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PROCESSING TRADE BIASES THE MEASUREMENT OF VERTICAL SPECIALIZATION IN CHINA

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Vertical specialization (VS) is often measured by the import contents of the exports, using an input–output (I–O) framework. Half of China's exports are processing exports, which largely depend on imported intermediate inputs and tie up upstream as well as downstream trade partners. Thus, one would expect to find strong VS for China. Using the 'ordinary' I–O tables, however, this is not the case. Because the production of processing exports is only a small part of total production, the average input structure in the I–O table hides the typical features of processing exports. Using adapted, tripartite I–O tables (for 2002 and 2007) in which the processing exports have been singled out, indeed reveals the expected strong VS in China.

Keywords: Vertical specialization; Processing trade; China; Input–output tables

JEL Codes: F10; C67

1. INTRODUCTION

Vertical specialization (VS) is an important part of the broader concept of international fragmentation. It is characterized by “increasing interconnectedness of production processes in a vertical trading chain that stretches across many countries, with each country specializing in particular stages of a good's production sequence” (Hummels et al., 2001, p. 76). This division of the production process into several stages, involving many countries or regions (Feenstra, 1998; Venables, 1999), has changed the production and trade patterns in the world economy (Arndt and Kierzkowski, 2001) and received due attention in recent literature. Given that a large part of China's exports are processing exports and given that these processing exports rely heavily on imports, China's exported goods are indirectly ‘made’ by many countries. China's processing trade can thus be seen as an exemplary case of VS. Processing trade refers to importing (all or part of the) raw and auxiliary materials, parts and components, accessories, and packaging materials from abroad free

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of duty, and re-exporting the finished products after processing or assembly by enterprises within mainland China.¹

The slicing up of production processes into ever smaller parts that often cross many national borders has had two consequences. First, it led to an enormous growth of trade in intermediate inputs and, second, many countries contribute to generating the final product by adding value. The implication is that the traditional trade statistics provide a distorted picture of world trade and of the role that a country plays therein. This has been well recognized and the OECD and WTO have recently launched their ‘Made in the World’ initiative. They propose ‘trade in value added’ as a better approach to measure international trade (OECD-WTO, 2012). In this paper we use the imported input content of the exports to measure VS, which is the counterpart of the domestic value-added content of the exports.

Given the strong dependence on imports, processing exports (which constituted 50.7% and 46.9% of China’s total exports in 2007 and 2010, see NBS, 2011) induce much less domestic economic activity than ‘ordinary’ (non-processing) exports do. The value added generated per Renminbi (RMB) of processing exports is therefore much lower than the value added generated per RMB of non-processing exports. For example, Lau et al. (2007) estimated for 2002 that the value added generated by 1,000 RMB of processing exports was 287 RMB, which is only 45.3% of the 633 RMB of value added generated by 1,000 RMB of non-processing exports.²

As a measure for the degree of VS, Hummels et al. (2001) propose to use the imported input content of exports. In order to take not only the direct but also the indirect requirements into consideration, they adopt an input–output (I–O) framework. When applied to the case of China, one would expect the exports to have a large import content. The reason is that the production of processing exports (which account for approximately half of the total exports) uses only little domestic inputs and relies strongly on imported inputs.

After introducing the methodology in the next section, we present the results for a set of 42 countries in Section 3. The findings for China do not confirm our expectation that Chinese exports should exhibit much import content. We argue that ordinary I–O tables do not reflect the typical nature of producing processing exports. Instead, they reflect the average production structure in which producing processing exports may only play a minor role. As a consequence, the typical production structure corresponding to VS is ‘hidden’ in the ordinary I–O table, which therefore yields biased results when measuring VS. This applies in particular to the case of China, where processing exports are an important part of total exports, but where the production of exports is only a very minor part of total production. In order to cope with the special characteristics of processing exports, Section 4 introduces a special (tripartite) I–O table for China that distinguishes between three types of production, one of them corresponding to processing exports. After adapting the methodology in Section 5, this tripartite table is applied in Section 6 and the results allow us to solve the problem of the bias in measuring the degree of VS. Conclusions are drawn in Section 7.

It should be emphasized that correctly measuring the degree of VS (or its counterpart, i.e. domestic value-added content of the exports) is not just an academic exercise, but is

¹ The imported goods involved in processing trade (usually called processing imports) can only be used to produce goods for processing exports. According to the regulations, processing imports are not allowed to be used for other purposes.

² Similar findings have been reported in Koopman et al. (2008, 2012).

also relevant from a policy perspective. Johnson (2014) convincingly argues that the use of value-added exports provides new insights into some important macro-economic and trade questions. For example, calculating how a fall in the final expenditures in country *A* affects GDP in country *B* (which can be done at the product level to study trade policy implications for specific commodities), or determining the effect on GDP of a depreciation of country *A*'s currency against country *B*'s currency, or how to adjust the trade imbalance between *A* and *B*. It also sheds new light on issues of competitiveness and industry specialization (Timmer *et al.*, 2013, 2014). For all of these applications, the correct measurement of VS is crucial.

2. METHODOLOGY

In measuring VS, we will follow the approach proposed by Hummels *et al.* (2001). The starting point is an I–O table with n industries. Let matrix $\mathbf{Z}$ denote the domestic interindustry flows z_{ij} from industry i to industry j , $\mathbf{e}$ the vector of exports e_i , $\mathbf{f}$ the vector of domestic final demands f_i (including household and government consumption, and gross fixed capital formation), $\mathbf{x}$ the vector of industry gross outputs x_i , and $\mathbf{M}$ the matrix with imports m_{ij} of product i by industry j .³ Matrix $\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$ gives the direct requirement for domestic input i per unit of output j (i.e. $a_{ij} = z_{ij}/x_j$). Matrix $\mathbf{B} = \mathbf{M}\hat{\mathbf{x}}^{-1}$ gives the direct requirement for imported input i per unit of output j (i.e. $b_{ij} = m_{ij}/x_j$). The direct import multiplier for industry j is given by the j th column sum of $\mathbf{B}$, that is, the j th element of the row vector $\lambda' = \mathbf{u}'\mathbf{B}$ where $\mathbf{u}$ is the summation vector consisting of ones. λ_j thus gives the total imports required to produce one unit of good j . The export-weighted average of the direct import multipliers yields the degree of direct vertical specialization (DVS), see Hummels *et al.* (2001, Equation 2, using a different notation, however)

$$\text{DVS} = \frac{\sum_j \lambda_j e_j}{\sum_j e_j} = \frac{\lambda' \mathbf{e}}{\mathbf{u}' \mathbf{e}} = \frac{\mathbf{u}' \mathbf{B} \mathbf{e}}{\mathbf{u}' \mathbf{e}}. \quad (1)$$

Producing a product for exports (or domestic consumption) requires not only imported inputs but also domestic inputs, whose production requires imported inputs. The first is the direct effect (which is covered by λ_j), the second is an indirect effect. The total effect takes the direct and all indirect effects into consideration and is obtained from the so-called Leontief inverse $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$. Its typical element, l_{ij} , gives the domestic production of good i that is necessary to satisfy one unit of exports (or domestic consumption) of good j . The total amount of imports that is required per unit of exports of good j thus equals $\mu_j = \sum_i \lambda_i l_{ij}$. This is the total import multiplier for industry j and is – using matrix notation – given by the j th element of the row vector $\mu' = \lambda' \mathbf{L}$. The export-weighted average of the total import multipliers yields the degree of total vertical specialization (TVS), see

³ Matrices are indicated by boldfaced capital letters (e.g. $\mathbf{A}$), vectors are columns by definition and are indicated by boldfaced lowercase letters (e.g. $\mathbf{x}$), and scalars (including elements of matrices or vectors) are indicated by italicized lowercase letters (e.g. c or α). A prime indicates transposition (e.g. $\mathbf{x}'$) and a hat (or circumflex) indicates a diagonal matrix (e.g. $\hat{\mathbf{x}}$) with the elements of a vector (i.e. $\mathbf{x}$) on its main diagonal and all other entries equal to zero.

Hummels et al. (2001, Equation 3, using a different notation, however)

$$\text{TVS} = \frac{\sum_j \mu_j e_j}{\sum_j e_j} = \frac{\mu' \mathbf{e}}{\mathbf{u}' \mathbf{e}} = \frac{\lambda' \mathbf{L} \mathbf{e}}{\mathbf{u}' \mathbf{e}} = \frac{\mathbf{u}' \mathbf{B} \mathbf{L} \mathbf{e}}{\mathbf{u}' \mathbf{e}}. \quad (2)$$

As another indicator that provides useful information, we propose the ratio of direct imports to total imports (RDTM), both as required for exports. At the industry level, this is obtained as the ratio of the direct import multiplier and the total import multiplier, $\text{RDTM}_j = \lambda_j / \mu_j$. The idea is that one unit of exports of good j directly requires λ_j of imported inputs. Taking also the indirect requirements into account yields μ_j , the total imports that are necessary per unit of exports of good j . The ratio RDTM indicates how much of the total import requirements are imported directly and how much runs through at least one other industry. In the case of processing exports of good j , the corresponding industry imports goods after which assembly-type of activities take place. The imports are in this case essentially direct imports. The production of non-processing exports relies much more on inputs imported by other industries or domestically produced inputs (which may depend on imported inputs). The ratio takes a value between 0 (no direct imports) and 1 (only direct imports). At the aggregate level, we have

$$\text{RDTM} = \frac{\text{DVS}}{\text{TVS}} = \frac{\sum_j \lambda_j e_j}{\sum_j \mu_j e_j} = \sum_j \left(\frac{\lambda_j}{\mu_j} \right) \left(\frac{e_j}{\sum_j e_j} \right) = \sum_j \text{RDTM}_j \left(\frac{e_j}{\sum_j e_j} \right). \quad (3)$$

3. A COMPARISON OVER TIME AND SPACE

Using the OECD I–O database we have calculated the measures for DVS, TVS and RDTM as given by Equations 1–3.⁴ The database covers 42 countries and three time periods (years around 1995, around 2000, and around 2005), and the I–O tables distinguish 48 industries. Table 1 presents the results, where the countries are ordered according to the value for TVS in 2005 (and countries for which the 2005 table is not available are listed alphabetically). For the USA in 1995, for example, we see that 1,000 US dollars (USD) of average exports require imports to the amount of 95 USD, of which 57 USD are direct imports (i.e. 59.5% of the total imports).

Table 1 shows that large countries and relatively small but self-supporting countries (such as Norway and New Zealand) are listed in the upper part of the table with relatively little VS. The bottom part of the table lists the small countries with relatively much VS. This applies to both the direct and the total measure. The two bottom rows of the table provide the overall averages, where the weighted average uses export values as weights. Because the larger countries (with relatively little VS) usually have the larger export values, the weighted averages for VS are smaller than the simple (i.e. unweighted) averages. With respect to the changes over time, observe that all average VS measures have increased over time. The growth in the average TVS was 24% (23% for the weighted average TVS) between 1995 and 2000, and slowed down to 5% (respectively, 10%) between 2000 and 2005.

⁴ See <http://www.oecd.org/sti/inputoutput>.

TABLE 1. Measures for VS, based on OECD tables.

	1995			2000			2005		
	DVS	TVS	RDTM	DVS	TVS	RDTM	DVS	TVS	RDTM
USA	0.057	0.095	0.595	0.072	0.116	0.623	0.078	0.127	0.611
India	0.058	0.104	0.556	0.075	0.125	0.602	0.067	0.129	0.517
Australia				0.086	0.152	0.564	0.080	0.143	0.559
Brazil	0.056	0.110	0.513	0.066	0.127	0.520	0.075	0.144	0.520
Japan	0.049	0.094	0.520	0.061	0.108	0.561	0.087	0.170	0.513
Norway	0.170	0.237	0.719	0.136	0.185	0.735	0.126	0.173	0.731
Indonesia	0.102	0.150	0.682	0.137	0.194	0.709	0.124	0.182	0.684
UK	0.152	0.225	0.674	0.144	0.205	0.703	0.130	0.187	0.693
New Zealand	0.100	0.183	0.546				0.103	0.189	0.548
Turkey	0.077	0.138	0.558	0.096	0.153	0.624	0.126	0.225	0.559
Chile	0.132	0.204	0.646				0.146	0.240	0.609
<i>China</i>	<i>0.077</i>	<i>0.164</i>	<i>0.468</i>	<i>0.097</i>	<i>0.198</i>	<i>0.493</i>	<i>0.117</i>	<i>0.253</i>	<i>0.464</i>
France	0.127	0.200	0.636	0.169	0.267	0.634	0.161	0.258	0.626
Canada	0.211	0.315	0.670	0.236	0.308	0.764	0.194	0.273	0.712
Germany	0.139	0.207	0.671	0.175	0.261	0.672	0.186	0.275	0.678
Greece	0.104	0.158	0.661	0.208	0.283	0.735	0.218	0.279	0.782
Romania				0.193	0.282	0.685	0.188	0.288	0.654
Italy	0.137	0.234	0.586	0.168	0.272	0.619	0.183	0.291	0.628
Poland	0.086	0.168	0.512	0.161	0.250	0.642	0.203	0.307	0.660
Sweden	0.210	0.295	0.712	0.236	0.327	0.721	0.240	0.335	0.716
Austria	0.229	0.299	0.766	0.269	0.344	0.781	0.256	0.346	0.739
Spain	0.180	0.269	0.669	0.229	0.342	0.669	0.230	0.346	0.666
Netherlands	0.243	0.337	0.722	0.269	0.373	0.722	0.255	0.353	0.721
Mexico							0.323	0.367	0.878
Denmark	0.226	0.296	0.762	0.279	0.346	0.805	0.299	0.371	0.805
Finland	0.189	0.291	0.649	0.222	0.337	0.660	0.274	0.382	0.718
Israel	0.162	0.200	0.809				0.322	0.389	0.828
Portugal	0.260	0.360	0.721	0.216	0.309	0.697	0.288	0.394	0.732
Belgium	0.297	0.410	0.723	0.337	0.462	0.729	0.282	0.404	0.697
Korea				0.256	0.401	0.639	0.250	0.407	0.614
Slovenia				0.340	0.438	0.777	0.360	0.457	0.787
Czech Republic				0.330	0.456	0.722	0.353	0.486	0.726
Slovak Republic	0.220	0.355	0.618	0.398	0.503	0.792	0.384	0.487	0.789
Ireland	0.400	0.469	0.853	0.481	0.533	0.903	0.431	0.507	0.850
Estonia	0.348	0.478	0.728	0.464	0.554	0.838	0.416	0.509	0.818
Hungary	0.401	0.478	0.838	0.511	0.603	0.848	0.484	0.560	0.863
Luxemburg	0.314	0.414	0.759	0.425	0.577	0.736	0.444	0.605	0.733
Argentina	0.079	0.128	0.622						
Russia	0.064	0.105	0.604	0.065	0.108	0.601			
South Africa	0.057	0.097	0.590	0.091	0.151	0.599			
Switzerland				0.142	0.225	0.629			
Taiwan	0.234	0.357	0.656	0.249	0.379	0.657			
Average	0.170	0.246	0.689	0.219	0.304	0.719	0.229	0.320	0.717
Weighted average	0.124	0.188	0.661	0.158	0.232	0.680	0.170	0.256	0.664

Notes: For the weighted average, export values have been used. Export data for Argentina, Romania and Taiwan are lacking. DVS = degree of direct vertical specialization, TVS = degree of total vertical specialization, RDTM = DVS/TVS = ratio of direct to total vertical specialization.

Observe that China is clearly in the upper part of the table with a VS that is well below average – both for its direct and total VS – in all three years, except for TVS in 2005 which is close to the weighted average. Given that roughly half of the Chinese exports are processing exports, the production of which relies heavily on imports, it is surprising that 1,000 RMB of exports require no more than 253 RMB of imports in 2005.

The RDTM is relatively stable around 0.7 and shows less variation across countries than DVS or TVS. The RDTM tends to be somewhat smaller for larger countries (i.e. the ones in the upper part of the table with relatively little VS). This is also reflected by the weighted averages being smaller than the simple averages. Observe that in all three years, the smallest value for RDTM is found for China, which is very peculiar. If we assume – following our expectations – that the RDTM for processing trade is close to 1, it is possible to arrive at an overall RDTM of 0.5 for China only if the remaining 50% of its exports have an RDTM that comes close to 0. That is, if the production of non-processing exports requires imports, the direct share is negligible. Most countries in Table 1 produce ‘ordinary’ (i.e. non-processing) exports and have an RDTM that is at least 0.5. Therefore, it is very unlikely that the RDTM for non-processing exports in China is close to 0.

4. ADAPTING THE I–O TABLE

The findings in the previous section suggest that China’s VS measures do not reflect the actual situation. Processing trade is the main body of China’s foreign trade and more than 80% (84.4% in 2007 and 83.8% in 2010) of processing trade in China is done by foreign-invested enterprises (FIEs).⁵ The import dependence of the processing exports is very high,⁶ whereas that of the non-processing exports is substantially lower. The ‘ordinary’ I–O table for China, however, does not reflect the difference in import dependence. Therefore, we will use a table that has been adapted so as to make a distinction possible between processing and non-processing exports.

In the same way as I–O tables have been constructed that make a distinction between rural industries and urban industries, or interregional I–O tables that distinguish several regions. The table used in this paper makes a distinction on the basis of the destination of

⁵ In China there are three types of FIEs: equity joint ventures (EJVs); co-operative joint ventures (CJVs); and wholly foreign-owned enterprises (WFOEs). Currently, an EJV is the most used type in China. It is a limited liability company (implying that the investor or partner is not personally liable for the debts that the company might make) and has the status of a Chinese legal person. It can, for example, buy land, hire Chinese employees, and construct buildings. In a CJV, the Chinese company usually is responsible for labor, land use rights, and factory buildings, while the foreign company contributes the necessary technology, key equipment, and capital. This joint venture is based on a contract in which matters such as the terms of co-operation, the division of earnings, the ownership of property upon the termination of the contract term, and the sharing of risks and losses are laid down. A WFOE is a limited liability company established within the territory of China in accordance with relevant Chinese laws, with foreign investments only. A WFOE has the status of a Chinese legal person, taking all risks and possessing all profits.

⁶ Processing trade includes two types: processing with imported materials (PIM) and processing with customer’s materials (PCM). PIM is the main form, accounting for more than 70% of China’s processing trade value (e.g. 73% in 2002 and 81% in 2007). These two types of processing trade are quite different in terms of input structure. This holds in particular for imported intermediate inputs, where PCM has a much higher ratio. In order to take the heterogeneity between PIM and PCM into account, they were treated separately when compiling the import matrix (which was done in collaboration with the NBS). Afterwards the data were aggregated into a single import matrix for processing exports.

TABLE 2. China's tripartite I–O table for analyzing processing trade.

	Intermediate use			Final use		
	D	P	N	DFD	EXP	TOT
D	$\mathbf{Z}^{DD}$	$\mathbf{Z}^{DP}$	$\mathbf{Z}^{DN}$	$\mathbf{f}^D$	0	$\mathbf{x}^D$
P	0	0	0	0	$\mathbf{e}^P$	$\mathbf{x}^P$
N	$\mathbf{Z}^{NP}$	$\mathbf{Z}^{NP}$	$\mathbf{Z}^{NN}$	$\mathbf{f}^N$	$\mathbf{e}^N$	$\mathbf{x}^N$
IMP	$\mathbf{M}^D$	$\mathbf{M}^P$	$\mathbf{M}^N$	$\mathbf{f}^M$	0	$\mathbf{x}^M$
VA	$(\mathbf{v}^D)'$	$(\mathbf{v}^P)'$	$(\mathbf{v}^N)'$			
TOT	$(\mathbf{x}^D)'$	$(\mathbf{x}^P)'$	$(\mathbf{x}^N)'$			

Notes: D = production for domestic use; P = production of processing exports; N = production of non-processing exports and other production of FIEs; DFD = domestic final demand; EXP = exports; TOT = gross industry outputs (and total imports in the column TOT); IMP = imports; and VA = value added.

the product (see Lau et al., 2006, 2007). Chinese statistics allow for distinguishing three types (or classes) of production within each industry.⁷ These types are: production for domestic use only (indicated by superscript D); production of processing exports (P); and (in the same industry) the combination of production of non-processing exports and production by FIEs for domestic use (N). The tables are based on China's I–O tables for 2002 and 2007 and have 42 industries (see Appendix A for the industry classification). The structure of the tripartite I–O table is given in Table 2.

The production of type N (non-processing exports and other production of FIEs) requires additional explanation. A large percentage of the production by FIEs is exported (45.1% of its sales revenue in 2002, 42.1% in 2007), the remaining part is used as a domestic intermediate input or is for domestic final demand.⁸ Yet, this other production of FIEs in Table 2 is not included in D (production for domestic use), but in N (together with the non-processing exports). The reason for doing so is twofold. First, the prime reason is that the inputs for most of the other production of FIEs are imported components, parts, or materials. The input structure is thus quite different from the input structure of production for domestic use and – following the observations by Wang and Lv (2005) – more similar to that of the production of non-processing exports (Lau et al., 2006, 2007).⁹ Second,

⁷ First, a distinction was made between processing exports (P) and ordinary exports (termed non-processing exports in this paper). This was done on the basis of the China Customs Database, which provides very detailed trade data at the HS 8-digit level by trade type. Second, the part of the FIEs' production that targets the domestic market was determined, which – together with the non-processing exports – makes up class N . For this, the industrial output values of FIEs by sector were obtained from the *China Statistical Yearbook* and the values of the exports from the *China Industrial Statistical Annals* by the National Bureau of Statistics of China. Third, production of type D was obtained as a residual (taking the national I–O table as the benchmark).

⁸ For FIEs, the main interests of the foreign parties are different. Western and Japanese investors primarily have a market-orientation, targeting to sell more products in the Chinese market. The investors from Hong Kong, Macao and Taiwan (in the Chinese literature and statistics indicated as overseas China, versus mainland China) mainly have an export-orientation, considering mainland China as a low-cost production base and export-platform (Xu and Tan, 2003; Buckley and Meng, 2005).

⁹ For example, both the other production of FIEs and the production of non-processing exports depend to a considerable extent on imported intermediates. This is because the quality requirements for exported goods (no matter whether processing or non-processing) are stricter than for goods produced for domestic use. In order to meet these requirements, export production depends on the imports of high quality intermediate products, whereas production for domestic use depends on domestic intermediate products which were in the past often of lower quality. It should be mentioned though that the gap with production for domestic use is declining. In future

some of the other production of FIEs is indirectly exported. Some FIEs do not use their processing imports directly to produce export goods. Instead, they transfer the imported goods to other FIEs that re-process or assemble them, after which the finished products are exported. These exports are classified in the statistics as non-processing exports.

The details of the construction of the I–O table as outlined in Table 2 are given by Chen et al. (2001, 2008, 2009) and Lau et al. (2007). When summarized, the following three issues have been the key. First, a concordance between international trade statistics and the I–O classification was required. China’s trade statistics provide detailed data for processing and for non-processing exports as well as for their corresponding imports, all by commodity. The definitions, conventions and methods of measurement underlying the trade statistics, however, differ from those used in I–O statistics. Therefore, a ‘concordance table’ between the trade statistics and the I–O classification had to be constructed. Using this table, the trade data (which are classified according to the Harmonized System Code) could be regrouped into the industry classification used for I–O tables.¹⁰

Second, a conversion of the valuation used in international trade statistics into that in I–O statistics was required. In the trade statistics, China’s exports are measured on a free on board basis while its imports are on a cost, insurance and freight basis. I–O tables, however, value the products in producer’s prices. All trade data therefore have been re-valued in producer’s prices. The UN BEC method (which was proposed in Dean et al., 2007) was adopted for the distribution of the imports. That is, commodities are split into three categories, namely for intermediate use, for household consumption, and for investment purposes.

Third, input coefficients had to be estimated for each of the three categories (D , P , and N) of production. China Custom Statistics did not only provide total imports by commodity, but also imports used for processing exports by commodity. The reason that such data are available is that the imports used for processing exports are free of duty and there are special rules to ensure that these processing imports are only used for processing exports.¹¹ On the basis of these data (and other related sources), the transaction table of imported intermediate inputs for the production of processing exports (i.e. $\mathbf{M}^P$) could be estimated. Unfortunately, only limited data were available for estimating $\mathbf{M}^D$ and $\mathbf{M}^N$. The overall rates of imported inputs for domestic use and for non-processing exports (including other production of FIEs) were obtained from aggregate data.¹² For the estimation, the proportional import assumption was adopted and a modified RAS procedure was used to reconcile the import matrices with the margins (which were known from the available statistics).

years, it may thus become more appropriate perhaps to combine the other production of FIEs with production for domestic use.

¹⁰ The Harmonized System Code is an international method of classifying products for trading purposes. The classification is used by customs officials around the world to determine the duties, taxes and regulations that apply to the products.

¹¹ Non-processing imports are for intermediate input use and for household consumption. A consequence is that all imports for household consumption are non-processing imports.

¹² Unfortunately, there is no detailed statistical information for the difference between firms engaged in normal exports and firms producing only for the domestic markets. While the difference does exist in reality, it is diminishing with the quality upgrading of domestic products in China. For a long time, domestic intermediate inputs were regarded of lesser quality than imported inputs. This was the case, in particular for products from small- and medium-sized firms run by so-called Township and Village Entities. Firms engaged in normal exports imported a larger share of (high quality) intermediate inputs markets than did firms producing for domestic markets, in order to meet the standards required by foreign markets.

It should be mentioned that Koopman et al. (2008, 2012) and Dean et al. (2011) have constructed similar (yet bipartite) I–O tables. They have split the ‘ordinary’ I–O table into two parts. Processing exports are dealt with in more or less the same way as was done in the tables used in this study. The first difference is their (implicit) assumption that the same production structure applies to both non-processing exports and domestic production. Although this may be true in the foreseeable future, the input structure for China’s ‘ordinary’ exports is at present (and in the near future) quite different from that for domestic use (Dietzenbacher et al., 2012). The existing differences between FIEs and domestic firms are thus completely absent in their tables. A second difference is with respect to the estimation techniques. Lau et al. (2006, 2007) started with the national I–O structure and vectors with control variables obtained from Customs statistics, after which the bi-proportional (RAS) reconciliation method was used to balance the table. Koopman et al. (2008) used estimates for certain variables, after which quadratic programming techniques were applied. A third difference is that our tables include an additional type of production but have fewer industries (42 instead of 83 in Koopman et al., 2008) and that our tables are for more recent years (for 2002 and 2007, instead of 1997 and 2002).¹³

5. ADAPTING THE METHODOLOGY

Whereas we had n industries in Section 2, we now have $3n$ industries according to Table 2. In its partitioned form, the $3n \times 3n$ matrix $\mathbf{A}$ with the direct requirements for domestic inputs per unit of output now becomes

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}^{DD} & \mathbf{A}^{DP} & \mathbf{A}^{DN} \\ 0 & 0 & 0 \\ \mathbf{A}^{ND} & \mathbf{A}^{NP} & \mathbf{A}^{NN} \end{bmatrix},$$

where $\mathbf{A}^{IJ} = \mathbf{Z}^{IJ}(\hat{\mathbf{x}}^J)^{-1}$, with $I = D, N$, and $J = D, P, N$. The matrices with the direct requirements for imported inputs per unit output are given by $\mathbf{B}^D$, $\mathbf{B}^P$, and $\mathbf{B}^N$, where $\mathbf{B}^J = \mathbf{M}^J(\hat{\mathbf{x}}^J)^{-1}$ with $J = D, P, N$. The direct import multipliers for industry j are again obtained as the j th column sum of the direct import requirements matrices, now distinguishing between the destinations of the production. That is, $(\lambda^D)' = \mathbf{u}'\mathbf{B}^D$, $(\lambda^P)' = \mathbf{u}'\mathbf{B}^P$, and $(\lambda^N)' = \mathbf{u}'\mathbf{B}^N$, and for industry j we have λ_j^D , λ_j^P , and λ_j^N , respectively. The degree of DVS for processing exports (DVS^P) is given by the weighted average of the corresponding direct import multipliers, using the processing exports as weights. This yields

$$\text{DVS}^P = \frac{\sum_j \lambda_j^P e_j^P}{\sum_j e_j^P} = \frac{(\lambda^P)' \mathbf{e}^P}{\mathbf{u}' \mathbf{e}^P} = \frac{\mathbf{u}' \mathbf{B}^P \mathbf{e}^P}{\mathbf{u}' \mathbf{e}^P}. \quad (4)$$

For the non-processing exports we have $\text{DVS}^N = \mathbf{u}' \mathbf{B}^N \mathbf{e}^N / \mathbf{u}' \mathbf{e}^N$. For the type producing only for domestic use, we will also calculate an average direct import multiplier, using the domestic final demands as weights. It is given by $\overline{\text{DIM}}^D = \mathbf{u}' \mathbf{B}^D \mathbf{f}^D / \mathbf{u}' \mathbf{f}^D$. It should be stressed that the average import multiplier can, in this case, not be interpreted as a

¹³ Koopman et al. (2008) also includes results for 2006, but these are obtained from their 2002 split table.

degree of DVS, because the type does not export. Still, it will be useful to compare the average amount of imports (in RMB) required per RMB of production across the three types, because it indicates the production's import dependence.

The national degree of DVS is obtained as the weighted average of DVS^P and DVS^N

$$DVS = \frac{\sum_j \lambda_j^P e_j^P + \sum_j \lambda_j^N e_j^N}{\sum_j e_j^P + \sum_j e_j^N} = \frac{DVS^P \times \mathbf{u}'\mathbf{e}^P + DVS^N \times \mathbf{u}'\mathbf{e}^N}{\mathbf{u}'\mathbf{e}^P + \mathbf{u}'\mathbf{e}^N}. \quad (5)$$

In a similar fashion also the total import multipliers are obtained. For the partitioned form of the Leontief inverse, we have

$$\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1} = \begin{bmatrix} \mathbf{L}^{DD} & \mathbf{L}^{DP} & \mathbf{L}^{DN} \\ 0 & \mathbf{I} & 0 \\ \mathbf{L}^{ND} & \mathbf{L}^{NP} & \mathbf{L}^{NN} \end{bmatrix}.$$

This yields

$$\begin{aligned} (\boldsymbol{\mu}^D)' &= (\boldsymbol{\lambda}^D)' \mathbf{L}^{DD} + (\boldsymbol{\lambda}^N)' \mathbf{L}^{ND}, \\ (\boldsymbol{\mu}^P)' &= (\boldsymbol{\lambda}^D)' \mathbf{L}^{DP} + (\boldsymbol{\lambda}^P)' + (\boldsymbol{\lambda}^N)' \mathbf{L}^{NP}, \\ (\boldsymbol{\mu}^N)' &= (\boldsymbol{\lambda}^D)' \mathbf{L}^{DN} + (\boldsymbol{\lambda}^N)' \mathbf{L}^{NN}. \end{aligned}$$

The j th element of each of these vectors gives the total amount of imports that is directly and indirectly used for one RMB of final demand for product j , no matter whether the final product is exported or is for domestic use. The degree of TVS for processing exports (TVS^P) is given by the weighted average of the corresponding total import multipliers, using the processing exports as weights. That is

$$TVS^P = \frac{\sum_j \mu_j^P e_j^P}{\sum_j e_j^P} = \frac{(\boldsymbol{\mu}^P)' \mathbf{e}^P}{\mathbf{u}'\mathbf{e}^P}. \quad (6)$$

For the non-processing exports, we have $TVS^N = (\boldsymbol{\mu}^N)' \mathbf{e}^N / \mathbf{u}'\mathbf{e}^N$. The average total import multiplier for the type producing only for domestic use is given by $\overline{TIM}^D = (\boldsymbol{\mu}^D)' \mathbf{f}^D / \mathbf{u}'\mathbf{f}^D$. Again, it indicates the average total import dependence of the final products by this group of industries, but cannot be interpreted as a measure of VS because the type does not export.

The national degree of TVS is again obtained as the weighted average of TVS^P and TVS^N

$$TVS = \frac{\sum_j \mu_j^P e_j^P + \sum_j \mu_j^N e_j^N}{\sum_j e_j^P + \sum_j e_j^N} = \frac{TVS^P \times \mathbf{u}'\mathbf{e}^P + TVS^N \times \mathbf{u}'\mathbf{e}^N}{\mathbf{u}'\mathbf{e}^P + \mathbf{u}'\mathbf{e}^N}. \quad (7)$$

6. EMPIRICAL ANALYSIS

6.1. The Degrees of VS

Based on the tripartite I–O tables for China, the degrees of VS have been calculated. The results for the separate industries are presented and discussed in the Supplementary Document (in Table S1 for 2002 and in Table S2 for 2007) that is accessible through the website

TABLE 3. Overview of the results at the aggregate level.

		2002			2007		
		DVS	TVS	RDTM	DVS	TVS	RDTM
Tripartite I–O table							
<i>P</i>	(1)	0.666	0.695	0.958	0.585	0.633	0.924
<i>N</i>	(2)	0.166	0.220	0.754	0.121	0.220	0.550
<i>D</i>	(3)	0.014	0.056	0.254	0.019	0.105	0.178
National average	(4)	0.406	0.449	0.906	0.333	0.409	0.815
National I–O table	(5)	0.150	0.279	0.538	0.171	0.312	0.548
Bipartite I–O table							
<i>P</i>	(6)	0.666	0.682	0.976	0.585	0.636	0.920
<i>N</i> + <i>D</i>	(7)	0.053	0.117	0.449	0.059	0.175	0.337
National average	(8)	0.347	0.389	0.893	0.300	0.386	0.776

Notes: *P* = production of processing exports; *N* = production of non-processing exports and other production of FIEs; *D* = production for domestic use. The results for *D* in row (3) are obtained by using the domestic final demands ($\mathbf{f}^D$) as weights. The results for *N* + *D* in row (7) used non-processing exports ($\mathbf{e}^N$) as weights.

of this journal. Table 3 gives an overview of the results at the aggregate level. For example, the results in row (1) are obtained from Equation 4 for the degree of DVS, from Equation 6 for the degree of TVS, and their ratio ($\text{RDTM} = \text{DVS}/\text{TVS}$) indicating the share of total imports that are direct. Note that the results are averages obtained from the industry results in the online Supplementary Document. For row (1) the processing exports ($\mathbf{e}^P$) were used as weights, for row (2) the non-processing exports ($\mathbf{e}^N$), and for row (3) the domestic final demands ($\mathbf{f}^D$). The national averages in row (4) follow from Equation 5 for DVS and Equation 7 for TVS. Note that these national averages do *not* take production for domestic use into account (because this type does not export). The national averages in row (4) are thus a weighted average of the results in rows (1) and (2).

The findings show a clear distinction between the three types of production. The columns DVS indicate that per 100 RMB of gross output in 2002 (no matter whether exported or for domestic use), the value of the direct imports amounted (on average) to 67 RMB for processing exports, to 17 RMB for non-processing exports, and to 1 RMB when producing for domestic use. For 2007, the corresponding imports were 59, 12, and 2 RMB. Similar differences are found when also the indirect import requirements are taken into account, that is, columns TVS. Per 100 RMB of final product (no matter whether exported or for domestic use) in 2002, the total import values were on average 70 RMB in industries of type *P*, 22 RMB in industries of type *N*, and 6 RMB in industries of type *D*. For 2007, we had 63, 22, and 11 RMB, respectively.

The results indicate that there are huge gaps between processing exports, non-processing exports, and domestic use only. Observe, however, that the gaps between the three categories have somewhat decreased between 2002 and 2007. The import content of processing exports has declined, whereas that of domestic consumption has grown. There are several aspects that contribute to this development. First, in the early 1990s, FIEs still showed an import dependency ratio of more than 90%, in particular high-tech FIEs relied mainly on imported materials (see Jiang *et al.*, 2001). The reason was that the technology and quality of domestic products could not meet the requirements of FIEs. Due to an improvement in the quality of domestic (i.e. Chinese) accessories – a trend that started already before 2002

– FIEs have increased their domestic accessories ratio. For instance, for enterprises with a Japanese investor, the domestic accessory ratio in China increased from only 20.0% in 1992 to 49.6% in 2002 (Jiang, 2002). Second, China's policy on processing trade has been adjusted in an effort to strengthen environmental protection as well as to reduce China's trade surplus with large trade partners. The adjustments included export restrictions on certain products of several labor-intensive or energy-intensive industries (including textiles, chemicals, plastic materials and furniture) and the removal or decline of tax rebates for certain export products. Third, the Chinese tax policy used to work against the use of domestic accessories. Imported materials for processing trade were exempted from taxes, while enterprises were not reimbursed for the taxes they paid on domestic products. Due to changes in this preferential tax policy, also the prices of domestic products have become very competitive.

Another remarkable outcome is the difference between the direct and the total VS degrees for the three categories. In the column RDTM we see for processing exports in 2002, that the (average) share of direct imports in total imports was no less than 96%, indicating that imports were primarily direct. For non-processing exports we have a 75% share, indicating that these exports required other domestic products as input, which – in their turn – required imports. The role of imports through such indirect effects was the strongest in the case of production for domestic use only, with an average share of direct imports in total imports of only 25%. For 2007, these shares have declined a bit and were 92% for industries of type *P*, 55% for *N*, and 18% for *D*. It indicates that the import dependence slowly shifted and became more indirect. Measured per unit of output, industries producing for processing and non-processing exports (and other production of FIEs) imported less and depended more on domestically produced inputs. At the same time, industries that produce for domestic use increased their imports per unit of output. For industries of type *P*, we therefore see that the DVS decreased and that the TVS decreased less. For type *N*, the DVS decreased whereas the TVS remained the same. For type *D* we find an increase in DVS and a larger increase in TVS.

The national average degrees of direct VS and total VS yield that per 100 RMB of exports on average 41 RMB of direct imports and 45 RMB of direct and indirect imports were required.¹⁴ In 2007 the national average import dependence of the exports had decreased to 33 RMB directly and 41 RMB in total, which is consistent with the growing domestic accessory ratio in producing exports as mentioned earlier in this subsection. These average VS degrees are substantially larger than the results reported in Table 1 for OECD countries. China's VS degrees as obtained from using the tripartite I–O tables are comparable to those of small, trade-dependent countries such as Belgium or the Slovenia.

6.2. The Bias in the VS Degrees

Row (5) in Table 3 is obtained from the 'ordinary' I–O tables for China in 2002 and 2007. That is, the table where no distinction is made between the specific types of production

¹⁴ According to the NBS, the processing exports in 2002 amounted to 179.9 billion USD (55.3% of the total exports) and the non-processing exports were 145.7 billion USD (44.7%). For 2007 these figures were 617.6 billion USD (50.7% of the total exports) and 601.7 billion USD (49.3%), respectively. It should be mentioned that the export values in NBS (2011) differ from those in the input-output table (which are larger because they include both trade in goods and in services).

(processing exports, non-processing exports, and production for domestic use only). The result is that the national direct VS degree in 2002 is reduced to 0.150, and the total VS degree to 0.279. These outcomes are somewhat larger than the findings for China on the basis of the OECD database as reported in Table 1, but substantially smaller than our findings in the previous subsection (0.406 and 0.449, respectively). The results from the ‘ordinary’ I–O table seriously underestimate the VS in China. The reason is that the characteristic feature of VS (i.e. production for exports is highly import dependent) is no longer visible in the ‘ordinary’ I–O table, because producing export goods is a relatively minor part of the production (in particular for a large country such as China).

The ‘ordinary’ I–O table is obtained from Table 2 by aggregating over the sectors D , P , and N . For example, for the import matrix we have $\mathbf{M} = \mathbf{M}^D + \mathbf{M}^P + \mathbf{M}^N$ and the gross output vector yields $\mathbf{x} = \mathbf{x}^D + \mathbf{x}^P + \mathbf{x}^N$. According to Equation 1, the national direct VS degree is given by $\text{DVS} = \mathbf{u}'\mathbf{B}\mathbf{e}/\mathbf{u}'\mathbf{e}$, which is a weighted average of the direct import multipliers λ_j , with $\lambda' = \mathbf{u}'\mathbf{B}$. For these import multipliers we have

$$\begin{aligned}\lambda' &= \mathbf{u}'\mathbf{B} = \mathbf{u}'\mathbf{M}\hat{\mathbf{x}}^{-1} = \mathbf{u}'(\mathbf{M}^D + \mathbf{M}^P + \mathbf{M}^N)(\hat{\mathbf{x}}^D + \hat{\mathbf{x}}^P + \hat{\mathbf{x}}^N)^{-1} \\ &= \mathbf{u}'(\mathbf{B}^D\hat{\mathbf{x}}^D + \mathbf{B}^P\hat{\mathbf{x}}^P + \mathbf{B}^N\hat{\mathbf{x}}^N)(\hat{\mathbf{x}}^D + \hat{\mathbf{x}}^P + \hat{\mathbf{x}}^N)^{-1} \\ &= (\lambda^D)'\hat{\omega}^D + (\lambda^P)'\hat{\omega}^P + (\lambda^N)'\hat{\omega}^N,\end{aligned}\tag{8}$$

where $\hat{\omega}^J = \hat{\mathbf{x}}^J\hat{\mathbf{x}}^{-1}$ or $\omega_i^J = x_i^J/x_i$, with $J = D, P, N$. That is, the direct import multiplier for industry i is a weighted average of the direct import multiplier for the processing exports industry i , the non-processing exports industry i , and the industry i that produces only for domestic use. The weights are the shares of gross output of each of these three types in the total gross output of industry i .

In contrast, the national direct VS degree calculated in Equation 4 yields $\text{DVS} = \lambda'\mathbf{e}/\mathbf{u}'\mathbf{e}$ with

$$\lambda' = (\lambda^P)'\hat{\mathbf{v}}^P + (\lambda^N)'\hat{\mathbf{v}}^N,\tag{9}$$

where $\hat{\mathbf{v}}^J = \hat{\mathbf{e}}^J\hat{\mathbf{e}}^{-1}$ or $v_i^J = e_i^J/e_i$, with $J = P, N$ and $e_i = e_i^P + e_i^N$.

Comparing the expressions 8 and 9, we see that deriving the direct VS degree from the tripartite I–O table adopts the shares of processing and non-processing exports as weights, while using the ‘ordinary’ I–O table adopts the output shares as weights and includes the production for domestic use only. The same applies to the total VS degrees approximately.¹⁵ In Equation 9, the total of all processing exports in the tripartite I–O table is 48.0% of the total exports (and the share of non-processing exports is thus 52.0%) in 2002. In Equation 8, the total output of the processing exports is 4.8% of total gross output, the output share for non-processing exports is 12.8%, and for industries producing for domestic use it is 82.4%.

We already mentioned that Koopman *et al.* (2008) and Dean *et al.* (2011) have used a bipartite I–O table. Making a distinction only between production for processing exports (type P , as before) and other production induces a similar type of bias. The bottom part

¹⁵ The total VS degree includes the inverse of the matrix $(\mathbf{I} - \mathbf{A})$. Because this is a nonlinear operation an aggregation bias will occur, in the sense that the inverse of the aggregate matrix differs from the aggregate of the original inverse.

of Table 3 presents the results that are obtained by using an aggregated form of the tripartite I–O table. That is, the bipartite I–O table follows from aggregating the industries of types N and D (which is indicated as $N + D$). The production for non-processing exports (N) depends more on imports than production for domestic use (D) does. Aggregating the two types yields an average import dependence that is lower than that of the non-processing exports. When calculating the national average, however, the import dependencies of P and the import dependencies of N or $N + D$ are still weighted with the same shares. This implies that the national degree of VS is smaller for the bipartite than for the tripartite table. For example, for the direct imports, the national degree of VS is found as $0.480 \times 0.666 + 0.520 \times 0.053 = 0.347$ for the bipartite table and as $0.480 \times 0.666 + 0.520 \times 0.166 = 0.406$ for the tripartite table.

The differences between the national averages points at the issue of aggregation bias, which has received considerable attention in the I–O literature. Theil (1957) and Ara (1959) already examined the requirements that need to hold for the aggregation bias to be zero.¹⁶ For example, when the aggregated sectors have homogeneous input structures, which is a very strong assumption, the bias is zero. In the present case, heterogeneity of input structures was the key reason to distinguish between three types of production instead of between two types. The results confirm that heterogeneity between type N and type D production affects the results. Going from the national table to the bipartite table first and then to the tripartite table, the national average TVS in 2002 increases from 0.279 to 0.389 and further to 0.449. Although the step from the national to the bipartite table is the most important, the step from the bipartite to the tripartite table is still responsible for explaining 35% of the total aggregation bias.

Recent I–O literature focuses on reducing the aggregation bias by refining the data sets. For example, Ogawa et al. (2012) split the manufacturing industries in Japan into small and large sectors to study the propagation mechanism of balance sheet deterioration in financial institutions and firms. Another example is Lindner et al. (2012) who developed a methodology to disaggregate an industry into an arbitrary number of new (sub-) industries when the only information is available for the output weights of the sub-industries.

7. CONCLUSIONS

An important part of China's trade is processing trade. That is, goods are imported from abroad, assembled in China and returned as export goods. This is exactly what has been coined VS, international fragmentation, outsourcing, or slicing the global value chain. Hummels et al. (2001) have proposed to measure VS as the import content of a country's exports. Given the fact that approximately half of China's exports are processing exports (with a huge import dependency), one would expect that China's VS degree is much larger than the VS degrees of countries with a comparable size. The results obtained from the 'ordinary' I–O table for China cannot substantiate this hypothesis.

¹⁶ The tripartite input-output table is very similar to an inter-regional table (with regions instead of types of production). Miller and Blair (1981) were the first to empirically investigate the aggregation bias due to spatial aggregation, which is exactly what we have done in this subsection. See also Blair and Miller (1983) and Miller and Shao (1990) for aggregation in a multi-regional context.

In this paper, we have shown that the strong import dependence that is so characteristic for processing exports is hidden in the ‘ordinary’ I–O table. The I–O table gives for each industry the average structure of domestic and imported inputs. Most production (over 80%), however, takes place in industries that focus on domestic use only, while only a small part (5%) of production occurs in industries involved in processing exports. Therefore, the production structure of the Chinese economy as sketched by the I–O table largely resembles the structure of the industries aiming at the domestic market only.¹⁷

The typical feature of processing exports can be made visible when this type of production is singled out. This paper has used an adapted, tripartite I–O table that for each industry distinguishes between the production for processing exports, for non-processing exports and for domestic final use only. It turns out that the total VS degree of processing exports was no less than 0.70 in 2002 (and 0.63 in 2007), that of non-processing exports was much lower, 0.22 (0.22), while the overall total VS degree was 0.45 (0.41). As was hypothesized, this is a considerable difference with the findings obtained from the ‘ordinary’ national I–O tables (0.28 in 2002 and 0.31 in 2007). Comparing the results for 2002 and 2007 indicated a general tendency that processing exports have become less import intensive and depend more on Chinese domestically produced inputs, whereas imports have become more important for domestic production. The import dependence was also found to become more indirect.

Using the ‘ordinary’ I–O table thus seriously underestimates the measurement of VS. Although our results were obtained for China, it should be emphasized that it is likely to hold also for other countries. In particular, it is expected to apply to large countries with a substantial domestic market and with much processing trade (e.g. Mexico, Brazil, Indonesia, and Vietnam). Whereas processing trade may be very important for the exports (and thus a dominant factor in measuring VS), the corresponding production is relatively unimportant when compared to the production for domestic use. In such cases, the ‘ordinary’ I–O table cannot reflect the role of processing trade adequately and will yield an underestimation of VS. The case of China is rather unique, because data exist that allowed us to quantify the extent of underestimation. Such data exist due to China’s regulations, which state that producers involved in processing trade were exempted from taxes on imported goods and that processing imports could only be used for producing processing exports. Monitoring such regulations necessitates that customs and tax authorities gather very specific information, which exactly fulfills the requirements to adapt the I–O table. Whereas China’s case is not unique and is likely to hold for other countries as well, it will be difficult to verify because the Chinese data are unique.

Correctly measuring VS (or its counterpart, i.e. domestic value-added content of the exports) is important. For example, Johnson (2014) reports that in 2004 the US trade deficit with China was 125 billion USD when gross trade figures were used. The imbalance was ‘only’ 94 billion USD, however, when measured as the difference between US value-added exported to China minus Chinese value-added exported to the USA. The calculations used

¹⁷ As one of the referees pointed out, some countries may have organized the classification of their industries in such a way that establishments in industries have similar production structures. That is, establishments that just process manufactured goods (i.e. focus on simple parts assembly as opposed to producing the raw parts themselves) are purposely separated from their more complex manufacturing equivalents. In that case, the aggregation bias which is at the heart of this paper will not occur. This does not apply to China, however, certainly not at the level of 42 industries.

data from the World Input–Output Database (Dietzenbacher et al., 2013), which is based on ‘ordinary’ national I–O tables. The results in this paper suggest that the US–China trade imbalance is even much smaller, given the fact that the high import dependence of approximately half of China’s exports is not well reflected. Calculating the imbalance is something for future research, because it requires that the tripartite I–O table for China is fully incorporated into the world I–O table. It should be clear though that in the policy discussion on the appreciation of the Renminbi against the USD, it matters a lot whether the US–China trade deficit is reported to be 125 billion USD, or 94, or even much less.

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SUPPLEMENTAL DATA

Supplemental material for this article is available via the supplemental tab on the article’s online page at <http://dx.doi.org/10.1080/09535314.2014.955463>

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