} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & c_n^{rs} \end{bmatrix}, \quad (4)$$

where c_i^{rs} is the proportion of trade from region r to region s in the total trade of region r . The matrix $\mathbf{C}\mathbf{A}\mathbf{X}$ describes the sources of intermediate inputs as well as the distribution of intermediate use for sectors across regions

$$\mathbf{E} = \begin{bmatrix} \hat{\mathbf{E}}^1 & 0 & \dots & 0 \\ 0 & \hat{\mathbf{E}}^r & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \hat{\mathbf{E}}^m \end{bmatrix}, \quad \mathbf{M} = \begin{bmatrix} \hat{\mathbf{M}}^1 & 0 & \dots & 0 \\ 0 & \hat{\mathbf{M}}^r & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \hat{\mathbf{M}}^m \end{bmatrix}. \quad (5)$$

$\hat{\mathbf{E}}^r$ and $\hat{\mathbf{M}}^r$ denote the diagonal matrices of region r 's exports and imports, respectively. The input for the production of $\mathbf{E}^r$ can be from local sources, from other provinces or from foreign countries, while $\mathbf{M}^r$ only represents 'true imports', i.e. purchases from foreign suppliers

$$\mathbf{F} = \begin{bmatrix} \mathbf{f}^1 & & & \\ & \ddots & & \\ & & \mathbf{f}^r & \\ & & & \ddots \\ & & & & \mathbf{f}^m \end{bmatrix}, \quad (6)$$

$\mathbf{f}^r$ is the final demand vector of region r with n elements f_i^r , which denotes the final demand for product i in region r .

The crucial step in applying the Chenery–Moses model is the determination of the interregional trade coefficient c_i^{rs} , which is given by

$$c_i^{rs} = \frac{t_i^{rs}}{\sum_r t_i^{rs}}, \quad (7)$$

where t_i^{rs} is the interregional trade of product i from region r to region s .

The main assumption of the Chenery–Moses model is that every sector in region s consumes the same proportion of product i imported from region r . Therefore, in the compilation of the IRIO table, only the data of interregional trade for each product are required and there is no need to estimate the full trade matrices.

The estimation of interregional trade t_i^{rs} is based on the gravity model (see, e.g. Leontief and Strout, 1963) which supposes a negative correlation between bilateral trade flows and geographic distance, and a positive correlation between these trade flows and the market sizes of the selling and the purchasing regions:

$$t_i^{rs} = \frac{x_i^r y_i^s}{\sum_r x_i^r} q_i^{rs}, \quad (8)$$

where t_i^{rs} is the trade of sector i from region r to region s ; x_i^r is the total output of sector i in region r ; y_i^s is the total demand of region s for the product of sector i ; q_i^{rs} is the interregional trade parameter (a friction coefficient) for sector i from region r to region s .

The estimation of the trade parameters q_i^{rs} is crucial in the determination of interregional trade. In this study, a proportionality assumption on the distribution of interregional commodity flows is used to calculate trade parameters q_i^{rs} (Ihara, 1979 and 1996, Liu and Okamoto, 2002). This method assumes that the interregional flows of representative commodities can substitute for the distributional proportions of the interregional commodity flows, which can be used to construct the interregional trade parameters q_i^{rs} :

$$q_i^{rs} = \frac{h_i^{rs}}{(h_i^{ro} h_i^{os} / h_i^{oo})}, \quad (9)$$

where h_i^{rs} is the interregional flow of representative commodity of sector i from region r to region s ; h_i^{ro} is the total outflow of sector i in region r ; h_i^{os} is the total inflow of sector i in region s and h_i^{oo} is the total outflow of sector i in all the regions.

3. THE MODEL COMPILATION PROCEDURES

The interregional trade estimation starts from the estimation of sectoral interregional commodity flows h_i^{rs} in Equation 10. The patterns of interregional commodity flows differ significantly across sectors. Hence, different approaches should be adopted targeting specific sectoral properties, and understanding of sectors is an essential requirement for devising an appropriate estimation procedure. In this study, the sectors are categorized into several groups according to their specific characteristics (Figure 2).

FIGURE 2. Sector category in the estimation of interregional commodity flows.

FIGURE 3. Approaches to estimate interregional commodity flows of material sectors.

3.1. Material Sectors

The category of material sectors is further divided into manufacturing sectors and primary industries. Sector group-specific approaches are applied to estimate interregional commodity flows, see Figure 3.

(1) Manufacturing sectors

The rates at which the interregional commodity flows decrease with distance can differ markedly across manufacturing sectors. For the light industrial sectors (such as the manufacture of textiles and wearing apparel), distance is not the crucial factor affecting their interregional commodity flows, since their products can be conveniently transported to external markets at a relatively low transportation cost. On the contrary, the interregional commodity flows of sectors with ‘hard-to-transport’ products (such as metal products, electrical machinery and equipment) decrease at a high rate, due to their high transportation

TABLE 2. The categorisation of manufacturing sectors in the interregional commodity flow estimation.

Sector code	Sector name	Group
12	Manufacture of textile	VL
13	Manufacture of textile wearing apparel and leather	
29	Manufacture of measuring instruments	L
28	Manufacture of communication equipment and computers	
30	Manufacture of machinery for cultural activity and office work	M
11	Manufacture of foods	
16	Processing of petroleum and coking	H
21	Manufacture of special purpose machinery	
22	Manufacture of railroad transport equipment	VH
24	Manufacture of parts and accessories for motor vehicles	
25	Manufacture of ships	H
17	Manufacture of raw chemical materials and chemical products	
23	Manufacture of motor vehicles	VH
14	Manufacture of timber and furniture	
15	Manufacture of paper, printing, paper articles and toys	H
20	Manufacture of metal products	
26	Manufacture of other transport equipment	VH
27	Manufacture of electrical machinery and equipment	
31	Other manufacturing sectors	H
32	Recycling and disposal of waste	

cost. Furthermore, sectors mainly depending on sales to local markets are also identified as having a high rate of decrease with distance. In this study, we categorize the manufacturing sectors into five groups, according to the rate of decrease of their sales flows with distance: very high (VH), high (H), medium (M), low (L) and very low (VL). Table 2 presents the categorization.

Then, the decreasing curves (which share many properties with gravity equations) for each group are derived, based on an integration of the non-survey approach and mathematical deduction. There are three basic presumptions in the determination of the mathematical functions of the decreasing curves. First, the shapes of the curves are assumed to be exponential, like in previous studies (Black, 1973; Erlander and Stewart, 1990). Second, the five curves start from the same point (400 km, 17,000 ton), which reflects the underlying assumption that interregional commodity flows do not decline with distance as long as these are smaller than 400 km. The figure is determined based on average interprovincial distances and data on provincial freight transportation (*China Statistical Yearbook*, 2003). Third, each of the five decreasing curves is assumed to go through one of five presupposed points, the coordinates of which are, respectively: (1,000 km, 3,000 ton), (1,000 km, 6,000 ton), (1,000 km, 8,000 ton), (1,000 km, 12,000 ton) and (1,000 km, 16,000 ton). These five points are based on a combination of our expertise knowledge of sector properties and referential data (National Bureau of Statistics of China, 2003b, China Communications and Transportation Association, 2003). After knowing the starting point, the presupposed points and the exponent function pattern, the preliminary shapes of the five decreasing curves are determined (see Figure 4). Next, the data of total commodity flows are adjusted to be consistent with the curves' mathematical functions, which complete the preliminary estimation of interregional commodity flows. A rationality test on the preliminary results

FIGURE 4. The preliminary determination of the five decreasing curves.

is conducted to judge whether the preliminary results are acceptable or still need further adjustments. This rationality test includes two parts. One is the test on ‘flow direction’ of each manufacturing sector in each province. For example, for a region like Beijing, which is poor in energy resources, its processing of the petroleum and coking industry should have a net inflow of oil. The other part is the test on flow quantities for each manufacturing sector in each province relative to its total output. If a sector has low output but quite high ‘net outflow’, the rationality test fails. If any sector fails in the rationality test, the choice of presupposed points is adjusted and all the above procedures are repeated once again. The process is continued until all the results passed the rationality test and thus the interregional commodity flows of manufacturing sectors were determined.

(2) Primary industries

The interregional commodity flows of primary industries have been estimated based on interregional transportation data via railroad, river and air. Since these transport data are

TABLE 3. Correspondence of primary industries and the representative commodities.

Sectors	Representative Commodities
1. Agricultural sectors	Grain
2. Forestry	Timber
3. Logging and transport of timber and bamboo	Timber
7. Mining and washing of coal	Coal
8. Extraction of petroleum and natural gas	Petroleum
9. Mining and processing of metal ores	Metal ore
10. Mining and processing of non-metal ores	Salt, non-metal minerals and phosphorite

TABLE 4. Approaches for estimating interregional commodity flows of non-material sectors.

Sectortype	Sector code	Data sources	Approaches
Electricity supply	33	Electric industry statistic information Compilation 2002, <i>China Statistical Yearbook 2003</i>	Step 1. Categorize all the provinces into four groups according to the network distribution of the electricity supply in China. (1) Northeast China (including Liaoning, Jilin and Heilongjiang). (2) North China (including Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia). (3) Northwest China (including Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang). (4) Other part of China (including Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou and Yunnan). Step 2. Assume electricity is only traded across the provinces within each group (This assumption is necessary because it fits the actual pattern of China's electricity consumption.) Step 3. Distribute the electricity across provinces according to the amount of gross provincial products
Transportation	37	Interregional Railway Transportation data 2002	Transpose the matrix of railway passenger transportation turnover
	38		Transpose the matrix of railway freight transportation turnover
	39		Transpose the matrix of railway freight transportation turnover
	41		Transpose the matrix of water freight transportation turnover
	42		Transpose the matrix of air passenger transportation turnover
	43		Transpose the matrix of air freight transportation turnover
Specified service sectors	48	Interregional Railway Transportation data 2002	The matrix of railway freight transportation

(Continued).

TABLE 4. Continued.

Sectortype	Sector code	Data sources	Approaches
Scientific research	49	<i>China Statistical Yearbook 2003</i>	Step 1. Aggregate the matrix of railway passenger transportation with the matrix of air passenger transportation. Step 2. Transpose the aggregated matrix.
	53		Step 1. Aggregate the matrix of railway passenger transportation with the matrix of air passenger transportation. Step 2. Transpose the aggregated matrix.
	54		Take the data of 'the transaction value in technical market of each province' as the data foundation. Step 1. Use the data of the technology inflows (contracts) in technical market of each province as the total inflows of scientific research of each province. Step 2. Distribute each province's total inflows according to their interior expenditure on technology.
Education	57	<i>China Statistic Yearbook 2003</i> Relevant websites	Step 1. Select 11 typical provinces (Beijing, Tianjin, Shanghai, Jiangsu, Zhenjiang, Shandong, Henan, Hubei, Guangdong, Sichuan, and Shaanxi) as the study area. Step 2. Take the number of students matriculated through National Matriculation Test in each province as the total outflows of each province. Step 3. Distribute the outflows across provinces, using the ratio of (Educational expenditure $\times$ provincial Gross Domestic Product)/distance

confined to eight representative commodities (grain, timber, coal, petroleum, metal ore, salt, non-metallic minerals and phosphorite), we linked each of the primary industries to one of these commodities (Table 3).

3.2. Non-material Sectors

Reliable data for non-material sector trade are difficult to obtain since trade in non-material products happens 'invisibly'. In our estimation, indicators are selected to represent the interregional flows of non-material sectors. However, this estimation is still constrained by data limitations. Twelve non-material sectors are assumed to have interregional commodity trade, based on sector characteristics and available data. The non-material sectors

that are assumed to have no interregional trade can be roughly classified into three types: (1) sectors having no or negligible interregional trade, (almost) by definition, such as urban public traffic (sector 40), storage (sector 45), health and social security (sector 58), etc. (2) sectors having interregional trade but only limited to specified regions, such as production and supply of gas and water (sector 34 and sector 35) and (3) sectors having interregional trade but the relevant data are inaccessible, such as construction (sector 36), information transmission and computer services (sector 47), and leasing and business service (sector 52). According to the approaches applied in estimating interregional commodity flows, the 12 non-material sectors assumed to have interregional commodity trade are categorized into five main types: electricity supply, transportation, specified service sectors, scientific research and education. The approaches used to estimate the interregional commodity flows of non-material sectors are elaborated in Table 4. In the estimation of the interregional commodity flows for hotels and catering services (sector 49) and tourism (sector 53), passenger transportation data are used as representative indicators since the across-region consumptions on hotel, catering and tourism usually happen when people travel to another place (by train or plane). This will not cause repeated calculation with interregional trade of transportation sectors in that the interregional trade of transportation sector refers to the journey part (before arriving at the destination) which is separate with the consumption on the services of hotel, catering and tourism.

After completing the estimation of interregional commodity flows h_i^{rs} of all the sectors, the trade parameter q_i^{rs} , interregional trade t_i^{rs} and interregional trade coefficient c_i^{rs} can be obtained in succession by means of Equations 10, 9 and 8. In the final step, China IRIO-2002 can be obtained through matrix multiplication according to Equation 1.

FIGURE 5. The impacts of changing starting point on the shape of curve L.

4. SENSITIVITY TEST

As explained in Section 3.1, a non-survey approach is adopted to determine the shapes of the decreasing curves in the estimation of the commodity flows of manufacturing sectors. The presumption on the two points crossed by the curves determines the mathematical functions of the curves and thus affects the final estimation results. In other words, the estimation results of the IRIO model closely relate to the 'manual-preset' parameters drawn from referential statistics and experts' judgements. Hence, questions like 'how much will the final results be affected when the manual-preset points deviating from the ones adopted in this study?' Consequently, we carry out a sensitivity test to inspect the model's response to the variations in the preset parameters, which have been set using as much expertise as possible.

Changing the coordinate of the first or the second point can impact the shape of the decreasing curves. Taking curve L as an example, its curve shape changes correspondingly when the starting point decreases and increases by 2%, 5% and 8% (Figure 5). Similar changes can be mimicked by changing the preset value of the first point.

In the sensitivity test, the starting points of the five curves are firstly adjusted to a deviation from the original positions (measured by the coordinates of the points) by a certain percentage. Then the shapes of the five curves are changed accordingly, resulting in the

TABLE 5. Average impacts on the results (change the starting point).

Curve type	Average impacts on the results		Changes of the starting point					
			- 8%	- 5%	- 2%	+ 2%	+ 5%	+ 8%
VL	Direct impacts	h_i^{rs}	20.8%	5.4%	11.0%	- 4.6%	4.6%	27.4%
	Indirect impacts	q_i^{rs}	- 1.9%	0.8%	0.8%	- 4.6%	- 4.6%	- 6.2%
		t_i^{rs}	- 1.8%	0.8%	0.8%	- 4.2%	- 4.5%	- 6.2%
	Final impacts	c_i^{rs}	- 1.8%	0.7%	0.7%	- 0.9%	- 4.2%	- 5.1%
L	Direct impacts	h_i^{rs}	69.2%	78.3%	53.3%	36.1%	45.1%	27.8%
	Indirect impacts	q_i^{rs}	7.5%	16.6%	2.0%	- 3.4%	3.4%	- 8.7%
		t_i^{rs}	6.5%	14.6%	1.7%	- 3.1%	3.1%	- 7.8%
	Final impacts	c_i^{rs}	4.4%	10.3%	1.0%	- 2.0%	2.0%	- 4.5%
M	Direct impacts	h_i^{rs}	66.2%	43.4%	26.3%	15.4%	- 26.0%	- 26.0%
	Indirect impacts	q_i^{rs}	6.7%	21.7%	- 11.8%	- 19.2%	- 17.6%	- 17.6%
		t_i^{rs}	5.6%	15.5%	- 7.6%	- 12.9%	- 10.3%	12.7%
	Final impacts	c_i^{rs}	4.9%	11.6%	- 2.9%	- 6.9%	4.0%	- 10.3%
H	Direct impacts	h_i^{rs}	96.0%	68.8%	43.8%	36.2%	- 31.0%	- 37.7%
	Indirect impacts	q_i^{rs}	14.0%	- 3.8%	- 3.8%	- 23.2%	- 31.0%	- 37.7%
		t_i^{rs}	8.2%	- 3.8%	- 3.8%	- 23.2%	- 24.5%	- 31.2%
	Final impacts	c_i^{rs}	8.2%	2.2%	2.2%	- 12.8%	12.9%	12.1%
VH	Direct impacts	h_i^{rs}	35.0%	22.8%	- 46.8%	- 57.4%	- 61.6%	- 65.1%
	Indirect impacts	q_i^{rs}	- 32.1%	21.5%	- 31.5%	- 39.2%	- 42.3%	- 44.9%
		t_i^{rs}	- 20.9%	15.3%	- 13.9%	- 23.3%	- 27.1%	- 30.5%
	Final impacts	c_i^{rs}	- 1.5%	13.7%	11.6%	- 9.5%	- 14.0%	- 17.5%

TABLE 6. Average impacts on the results (change the second point).

Curve type	Average impacts on the results		Changes of the second point					
			− 8%	− 5%	− 2%	+ 2%	+ 5%	+ 8%
VL	Direct impacts	h_i^{rs}	− 17.0%	− 4.6%	− 4.6%	13.2%	11.0%	30.0%
	Indirect impacts	q_i^{rs}	− 6.7%	− 4.6%	− 4.6%	− 3.1%	− 3.1%	− 1.8%
		t_i^{rs}	− 6.7%	− 4.2%	− 4.2%	− 3.1%	− 3.1%	− 1.8%
	Final impacts	c_i^{rs}	− 5.3%	− 0.1%	− 2.7%	− 3.1%	− 3.1%	− 1.9%
L	Direct impacts	h_i^{rs}	− 13.9%	14.5%	12.6%	56.4%	88.0%	129.2%
	Indirect impacts	q_i^{rs}	− 12.3%	− 8.7%	4.9%	2.0%	7.5%	12.8%
		t_i^{rs}	− 6.7%	− 7.8%	4.3%	1.7%	6.5%	11.2%
	Final impacts	c_i^{rs}	− 0.3%	− 4.5%	2.4%	1.0%	4.4%	8.3%
M	Direct impacts	h_i^{rs}	− 37.3%	− 26.0%	− 19.2%	57.8%	87.2%	125.6%
	Indirect impacts	q_i^{rs}	− 25.7%	− 17.6%	13.3%	− 3.5%	6.7%	15.6%
		t_i^{rs}	− 24.5%	− 10.3%	− 12.9%	− 1.6%	5.6%	12.0%
	Final impacts	c_i^{rs}	− 15.9%	− 0.4%	− 6.9%	1.5%	4.9%	12.4%
H	Direct impacts	h_i^{rs}	− 48.7%	− 37.7%	33.7%	87.6%	123.1%	169.6%
	Indirect impacts	q_i^{rs}	− 48.7%	− 37.7%	− 23.2%	− 3.8%	14.0%	27.6%
		t_i^{rs}	− 42.2%	− 31.2%	− 23.2%	− 3.8%	8.2%	22.2%
	Final impacts	c_i^{rs}	− 13.6%	− 1.8%	− 16.8%	2.2%	8.2%	15.2%
VH	Direct impacts	h_i^{rs}	− 73.2%	− 68.2%	− 84.2%	− 46.9%	57.3%	128.1%
	Indirect impacts	q_i^{rs}	− 50.9%	− 47.2%	37.4%	− 31.5%	− 32.1%	15.2%
		t_i^{rs}	− 48.8%	− 39.1%	24.3%	− 13.9%	− 20.9%	− 11.2%
	Final impacts	c_i^{rs}	− 19.4%	− 17.4%	− 11.6%	13.9%	− 1.5%	− 6.0%

direct impacts on the commodity flow (h_i^{rs}). The changes on commodity flow can lead to impacts on the interregional trade parameter (q_i^{rs}), interregional trade (t_i^{rs}) and interregional trade coefficient (c_i^{rs}) through Equations 10, 9 and 8, respectively. According to the order in which the parameters are affected, the impacts on the commodity flow (h_i^{rs}) are called ‘direct impacts’; the impacts on the interregional trade parameter (q_i^{rs}) and interregional trade (t_i^{rs}) are called ‘indirect impacts’ and the impacts on interregional trade coefficient (c_i^{rs}) are called ‘final impacts’.

We use the average impacts on these parameters to depict the general impacts induced by the changes of the curve points (Tables 5 and 6). It can be seen from Table 5 that the commodity flow (h_i^{rs}) reveals a large fluctuation from 4.6% to 96% directly responding to the changes in the starting point. With the mathematical calculation continuing, the indirect impacts show a declining tendency, with impacts on interregional trade parameter (q_i^{rs}) ranging from 0.8% to 44.9% and interregional trade (t_i^{rs}) ranging from 0.8% to 31.2%. In the end, the final impacts on the result stabilize at a range no higher than 20%. The impacts of the changes in the second point on these parameters turn out to be similar (Table 6): the commodity flow greatly fluctuates ranging from 4.6% to 169.6%, whereas the impacts on the final results stay within a range of 20% around the original value.

The test outcomes verify the stability of the result of the model estimation. Although the deviations of the ‘manual-preset’ parameters can affect the model estimation result, the impacts on the results are not dramatically high.

5. CONCLUDING REMARKS

This paper elaborates the model compilation procedure of China IRIO-2002. We highlight the key features of the model compilation. First, the utilization of representative commodities to estimate the interregional commodity flows of the primary industries provides an efficient way to reduce data requirements and thus alleviates the complexity of the procedure. Second, the adoption of decreasing curves to estimate the interregional transportation of manufacturing sectors in relation to distance may overcome the difficulty of unavailable transportation data in manufacturing sectors. Third, the selection of appropriate indicators to estimate the interregional commodity flows of non-material sectors made it possible to quantify interregional non-material product flows.

We conducted a sensitivity test to find out whether the final outcome of the model will be greatly impacted by the deviations of the 'manual-preset' parameters in the estimation of manufacture commodity flows. The sensitivity test outcomes indicate that the impacts of the deviations of the 'manual-preset' parameters on the model results are not higher than 20%.

The China IRIO-2002 compilation as described in this study might provide useful inspiration for developing IRIO models at the levels of micro-regions.

Note: China IRIO-2002 is available for the international research community. In our book *China Interregional Input-output model and Interregional Economic Connections* (in Chinese), a simplified version of China IRIO-2002 (20-sector division) is provided in the accompanying CD. The version with full detail (60 sectors) can be obtained by contacting the authors.

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Appendix 1. Sectors in China IRIO-2002

Types	Sectors
Material sectors	1. Agriculture 2. Forestry 3. Logging and Transport of Timber and Bamboo 4. Animal Husbandry 5. Fishery 6. Services in Support of Agriculture 7. Mining and Washing of Coal 8. Extraction of Petroleum and Natural Gas 9. Mining and Processing of Metal Ores 10. Mining and Processing of Nonmetal Ores 11. Manufacture of Foods 12. Manufacture of Textile 13. Manufacture of Textile Wearing Apparel and Leather 14. Manufacture of Timber and Furniture 15. Manufacture of Paper, Printing, Paper Articles and toys 16. Processing of Petroleum and Coking 17. Manufacture of Raw Chemical Materials and Chemical Products 18. Manufacture of Non-metallic Mineral Products 19. Smelting and Pressing of Metals 20. Manufacture of Metal Products 21. Manufacture of Special Purpose Machinery 22. Manufacture of Railroad Transport Equipment 23. Manufacture of Motor Vehicles 24. Manufacture of Parts and Accessories for Motor Vehicles 25. Manufacture of Ships 26. Manufacture of Other Transport Equipment 27. Manufacture of Electrical Machinery and d Equipment 28. Manufacture of Communication Equipment and computers 29. Manufacture of Measuring Instruments 30. Manufacture of Machinery for Cultural Activity and Office work 31. Other Manufacturing Sectors
Non-material sectors	32. Recycling and Disposal of Waste 33. Production and Supply of Electric Power and Heat Power 34. Production and Supply of Gas 35. Production and Supply of Water 36. Construction 37. Passenger Transport via Railway 38. Freight Transport via Railway 39. Transport via Road 40. Urban Public Traffic 41. Water Transport 42. Air Passenger Transport 43. Air Freight Transport 44. Transport via Pipeline 45. Storage 46. Post 47. Information Transmission and Computer Services

(Continued).

Appendix 1. Continued.

Types	Sectors
	48. Wholesale and Retail Trades
	49. Hotels and Catering Services
	50. Financial Intermediation and Insurance
	51. Real Estate
	52. Leasing and Business Services
	53. Tourism
	54. Scientific Research
	55. Technical Services , Geophysical Prospecting and Water Conservancy
	56. Public Facility Management and Household Services
	57. Education
	58. Health and Social Security
	59. Cultural, Media, Sport and Entertainment
	60. Public Management and Services