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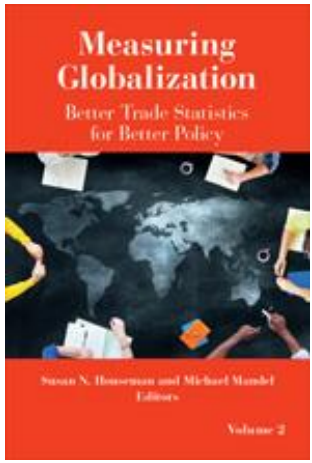

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Chapter 7 (pp. 205-228) in:
Measuring Globalization: Better Trade Statistics for Better Policy, Volume 2, Factoryless Manufacturing, Global Supply Chains, and Trade in Intangibles and Data
Susan N. Houseman and Michael Mandel, eds.
Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, 2015
DOI: 10.17848/9780880994903.vol2ch7

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Import Uses and Domestic Value-Added in Chinese Exports

What Can We Learn from Chinese Microdata?

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Estimating the economy-wide and sectoral domestic value-added in exports requires an input-output (I-O) table with good information on import uses. Normally, statistical agencies do not compile this information at the sectoral level. The I-O experts either break down the data on total import uses or make an inference from available but limited microdata. In so doing, they often explicitly rely on the proportionality assumption to assign imported inputs to different sectors, or else they implicitly resort to the proportionality assumption when making generalizations about the import use patterns by a sample of firms. However, this assumption is hardly valid in reality, because individual sectors normally do not have the same patterns of import use as the overall economy, and also because firms are heterogeneous and they often behave differently in international trade (Bernard et al. 2007). As a result, these approaches tend to lead to biased estimates, as shown by the microdata work at the U.S. Census Bureau (Feenstra and Jensen 2012) and the microdata work for Germany (Winkler and Milberg 2009). Meanwhile, I-O-based trade-related estimates are sensitive to the structure of the import matrix, such as for emission estimation, as

shown in Dietzenbacher, Pei, and Yang (2012), and for vertical specialization (VS) estimation, as in Yang et al. (2013).[1]

Therefore, when the World Trade Organization (WTO) and the Organisation for Economic Co-operation and Development (OECD) launched the "Made in the World Initiative" in 2011 to promote worldwide research on domestic value-added share (DVS) estimation and to enhance understanding of the global value chain, they pointed out that "the key challenges in the immediate future concern the quality of trade statistics and the assumptions made to allocate imports to users" and that linking traders to the manufacturers would form an important part of the work (Ahmad et al. 2011). In addition to the Trade by Enterprise Characteristics (TEC) joint project with Eurostat, the OECD's exercise with Turkish microdata is another attempt to reveal the patterns of firm heterogeneity in trade and production and, based on that, to improve trade in value-added measures (Ahmad and Araujo 2011).

There are two threads of methodologies with which to estimate China's DVS in exports under an I-O framework: one relies on assumptions or optimization programming to derive key coefficients, and the other employs real data to obtain these coefficients. The former approach includes the work of Dean, Fung, and Wang (2011) and of Koopman, Wang, and Wei (2012). Koopman, Wang, and Wei split the officially published Chinese 2007 I-O tables into two parts—1) processing and 2) normal trade—in their modified Chinese I-O tables. Ma, Wang, and Zhu (2013) take the modified I-O table that Koopman, Wang, and Wei developed and further split it by producers' ownership. In doing so, Ma, Wang, and Zhu also incorporate micro firm-level data and other real data. Even though their approach contains real data, it falls into the former category, given the complexity of the I-O tables' structure after two rounds of splitting and the lack of import-use information in the microdata, as will be shown in this chapter.

On the other hand, the Chinese National Bureau of Statistics (NBS) follows the latter approach. When compiling China's 2007 input-output table, NBS researchers for the first time used a survey of firms to prepare the import-use coefficients. Recently, in updating the I-O tables and also as China's response to the WTO/OECD Made in the World Initiative, the NBS decided to employ import-use matrices from two sources. While the NBS will keep the previous 2007 matrix, the Chinese General Administration of Customs has started its own indepen-

dent firm survey on import uses. The approaches by the two agencies are quite different. The NBS has jurisdiction over enterprise production data collection, and its survey is an added module to its existing annual survey on above-scale industrial production enterprises, called the Annual Survey of Industrial Production (ASIP). On the other hand, Customs is responsible for managing the customs clearance documents provided by firms doing international trade. These firm-level trade data form the basis on which Customs conducts the survey.

The two agencies are trying to reach the same goal from different starting points and by taking different routes. The two microdata sets have rich information on firms' production, financial positions, and trade. Combined, they would be able to provide much-needed information on firms' import uses. However, the two threads of similar work are independent of each other. Therefore, among various sampling problems, the biggest problem with the two approaches is that neither of them is based on prior knowledge of both production and trade distribution patterns in the population.[2] Although this chapter does not include them, surveys on import uses by the two agencies serve as background for our analysis of the combined production and trade microdata sets on import uses.

Surveys are costly. Unless existing microdata are exhausted, surveys would not be efficient and, even worse, could lead to aggregation bias if they were not based on samples representative of Chinese firms' trade and production patterns, as the proportionality assumption would be implicitly applied.

Needless to say, the ideal approach is to make the best use of existing microdata on trade and production. Upward, Wang, and Zheng (2013) made the first attempt to do so in estimating China's DVS in exports. However, their work suffers from several flaws. These include

- proportionality assumption on import uses between domestic and export production,
- no differentiation regarding the proprietary rights between the two submodes of processing trade—1) processing with imported materials (PWIM) and 2) processing and assembly with provided imported materials (P&A),
- ignoring trading agency issues,
- treating the import and export data in the firm-level trade data set as having been used or produced by the same firms, and

- giving no consideration of the imported inputs embodied in domestic inputs.

Despite the above problems, Upward, Wang, and Zheng (2013) represent the right direction in which to move to pursue the microdata work in order to estimate the Chinese DVS in exports. This chapter follows this direction. Specifically, like Upward, Wang, and Zheng, we combine the two microdata sets used respectively and independently by the NBS and Customs. We identify the production enterprises that also do international trade by linking the two data sets. This enables us to reveal the patterns of Chinese firm heterogeneity in trade and production, which justify further exploration of the microdata in import uses and DVS estimation. After appropriately treating the problems in Upward, Wang, and Zheng, identified above, this chapter provides various estimates of DVS boundaries.

The chapter has five sections, counting this one. The next section, "Chinese I-O Table Development: Backgrounding the Microdata Work," introduces the recent development of Chinese I-O tables as background for our microdata work. Section Three, "Chinese Microdata and Firm Heterogeneity," explores the merged microdata and reports various measures of firm exposure to international trade to illustrate not only the within-sample but also the between-sample firm heterogeneity. Section Four, "Estimating DVS: Boundaries and Confidence," estimates Chinese DVS in exports based not only on various samples pulled from the microdata population but also on the aggregate commodity-level trade data. It provides lower and upper boundaries for DVS and the associated confidence levels. Section Five concludes with our speculation on how a firm survey project might improve the VS/DVS estimation.

CHINESE I-O TABLE DEVELOPMENT: BACKGROUNDING THE MICRODATA WORK

Recent Chinese I-O Table Development

As a tool of central planning, Chinese I-O tables traditionally had a domestic focus when the country was closed to the outside world, before 1978. The treatment of international trade in the I-O tables was mini-

mal, assuming as it did that domestic and imported goods were identical. But with China increasingly opening up to foreign trade and investment, this assumption was later relaxed so that domestic and imported goods were treated as differentiated products. Pioneered by Chen et al. (2001) and continued in Chen et al. (2012), the structure of Chinese I-O tables has undergone dramatic change in the past decade to reflect the unique feature of Chinese foreign trade: About half of the country's foreign trade is administered under the processing trade regime. The separation of processing trade, normal trade, and domestic production in the Chinese I-O tables is justified by the theory of firm heterogeneity (Melitz 2003). The new I-O table has a rich trade structure and requires more information to fill in the coefficients, including the import-use matrices, which are crucial to estimating DVS in exports.

DVS Estimation without Import-Use Information

What can we know about the Chinese DVS in exports if we do not know the information on import uses? Table 7.1 shows several estimates based on public data. When talking about DVS in exports, one may be quick to think of it as a country's net exports in goods and services, or its current account balances. This is true only if imports used for final domestic consumption replace the same amount of domestic resources, which would otherwise be used for the same domestic production but instead are allocated to export production. This is a strong assumption. More often than not, imports for final domestic use are not perfect substitutes for goods or services in the export sector. This proxy overestimates the foreign content in exports or underestimates the DVS in exports. The proxy could be treated as the lower bound of the real DVS in exports. As shown in Table 7.1, this measure of lower-bound DVS (Total DVS1_lower) ranges between 8.2 and 25.3 percent over the period 2001–2010, reaching its high of 25.3 percent in 2007.

Furthermore, by breaking down Chinese foreign trade into normal and processing trade, the numbers for which are readily available from major Chinese government Web sites, we could treat processing imports as the only imported intermediates used for exports. This allows us to obtain an estimate of lower-bound vertical specialization, or VS, ranging from 26.4 to 37.5 percent over 2001–2010 and measuring 30.3 percent for 2007, which translates into an upper bound of DVS in exports of 69.7 percent for that year (Total DVS2_upper in Table 7.1).

Table 7.1 Estimates of Domestic Value-Added Shares in Exports without Import-Use Information (%)

	CA balances/ total exports	Total			L&M firms		
Year	Total DVS1_lower	Processing imports/ processing exports	Processing imports/ total exports	Total DVS2_upper	Processing imports/ processing exports	Processing imports/ total exports	Total DVS3_upper
2001	10.6	63.7	35.3	64.7	64.9	49.2	50.8
2002	11.5	67.9	37.5	62.5	67.9	51.0	49.0
2003	8.2	67.4	37.2	62.8	67.3	51.1	48.9
2004	8.3	67.6	37.4	62.6	69.9	50.6	49.4
2005	16.4	65.8	36.0	64.0	67.9	49.6	50.4
2006	21.6	63.0	33.2	66.8	62.4	44.8	55.2
2007	25.3	59.6	30.3	69.7	57.6	40.5	59.5
2008	24.4	56.0	26.4	73.6	—	—	—
2009	18.3	54.9	26.8	73.2	—	—	—
2010	14.7	56.4	26.5	73.5	—	—	—

NOTE: “CA” stands for “current account.” “L&M” stands for “large and medium-sized firms.” “DVS” stand for “domestic value-added share.” — = data not available.

SOURCE: Authors’ calculations based on data from National Bureau of Statistics of China Web site and China Customs Statistics (CCS).

In short, with the data on current account balances and the Chinese trade statistics alone, we can at best estimate only a range of Chinese DVS in exports, which for 2007 is 25.3 to 69.7 percent. To narrow down the lower and upper boundaries, we need to explore other data sources, which is the focus of the remaining part of the chapter.

Microdata Approach: What Can We Do, and What Can't We Do?

At the firm level, the Customs statistics have the same variables as those in the commodity-level trade statistics. Together with the firm production data, they raise the hope of estimating firm-level I-O tables. However, the following three problems hamper our efforts to do so:

1) The production enterprise data contain only total input use, but not its breakdown into domestic or foreign sources, or into different sectors.
2) The production enterprise data, normally without an import-use module, do not have import information and only have total exports. There is detailed import and export information in the firm trade data set, but the trading companies may resell the imports to other production firms and may also help export products made by other firms.
3) Neither of the two data sets has interfirm transaction information in either inputs or final products.

As a result, with the current Chinese firm-level data, it is difficult to give a precise DVS estimate. However, with rich information, it could be used to reveal the stylized patterns of firms' trade and production and serve as the basis for sensible assumptions and for efficient and unbiased survey design.

CHINESE MICRODATA AND FIRM HETEROGENEITY

Chinese Microdata Sets and Their Matching

We use two sets of 2007 Chinese firm-level data. First, the Customs data has product-level transaction information for 236,505 trading com-

panies, which is the entire population of firm-level trade statistics. Second, ASIP data has 336,768 enterprises—all state-owned enterprises and other enterprises with annual sales of more than 5 million yuan—and covers 95 percent of industrial output and 98 percent of industrial exports, approximately the whole population of the Chinese industrial enterprises.

To merge the two data sets by firm name and other identifying information produces the linked data set, which is a subset of each of the two data sets. This is a standard exercise for researchers working on Chinese microdata. They may differ in specific matching criteria, but they use a similar strategy and therefore produce similar overall results. In this chapter, the matching exercise includes only trade data with nonzero exports and excludes those with zero exports but nonzero imports. This is a shortcoming for research on import uses. In terms of firm size, firms in the matched data set do both production and direct trade and tend to be large and medium (L&M), while firms in the nonmatched data set are generally small. Key summary statistics of the matching exercise for this chapter are presented in Table 7.2.

Among the 336,768 firms in the ASIP data set and the 236,505 firms in the trade data set, only 65,545 firms are successfully matched, accounting for 19.5 and 27.7 percent of the two data sets, respectively. The shares are small, but they account for 82.9 percent of the total of 79,103 exporting ASIP firms. In terms of trade volume, the matched firms handle 35.1 and 27.8 percent of the total exports for the two data sets, respectively. The ASIP data set does not have the import variable, and this data set accounts for only 16.9 percent of the total imports for the trade data set, lower than the same export share. The output and sales variables only appear in the ASIP data set, and they are almost the same in value, roughly 40–41 trillion yuan in total and 21–22 trillion yuan for exporting ASIP. Therefore, the L&M firms produce and sell about 18.5 percent of all ASIP firms' sales/output and 34.5 percent of exporting ASIP firms' sales/output.

There are several reasons that a large number of firms in the two data sets are not matched, in addition to the lack of accurate identification information. For the 80.5 percent of the total ASIP firms and the 17.1 percent of the exporting ASIP firms that are not matched, they either do not export at all or do not export directly, and therefore their names do not show up in the Customs registry. As for the 72.3 percent

Table 7.2 Summary Statistics of the 2007 Enterprise and Trade Data

Data Set	Firm numbers	Exports	Imports	Output	Sales
ASIP	336,768	7.34		40.50	40.00
Exporting ASIP	79,103	7.34		21.90	21.30
Trade data	236,505	9.27	7.27		
L&M (matched)	65,545	2.58	1.23	7.54	7.34
L&M ASIP exp > 0	50,277	2.31	1.05	5.95	5.81
L&M imp > 0	37,536	2.17	1.23	5.48	5.38

NOTE: Values for "Exports," "Imports," "Output," and "Sales" columns are in trillions of yuan. "ASIP" stands for "Annual Survey of Industrial Production." "L&M" stands for "large and medium-sized firms." Blank cell = data not applicable.

SOURCE: Authors' calculations based on data from National Bureau of Statistics of China Web site and China Customs Statistics (CCS).

of the firms in the trade data set that are not matched, they could be pure trading companies with no production at all, or they could be production firms that are not included in the ASIP data set.

In the L&M data set, there are two subsets that are used in this chapter. The subset "L&M ASIP exp > 0" represents the firms whose exports in the production data are also positive. The last row in Table 7.2 shows a subset of the matched data with positive imports (L&M imp > 0). This is the data set that Upward, Wang, and Zheng (2013) use in estimating China's DVS in exports. Because it is the smallest sample in terms of number of firms, its representativeness of the whole population is in doubt, and both firm heterogeneity within the data set and firm heterogeneity across samples deserve careful scrutiny if the aggregate DVS is to be derived from it.

Firm Heterogeneity in Trade and Production Patterns

The intermediates include two parts: 1) processing imports are treated as intermediates, and 2) intermediates under normal imports are identified with the "broad economic categories" (BEC) classification developed by the United Nations Statistics Division. Because of the existence of two submodes of processing imports, two different definitions are adopted for imported intermediates under processing imports in estimating DVS. One defines all processing imports as intermedi-

ates, and the other includes only processing with imported materials, or PWIM. To be consistent, the second definition is adopted when firms' input and output are used in estimating DVS together with import data, as the P&A (processing and assembly with provided imported materials) imports are not counted as input and not part of the output, either.

Trade intensity by ownership is shown in Table 7.3. The shares of intermediate imports in processing exports are listed in the first two columns. In comparing the shares in the L&M samples with those in the total population of trade statistics, we see that collective enterprises, wholly foreign-funded enterprises, and joint ventures behave similarly, whereas state-owned enterprises and private firms show significant differences. These differences possibly stem from the high concentration of pure trading companies among state-owned trading enterprises and the prevalence of small private firms in China's processing trade sector, since neither of these concentrations is included in the L&M samples. In both the total population and the L&M samples, only wholly foreign-funded enterprises have higher-than-average shares.

In the third and fourth columns in Table 7.3, normal imports of intermediates (defined in the BEC classification as a share of normal exports) are listed, showing large differences between the L&M samples and the population for all types of firms. Therefore, L&M samples are not representative of the population for this indicator either. Foreign firms (wholly foreign-funded firms and joint ventures) and state-owned enterprises have higher-than-average shares in both the total population and the L&M samples.[3]

In terms of the share of processing exports in total exports, shown in the fifth and sixth columns in Table 7.3, foreign firms (wholly foreign-funded firms and joint ventures) have the highest shares, and they are even higher in the L&M samples (85.9 and 65.5 percent, respectively), far ahead of the closest state-owned enterprises (34.2 percent). But the opposite is true for normal export share in total exports, as foreign firms have the lowest shares, shown in the seventh and eighth columns.

Across and within sample variations

Firm heterogeneity can be revealed in many ways. As we report in an earlier version of this chapter, which is available on the Web (Yao, Ma, and Pei 2013), when constructing export intensity (export/output)

Table 7.3 Use of Imported Intermediates and Exports Breakdown by Firm Type, 2007 (%)

	Imported intermediates as share of export value				Share of exports by customs category			
Formula	Processing imports/ processing exports		Normal BEC input imports/normal exports		Processing exports/ total exports		Normal exports/ total exports	
Firm type	Total	L&M firms	Total	L&M firms	Total	L&M firms	Total	L&M firms
Collective enterprises	41.6	41.0	37.8	14.9	24.1	15.4	75.9	84.6
Wholly foreign-funded enterprises	63.1	61.9	78.7	52.4	81.8	85.9	18.2	14.1
Joint ventures	48.3	46.7	73.7	59.2	59.7	65.5	40.3	34.5
Private firms	58.7	47.2	25.6	6.4	9.8	14.9	90.2	85.1
State-owned enterprises	63.4	38.0	104.4	64.3	26.6	34.2	73.4	65.8
All	59.7	57.6	62.7	40.7	50.6	70.4	49.4	29.6

NOTE: "L&M" stands for "large and medium-sized firms." "BEC" stands for the "broad economic categories" classification.
SOURCE: Authors' calculations based on data from National Bureau of Statistics of China Web site and China Customs Statistics (CCS).

and intermediates import intensity (imports input/output and imports input/input) indicators, we see considerable firm heterogeneity across and within sectors or samples, as well as evidence of importing agency problems, shown as larger-than-one intermediate import ratios over total output or input. To put things in perspective, Table 7.4 assembles some aggregate measures together with shares of value-added in output, with breakdown by firm ownership (domestic or foreign) and size.

For import intensity, large discrepancies exist between domestic and foreign firms, as foreign firms' import shares are much higher. There are some differences across firm size but more differences within the same size group for the share of imported input in total input, as shown by the difference between the weighted and simple averages, where total input value is used as the weight.

For export intensity, too, domestic and foreign firms behave differently: Again, foreign firms' export shares are higher. Compared to the "L&M ASIP exp > 0" sample, firm size matters more for the "Other exporting ASIP" sample, in which larger firms tend to export a smaller share of total output.

Value-added share in total output (Value-added/output) is a new indicator. While the aggregate measures in the two samples are quite similar, they can differ by as much as 6.3 and 58.6 percent, respectively, for the sectors "Artcrafts and other manufacturing" (China Industrial Classification [CIC] 42) and "Tobacco" (CIC 16), as shown in the tables of an earlier version of this chapter (Yao, Ma, and Pei 2013).

In summary, the existence of firm heterogeneity is extensive, and the issues of proprietary rights in processing imports and trading agency are real. These will complicate the efforts to estimate the DVS in Chinese exports.

ESTIMATING DVS: BOUNDARIES AND CONFIDENCE

Proportionality Assumption on Domestic and Export Production

Proportionality assumption regarding import uses means two things: 1) imports are proportionally allocated among different sectors, and 2) within each sector, they are further proportionally allocated between

Table 7.4 Summary Indicators by Type of Ownership and Firm Size, 2007 (%)

				Type of ownership		Firm size (no. of employees)			
Indicator	Data set	Average	All	Domestic	Foreign	<50	50–200	200–1,000	>1,000
Import input/	L&M	Weighted	22.8	6.3	29.4	28.7	24.6	21.3	23.9
input		across firms	59.0	22.0	71.0	38.0	57.4	69.5	29.7
Import input/	L&M	Weighted	17.3	4.8	22.2	21.6	18.6	16.2	18.2
output		across firms	16.1	5.3	19.6	18.9	15.8	15.4	18.5
Export/output	L&M	Weighted	45.6	37.0	59.5	55.0	50.1	50.8	52.5
	ASIP exp > 0	across firms	62.1	51.1	68.9	58.9	60.9	63.8	62.6
	Other exporting	Weighted	41.5	37.5	55.3	62.3	55.6	43.1	32.9
	ASIP firms	across firms	66.7	64.3	71.4	70.5	69.4	62.8	46.2
Value-added/	L&M	Weighted	25.9	25.8	26.0	25.7	25.4	26.1	26.0
output		across firms	26.7	25.6	27.4	24.4	26.1	27.6	28.4
	Other exporting	Weighted	27.1	26.9	27.6	24.1	26.6	27.1	27.8
	ASIP firms	across firms	28.3	27.5	30.0	23.8	27.5	31.1	31.8

NOTE: For the first indicator, total input value is used as the weight, and for the remaining three indicators, output value is used as the weight. "L&M" stands for "large and medium-sized firms." "ASIP" stands for "Annual Survey of Industrial Production."

SOURCE: Authors' calculations based on data from National Bureau of Statistics of China Web site and China Customs Statistics (CCS).

domestic and export production. If the importing agency problem could be solved so that the import data truly reflected the amount of intermediate imports used in a firm's production, then the L&M data set would be able to remedy the first problem. Thus, the importing agency issue is a focus of this chapter. As for the second problem, unfortunately, firm-level data alone are of little help, as they do not contain information on how firms split intermediate imports between domestic and export production.

When Hummels, Ishii, and Yi (2001) first employ I-O tables to estimate VS, they assume an equal percentage of foreign input in domestic output and exports. Upward, Wang, and Zheng (2013) retain this assumption in estimating China's vertical specialization (VS). Working from a data set similar to L&M, Upward, Wang, and Zheng distinguish between processing and normal trade and apply this assumption to normal trade only. That is, within normal trade, imports are allocated to domestic and export production proportionally to domestic output and normal exports. This assumption is oversimplified but still acceptable. However, when Upward, Wang, and Zheng actually do the calculation, they use the following formula to determine the ratio of intermediate import in domestic output and normal exports:

$$r^{uwz} = \frac{M^{bec}}{Y - X^{p}} . \tag{7.1}$$

This is problematic, because imports for processing and assembly ($M^{p\&a}$) in the trade data set are included only in X^{p} but not in Y. Therefore, the denominator in the above formula gives a lower value for domestic output and normal exports, or a higher share of foreign content in domestic output and normal exports. $M^{p\&a}$ accounts for 17.0 and 24.2 percent of L&M processing imports and total processing imports, respectively, and these are not trivial amounts. As such, the problem associated with $M^{p\&a}$ in the above formula cannot be ignored.

Imports for Processing and Assembly and a Lower VS Boundary

This chapter corrects this problem and modifies the above formula by deducting $M^{p\&a}$ from processing exports when calculating the ratio of normal intermediate imports defined by BEC (M^{bec}):

$$r = \frac{M^{bec}}{Y - (X^{p} - M^{p\&a})} = \frac{M^{bec}}{DN}, \quad (7.2)$$

where *DN* represents domestic output and normal exports.

Export production often uses more foreign inputs than domestic production. This can be seen from trade intensity measures by ownership breakdown in Tables 7.3 and 7.4, where foreign-funded enterprises (FFEs) have higher shares of intermediate imports in normal exports, total input, and total output. Because FFEs dominate Chinese foreign trade in both imports and exports, a link can be established showing that export production has higher shares of foreign intermediates than domestic production. Also, considering that a domestic content requirement is normally imposed on FFEs for domestic production, a lower bound of *VS* exists as a result of this policy. In fact, the proportionality assumption regarding the import uses among domestic and export production, as reflected in Equation (7.2), can be regarded as the lower bound:

$$VS^{lower} = M^{p} + \frac{M^{bec}}{Y - (X^{p} - M^{p\&a})} X^{n} = M^{p} + r \times X^{n}. \quad (7.3)$$

Trading Agency Problem

Imports and exports in the above equations mean the actual imports used as inputs by the firms and the actual exports produced by the firms. Because of the trading agency problem, trade volume from the trade data set does not meet this requirement at the firm level. However, since the L&M data already screened out the pure trading companies, production firms doing trading agency business are more likely to deal with firms in the same sector. Based on this assumption, we first sum up the variables across firms within a sector and then proceed to estimate sectoral *VS* using that formula. By so doing, we neutralize the trading agency problem among firms within a sector, but we also risk introducing aggregation bias. This can be illustrated by the following equations:

$$VS_{i}^{lower} = M_{i}^{p} + \frac{M_{i}^{bec}}{DN_{i}} \times X_{i}^{n}, \quad (7.4)$$

$$VS^{lower} = \sum M_{i}^{p} + \frac{\sum M_{i}^{bec}}{\sum DN_{i}} \times \sum X_{i}^{n}, \text{ and} \quad (7.5)$$

$$VS^{lower} - \sum VS_i^{lower} = \sum \left(\frac{X_i^n}{DN_i} - \frac{\sum X_i^n}{\sum DN_i^n} \right) \times M_i^{bec}. \quad (7.6)$$

Because both within and between sectors variations could be large, as suggested in the section titled "Chinese Microdata and Firm Heterogeneity," the two approaches may generate different sectoral *VS*, as the right-hand side of Equation (7.6) is not always zero. This potential bias can also occur when estimation is done at the whole manufacturing level. The lower bound of VS thus should be treated with less confidence.[4]

Upper VS Boundary

After determining that the estimation of the lower bound of *VS* should be treated with less confidence, we now turn to the upper-bound *VS* estimation. As exports use more intermediate imports than domestic production, the upper limit of *VS* can be achieved by assuming all intermediate imports are used for export production:

$$VS^{upper} = M^p + M^{bec} . \quad (7.7)$$

In contrast to the lower-bound *VS*, the upper-bound *VS* estimate is invariant of the level of analysis, commodity, or sectoral level. It is not subject to the constraint of the domestic content requirement, either. As a result, the confidence level is high for it, as long as we are confident in the BEC definition of intermediates.[5]

Results and Discussions

Sectoral and whole manufacturing shares of *VS* (*VSS*) over two samples, "L&M imp > 0" and "L&M," are reported in Table 7.5.[6] The lower bound of VSS is converted into the upper bound of DVS through the following formula:

$$DVS = 1 - \frac{VS}{X} = 1 - VSS . \quad (7.8)$$

Across all sectors, DVS upper bounds are 61.0 and 67.2 percent for the respective two samples. Among all sectors, DVS's in the CIC sectors "Food manufacturing" and "Beverages" (CIC 14 and 15), "Furni-

Table 7.5 VS Share (VSS) and DVS by Sector, Estimated with Microdata (%)

		L&M imp > 0		L&M	
CIC[a]	Sector description	VSS_ lower	Total DVS4_ upper	VSS_ lower	Total DVS5_ upper
13	Agriculture and food processing	32.2	67.8	20.5	79.5
14	Food manufacturing	11.5	88.5	8.3	91.7
15	Beverages	8.2	91.8	5.5	94.5
16	Tobacco	56.7	43.3	56.7	43.3
17	Textile	23.1	76.9	16.2	83.8
18	Clothing, footwear, and caps	27.9	72.1	22.7	77.3
19	Leather, fur, feather, and products	35.7	64.3	28.1	71.9
20	Timber and wood products	24.6	75.4	16.2	83.8
21	Furniture	12.5	87.5	10.2	89.8
22	Paper and products	56.9	43.1	50.3	49.7
23	Printing and recording	26.9	73.1	24.0	76.0
24	Culture, educ., and sports products	23.7	76.3	20.2	79.8
25	Energy resource processing	16.6	83.4	6.1	93.9
26	Raw chem. materials and products	49.0	51.0	39.2	60.8
27	Medicines	19.7	80.3	14.3	85.7
28	Chemical fibers	51.8	48.2	48.8	51.2
29	Rubber	39.2	60.8	35.2	64.8
30	Plastics	55.1	44.9	47.2	52.8
31	Nonmetallic mineral products	17.8	82.2	11.7	88.3
32	Ferrous metals processing	72.8	27.2	37.9	62.1
33	Nonferrous metals processing	50.9	49.1	36.8	63.2
34	Metal products	23.6	76.4	18.9	81.1
35	General purpose machinery	22.7	77.3	18.3	81.7
36	Special purpose machinery	29.0	71.0	25.7	74.3
37	Transport equipment	30.0	70.0	26.2	73.8
39	Electrical machinery & equipment	35.6	64.4	30.8	69.2
40	Electronics	66.6	33.4	64.9	35.1
41	Measuring, cultural, office machine	42.0	58.0	39.2	60.8
42	Artcrafts and other manufacturing	30.9	69.1	21.8	78.2
43	Waste recycling and processing	88.8	11.2	80.7	19.3
All		39.0	61.0	32.8	67.2

NOTE: Gross output (rather than total sales) is adopted in the denominator. "VSS" stands for "vertical specialization share." "DVS" stands for "domestic value-added share." CIC category 38 has been omitted from the table.

[a] "CIC" stands for China Industrial Classification.

SOURCE: Authors' calculations based on data from National Bureau of Statistics of China Web site and China Customs Statistics (CCS).

ture" (CIC 21), "Petroleum and coking processing" (shown as "Energy resource processing," CIC 25), and "Nonmetallic mineral products" (CIC 31) are among the highest, because these domestic sectors are not as much globalized as the sectors with the lowest DVS's, such as "Communication, computer, and other electronic equipment" (shown as "Electronics," CIC 40) and "Waste recycling and disposal" (shown as "Waste recycling and processing," CIC 43). The DVS patterns are consistent with import intensity patterns reported in an earlier version of this chapter (Yao, Ma, and Pei 2013), where sectors with higher DVS's tend to have lower intensity of intermediate imports, and vice versa.

Comparing the two data samples, DVS's in the "L&M" sample are consistently higher than those in the "L&M imp > 0" sample, simply because the former data set has records with zero imports. Firms that do not import intermediates may buy from other production firms that are also in the importing agency business. This is another example of the fact that sampling matters in DVS estimation and the view that the trading agency problem deserves careful treatment.

Table 7.6 reports the aggregate DVS's, both lower and upper bounds, for overall and normal trade estimated with different data sets and intermediate definitions. Some of the numbers are drawn from previous tables. The numbers with superscript "a" are the estimates with

Table 7.6 Estimated DVS Boundaries (%)

	Total DVS		Normal DVS		Shares of
Data scope and imports input	Lower	Upper	Lower	Upper	P&A in PI
CA balances (DVS1)	25.3				
Total PI (DVS2)		69.7			
L&M PI (DVS3)		59.5			
L&M imp > 0 PI BEC (DVS4)	50.7	61.0[a]	66.9	94.5[a]	17.0
L&M PI BEC (DVS5)	58.5	67.2[a]	77.8	96.4[a]	17.0
Total PI BEC	38.9	68.0[a]	37.3	96.3[a]	24.2

NOTE: "DVS" stands for "domestic value-added share." "P&A" stands for "processing and assembly." "PI" stands for "processing imports." "L&M" stands for "large and medium-sized firms." "BEC" stands for the "broad economic categories" classification. Blank cell = data not applicable.

[a] Signifies a number that is an estimate with less confidence.

SOURCE: Authors' calculations based on data from National Bureau of Statistics of China Web site and China Customs Statistics (CCS).

less confidence, in part because of the firm heterogeneity issue, as discussed earlier in regard to Equation (7.6).[7] As a reminder, Table 7.6 also lists the shares of processing and assembly imports in total processing imports for the three data sets affected by the proprietary rights issue. Taking this issue into consideration helps improve the confidence level in the GVC upper bounds for the three data sets.

Clearly, the range of DVS estimates varies, depending on the scope of the data and the associated definitions of intermediates. For overall DVS, both lower and upper bounds are estimated with confidence, and the true value could be anywhere in the range of 38.9 to 69.7 percent. For normal trade, the DVS could be anywhere in a much wider range, from 37.3 to 96.3 percent.

What have we learned from our DVS estimation results? First of all, DVS estimates are sensitive to data samples. Cross-sample variations for lower and upper DVS bounds as well as the ranges of possible DVS are significant, especially when compared to the overall DVS estimates. This suggests that none of the samples appear to be representative of the population.

Second, as reflected by the wide range of possible GVC values, DVS estimates are sensitive to assumptions on import uses. This is intuitive, as the import uses across sectors and across domestic and export production directly allocate the flow of foreign intermediates within a country, and they ultimately determine the sectoral and overall DVS's. It is also in line with previous findings in I-O table literature—e.g., Dietzenbacher, Pei, and Yang (2012) and Yang et al. (2013).

Given the uncertainties surrounding the true DVS numbers, it is natural and logical to speculate about a firm survey project on import uses that aims to obtain additional information for better DVS estimation.

CONCLUSION

This chapter does not estimate the exact true DVS value because we do not make arbitrary assumptions. Instead, we take stock of the possible estimates, and in so doing we clarify several conceptual issues, which helps to improve the methodology in the literature. We leave a

wide range for possible DVS estimates and only expect them to be narrowed down by future firm survey work.

Firm-level data have rich information that could be used to correct the bias in the import-use matrix caused by proportionality assumption in I-O table development. To realize the potential of such data, surveys need to overcome the nonrepresentative sampling and trading agency problems. They can do so, among other ways, by taking the following steps:

- First, identify the small production firms from firm-level trade data. This could be done by first screening the nonmatched small trading firms and then tracking them through firms' contact information to verify their production status. By incorporating these small trade and production firms, the L&M data set could be expanded to include large, medium, and small firms (LMS).
- Second, select a sample of firms from LMS to be covered by the survey. The questionnaire should include questions on the amount of imports that are for a firm's own use, the exports produced by customs regime, and the amount split between domestic production and export production, among others.

Of course, various other aspects of the firm distribution should also be considered, such as ownership, sector, location, and trading partners.

Firms are able to answer questions regarding direct import uses, but it is difficult for firms to know the uses of imports embodied in domestic inputs. Probably this is the only area that would require an assumption.

Notes

The authors thank Bradford Jensen for his encouragement, and Jie Chen, Kunfu Zhu, and Hongman Jin for their insights on the firm survey projects at the National Bureau of Statistics of China and the China Customs Statistics (CCS). Financial support from the Sloan Foundation is gratefully acknowledged. Jiansuo Pei also acknowledges financial support from the National Natural Science Foundation of China [No. 41205105] and Program for Young Excellent Talents, UIBE [No. 2013YQ01]. The authors are responsible for all errors.

1. The term "vertical specialization" is borrowed from Hummels, Ishii, and Yi (2001) and is defined as the value of imported intermediates in exports.

2. Details on the NBS and Customs import use surveys are documented in an earlier version of this chapter (Yao, Ma, and Pei 2013), which is available on the Web.
3. The higher shares for the state-owned companies are either because some of the traditional state trading companies have diversified their operations into production business and therefore are kept in the L&M data set, or because import of primary resources is often conducted by state-owned production enterprises with overseas investment.
4. Less confidence in the lower bound of VS is also due to lack of an exact minimum for domestic content requirement.
5. According to Timmer (2012), 14 percent of BEC codes can be both final goods and intermediates.
6. We do not attempt to compare the numerical results with those from other studies because our methodology is based on a different set of concepts, which makes it uncomparable.
7. VS is first estimated at sector level and then summed up across sectors. For VS estimation with the entirety of commodity trade data, in the last row of Table 7.6, there is no link between production output and trade data, and estimation can only be done with data summed over the whole database.

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Measuring Globalization

Better Trade Statistics for Better Policy

Volume 2

Factoryless Manufacturing, Global Supply Chains, and Trade in Intangibles and Data

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and
Michael Mandel
Editors

2015

W.E. Upjohn Institute for Employment Research
Kalamazoo, Michigan

Library of Congress Cataloging-in-Publication Data

Measuring globalization : better trade statistics for better policy / Susan N. Houseman and Michael Mandel, editors.
volumes cm
Includes bibliographical references and indexes.
ISBN 978-0-88099-488-0 (v. 1 : pbk. : alk. paper) — ISBN 0-88099-488-6 (v. 1 : pbk. : alk. paper) —ISBN 978-0-88099-489-7 (v. 1 : hardcover : alk. paper) — ISBN 0-88099-489-4 (v. 1 : hardcover : alk. paper)
1. Commercial statistics. I. Houseman, Susan N., 1956- II. Mandel, Michael J.
HF1016.M44 2015
382.01’5195—dc23

2014047579

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300 S. Westnedge Avenue
Kalamazoo, Michigan 49007-4686

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Cover design by Alcorn Publication Design.
Index prepared by Diane Worden.
Printed in the United States of America.
Printed on recycled paper.