Construction of a Global Input-Output Table Embedding Chinese Provincial Multi-Regional Input-Output Table

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Abstract

As the global value chain (GVC) continues to extend to the sub-national regions within the economies, the domestic value chain between Chinese provinces is also nesting into the global value chain. This study aims to construct a global input-output table with Chinese provincial multi-regional input-output (MRIO) table embedded. Three database sources are used: (1) global input-output table of 2017 sourced from the GTAP database; (2) Chinese provincial MRIO table of 2017; (3) China's custom data distinguishing domestic provinces and destination countries of 2017. The construction process is as follows. First of all, we construct a China's provincial MRIO, which contains 31 Chinese mainland provinces and 42 sectors. Secondly, the two sector classifications of China's provincial MRIO and GTAP IO table are mapped, and according to the strength of economic linkages between China and the other economies, the regions in GTAP database are merged into 15 economies. Thirdly, the Chinese customs data are mapped into the consistent sector classification we get above. Finally, we embed the Chinese provincial MRIO table into the global input-output table by adjusting China's provincial MRIO table with the GTAP global input-output table used as the controlling numbers. Thus, we could get a Global Input-Output Table including Chinese provinces.

Keywords: Multi-regional input-output, GTAP, Chinese provinces

1 Introduction

With the development of domestic regional integration and the continuous formation of

opening-up pattern, the economic linkages between Chinese provinces, and those between the provinces and international economies are both becoming closer and closer. As the global value chain (GVC) continues to extend to the sub-national regions within the economies, the domestic value chain between Chinese provinces is also nesting into the global value chain. Many studies of global value chain mainly rely on the inter-country input-output tables to construct the GVC framework, but there is no systematic model or database that links the global input-output table with the sub-national input-output tables, so as to effectively depict the systematic circular flows of international and domestic value chains.

To fill this gap, this study aims to build a global multi-regional input-output table with Chinese provinces embedded. Considering the match of the available years of the MRIOT databases, as well as the availability of the relevant satellite accounts, we choose to adopt the GTAP database to build the global MRIOT. Combining with Chinese provincial MRIOT and China's customs data, a global MRIOT embedding Chinese provinces will be constructed.

The remains of the paper are organized as follows. In section 2, the three databases involved will be introduced. Section 3 will show the detailed methods and procedures of how to construct a global MRIOT with Chinese provinces embodied, which will be followed by an illustrative example of the provinces-embedded MRIOT. Finally, conclusions will be given in section 5.

2 Databases

2.1 GTAP database relevant for MRIO Analysis

The GTAP database has IOTs at its core, and provide MRIOTs based on additional information. However, the GTAP MRIOT 2017 is not available yet. We therefore need to construct a global MRIOT based on the relevant data provided in GTAP v11. In IOA, basic prices are usually preferred (European Communities, 2008) but this price system is not available in GTAP. GTAP has two valuation conventions: 'Agent Prices' are what the purchaser pays and 'Market Prices' are the agent prices less commodity taxes. Because market prices include domestic margins as inputs into the production process, they are not basic prices. However, the GTAP market prices are closest to the basic price system preferred in IOA. For international trade data the GTAP database provides import duties, various export subsidies, and international margins, and this allows conversion between different price systems (cf. Oosterhaven et al., 2008). In

this study, data of the year 2017 from GTAP 11 Data Bases is adopted, which covers 142 countries and regions as well as 65 sectors.

2.2 Chinese provincial MRIOT

The Chinese provincial MRIOT of the year 2017 adopted in this study is taken from the Development Research Center of the State Council of China. The MRIOT is built based on the officially-released single regional input-output tables of Chinese provinces, as well as the customs data and railway transportation data. The inter-provincial trade flows are estimated using gravity model, and balanced by the minimizing cross entropy method. Similar with the GTAP database, the Chinese provincial MRIOT dose note include the information for distributing the interprovincial inflows and international imports over the agents. Therefore, the interprovincial and international trade is mapped with the BEC classification so that they can be distributed over the agents more reasonably. Figure 1 shows the format of the Chinese provincial MRIOT.

		Intermediate Use			Final Use				Total output
		Beijing	……	Xinjiang	Beijing	……	Xinjiang	Export	
Intermediate input	Beijing								
	……								
	Xinjiang								
	Import								
Initial input									
Total input									

Figure 1. Chinese provincial MRIOT

2.3 China's customs data

The Chinese customs data used in this study is at the HS 8-digit level (8564 commodities in total), including imports and exports of Chinese provinces in 2017. The destination countries of provincial exports and the source countries of provincial imports can be tracked in the database. FOB prices are used for exports and CIF prices are used for imports.

3 Embedding the Chinese provincial MRIOT into global MRIOT

3.1 Construction of global MRIOT

This study follows the method provided in Glen et al (2011) to convert the IO-relevant variables in the GTAP database into a global MRIOT, with some improvement in distributing imports and international transportation. First, the GTAP

variables are converted into an MRIO model with international transportation being exogenous. Although GTAP has provided imports data (hence exports) at the sector level, it does not track which sector has used the imported commodities. Therefore, to convert the GTAP database into an MRIOT, one has to include assumptions to estimate the information needed if there are not additional data. Glen et al (2011) assumes that the bilateral trade data is proportionally distributed across the consuming sectors, which is a widely adopted assumption in building the MRIO model. This study goes one step further to improve upon this assumption by taking the proportions from the GTAP MRIOT 2014 provided by the GTAP team (Carrico, 2020)[1], which has included the HStoBECtoSNA concordances to distribute the imports over sectors. The correspondence between the GTAP variables and the MRIO model is shown in Table 1 below.

Table 1. Correspondence between GTAP database and MRIOT

GTAP database	MRIOT	Description
$vdfm$	Z^{rr}	diagonal matrices of intermediate use
$vifm, vxmd$	Z^{rs}	off-diagonal matrices of intermediate use
$vd*m$	y^{rr}	diagonal matrices of final demand
$vifm, vxmd$	y^{rs}	off-diagonal matrices of final demand
vom	x^{r}	total output
$vfm, tax, margins, subsidy$	v^{r}	value added
vst	t^{r}	international transportation pool

Second, the international transportation pool is converted endogenously by distributing it to the suppliers by the proportions of the GTAP MRIOT 2014. In addition, according to the volume of trade, the countries and regions are aggregated to 15 (see Table 2).

Table 2. List of aggregated countries and regions

No.	Countries and Regions	Abbr.
1	China	CHN
2	Australia	AUS
3	New Zealand	NZL
4	Japan	JPN
5	the Republic of Korea	KOR
6	India	IND

[1] As stated in Carrico (2020), the GTAP team will provide an updated MRIOT in the 11th version of GTAP database, which is, however, not ready for now. We therefore take the proportions in the MRIOT 2014 temporarily, and will update to the new-releasing version when it is ready.

7	ASEAN	ASEAN
8	USA	USA
9	Canada	CAN
10	Mexico	MEX
11	European Union (excluding Germany)	EU
12	Germany	DEU
13	UK	UK
14	Russia	RUS
15	Rest of the world	ROW

Figure 2 shows the format of the global MRIOT 2017 built by this study.

		Intermediate Use			**Final Use**			**Total output**
		China	**……**	**USA**	**China**	**……**	**USA**	
Intermediate input	**China**							
	……							
	USA							
Initial input								
Total input								

Figure 2. Global MRIOT 2017

3.2 Concordance of the sector classifications

To embedding the Chinese provincial MRIOT in to the global MRIOT, the two sector classifications need to be mapped. According to the definition of the sectors, the sectors are aggregated to 18 consistent sectors (see Table 3).

Table 3. List of the aggregated sectors

No.	**Sector name**
A01	Agri
A02	Mining
A03	Food and Tobacco
A04	Textile
A05	Furniture
A06	Paper and Printing
A07	Petroleum coking ,nuclear fuel processing products, and chemical products
A08	Chemical products
A09	Mineral products
A10	Metal smelting and products
A11	Equipment Manufacture
A12	Electronic Instruments
A13	Other Manufacture
A14	Electricity, Gas manufacture, distribution and Water
A15	Construction

A16	Service for Production
A17	Service for Life
A18	Public Service

3.3 Processing of China's customs data

(1) HS-IO correspondence relationship processing

The HS-IO Correspondence Table compiled internally involves the HS 8-digit codes of a total of 8564 kinds of commodities, of which 115 categories of commodities correspond to multiple input-output sectors, and the remaining commodities only correspond to one input-output sector. Among these 115 commodities, 114 categories correspond to 2 input-output sectors, each accounting for 50%; the low-value simple customs clearance commodity (98040000) corresponds to 11 input-output sectors, and the percentage of conversion in each sector is determined according to the percentage in Table1.1. The corresponding proportions between the remaining products and the IO sectors are both 100%.

(2) HS-BEC correspondence relationship processing

According to the BEC classification of HS 8-digit code commodities, the trade data is divided into intermediate goods, final consumption goods and final investment goods. Among them, the processing import trade totally belongs to intermediate goods.

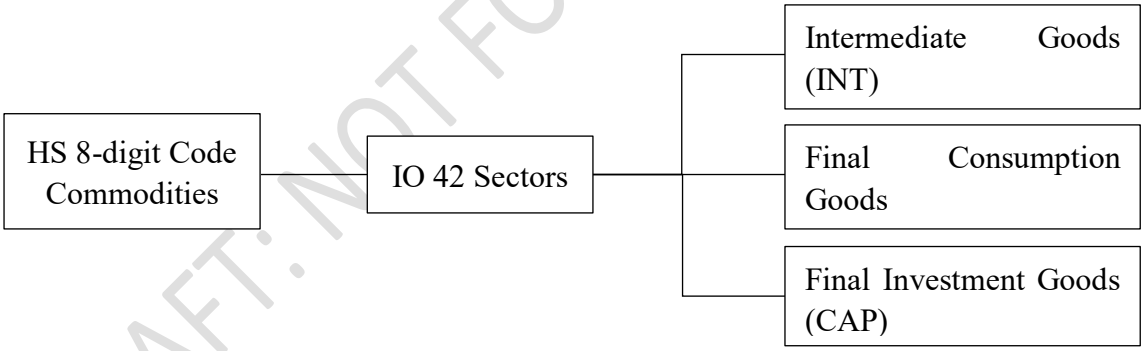


Figure 3. HS-IO-BEC Correspondence

(3) Summarizing by province and industry

The corresponding results are summarized according to the IO sector and the administrative region where the production is located (including 42 input-output sectors and 31 provincial administrative regions in total). The information on trading partner countries, trade methods, and company registration types are retained, and data can be extracted later according to specific needs.

3.4 Harmonizing the MRIO-relevant accounts across the databases

The Chinese provincial MRIOT of the year 2017 is then embedded into the global MRIOT 2017 by harmonizing the matrices at the Chinese provincial level with the corresponding control values from the global MRIOT. The idea of the harmonization is shown in Figure 4. Matrices in orange and blue will be harmonized to the control values from the global MRIOT. The initial values of those in orange color are taken from the Chinese provincial MRIOT, while the initial values of those in blue color are estimated from the Chinese customs data. The arrows show the correspondence between the provincial level matrices and the control values from the global MRIOT. A model based on the minimizing cross entropy method is then constructed to harmonizing the MRIOT (eq 1).

$$min(e) \qquad \text{eq 1}$$

$$s.t.\begin{cases} \sum_{s=1}^{31}\sum_{r=1}^{31} Z^{s,r} = {Z_g}^{c,c} \\ \sum_{s=1}^{31}\sum_{r=1}^{31} Y^{s,r} = {Y_g}^{c,c} \\ \sum_{r=1}^{31} V^{r} = {V_g}^{c,c} \\ \sum_{r=1}^{31} X^{r} = {X_g}^{c,c} \\ \sum_{r=1}^{31} Z^{s,r} = {Z_g}^{s,c} (s = 32, \dots, 45) \\ \sum_{s=1}^{31} Z^{s,r} = {Z_g}^{c,r} (r = 32, \dots, 45) \\ \sum_{r=1}^{31} Y^{s,r} = {Y_g}^{s,c} (s = 32, \dots, 45) \\ \sum_{s=1}^{31} Y^{s,r} = {Y_g}^{c,r} (r = 32, \dots, 45) \end{cases}$$

where e represents the objective function, which is built based on the definition of cross entropy (eq 2).

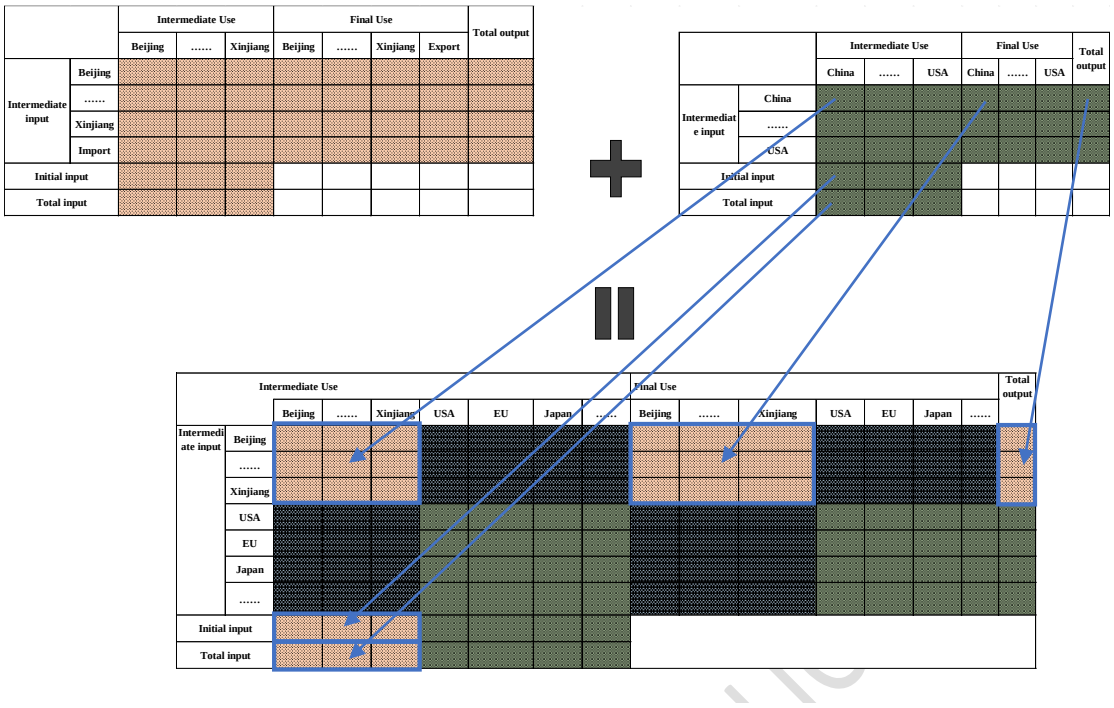
eq 2

$$
\begin{aligned}
e = & \sum_{s=1}^{31}\sum_{r=1}^{31}\sum_{m=1}^{18}\sum_{n=1}^{18} z_{m,n}^{s,r}\left(ln\, z_{m,n}^{s,r} - ln\, \bar{z}_{m,n}^{s,r}\right) \\
& + \sum_{s=1}^{31}\sum_{r=1}^{31}\sum_{m=1}^{18}\sum_{f=1}^{5} y_{m,f}^{s,r}\left(ln\, y_{m,f}^{s,r} - ln\, \bar{y}_{m,f}^{s,r}\right) \\
& + \sum_{r=1}^{31}\sum_{m=1}^{18} v_m^r(ln\, v_m^r - ln\, \bar{v}_m^r) \\
& + \sum_{r=1}^{31}\sum_{m=1}^{18} x_m^r(ln\, x_m^r - ln\, \bar{x}_m^r) \\
& + \sum_{s=32}^{45}\sum_{r=1}^{31}\sum_{m=1}^{18}\sum_{n=1}^{18} z_{m,n}^{s,r}\left(ln\, z_{m,n}^{s,r} - ln\, \bar{z}_{m,n}^{s,r}\right) \\
& + \sum_{s=1}^{31}\sum_{r=32}^{45}\sum_{m=1}^{18}\sum_{n=1}^{18} z_{m,n}^{s,r}\left(ln\, z_{m,n}^{s,r} - ln\, \bar{z}_{m,n}^{s,r}\right) \\
& + \sum_{s=32}^{45}\sum_{r=1}^{31}\sum_{m=1}^{18}\sum_{f=1}^{5} y_{m,f}^{s,r}\left(ln\, y_{m,f}^{s,r} - ln\, \bar{y}_{m,f}^{s,r}\right) \\
& + \sum_{s=1}^{31}\sum_{r=32}^{45}\sum_{m=1}^{18}\sum_{f=1}^{5} y_{m,f}^{s,r}\left(ln\, y_{m,f}^{s,r} - ln\, \bar{y}_{m,f}^{s,r}\right)
\end{aligned}
$$

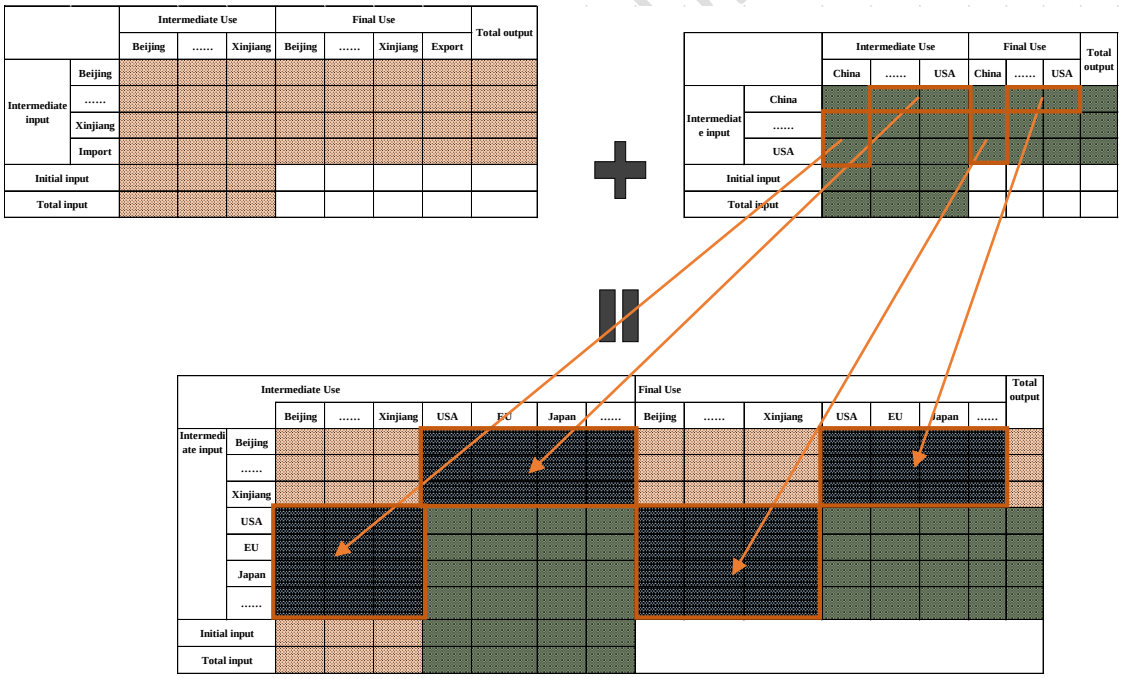
The meanings of the notations in eq 1 and eq 2 are shown in Table 4.

Table 4. Notation conventions

Notations	Meaning
Z	Intermediate use, of which the elements are $z_{m,n}^{s,r}$.
Y	Final demand, of which the elements are $y_{m,f}^{s,r}$.
V	Value added, of which the elements are v_m^r.
X	Total output, of which the elements are x_m^r.
$*_g$	Variables in global MRIOT.
$\bar{*}$	The initial value of the variables.
$*_{m,n/f}^{s,r}$	The superscripts represent the regions, while the subscripts represent the sectors (m,n)/final demand agents (f). $s,r = 1,2,\ldots,31,32,\ldots,45$, of which '$1,2,\ldots,31$' represent Chinese provinces, '$32,\ldots,45$' represent other international countries or regions, and 'c' represents China in the global MRIOT.



a. Matrices from Chinese provincial MRIOT



b. Matrices estimated from Chinese customs data

Figure 4. Embedding Chinese provincial MRIOT into global MRIOT

4 An illustrative example

(show later…)

5 Conclusions

This table can be used not only to depict the economic linkages between Chinese

provinces, but also to trace the economic linkages between Chinese provinces and other economies. Besides, it can also be used in studies involving both international regions and Chinese provinces, such as the position and participation of Chinese provinces in GVC, and the related carbon emission and environmental issues. (extend later…)

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