Hagino, Satoru; Kim, Jiyoung

Article

The usefulness of extended input-output tables incorporating firm heterogeneity

Journal of Economic Structures

Provided in Cooperation with:
Pan-Pacific Association of Input-Output Studies (PAPAIOS)

Suggested Citation: Hagino, Satoru; Kim, Jiyoung (2021) : The usefulness of extended input-output tables incorporating firm heterogeneity, Journal of Economic Structures, ISSN 2193-2409, Springer, Heidelberg, Vol. 10, pp. 1-28, https://doi.org/10.1186/s40008-021-00255-3

Hagino and Kim
Journal of Economic Structures (2021) 10:25
https://doi.org/10.1186/s40008-021-00255-3

Journal of Economic Structures

RESEARCH Open Access

The usefulness of extended input–output tables incorporating firm heterogeneity

Satoru Hagino[1] and Jiyoung Kim[2*]

*Correspondence:
jiyoung@okayama-u.ac.jp
[2] Graduate School of Humanities and Social Sciences, Okayama University, 3-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530, Japan
Full list of author information is available at the end of the article

Abstract

This study examines the usefulness of an extended input–output table (EIOT) incorporating the heterogeneity of Japanese firms based on differences in ratios of imported intermediate goods to total output. Using an EIOT, the vertical specialization indicator of Japan was calculated, which corresponds to the foreign value added included in exports. In this process, differences in intermediate input ratios were measured examining different types of firms using firm-level microdata from the Basic Survey of Japanese Business Structure and Activities. The results indicate that distinguishing between exporting and non-exporting firms is relevant for assembly industries such as electronics and automobiles, as widely discussed in the literature. In contrast, for primary materials industries, such as paper, chemical, and metal industries, other distinctions appear to be more relevant. For example, for the chemical industry, wherein firms tend to have large, integrated manufacturing plants, the differences in intermediate import ratios are largest when distinguishing large firms from small and medium firms. For paper and metal industries, which rely on foreign raw materials, the difference is largest when distinguishing between firms with and without foreign affiliates. By incorporating such heterogeneity, the vertical specification indicator increases by 70%; thus, the EIOT captures the foreign value added more comprehensively.

Keywords: Extended input–output table, Trade in value added, Incorporating firm heterogeneity, Vertical specialization

JEL classification: D57, F1

1 Introduction

In recent years, international conferences on national accounts have proposed extending input–output tables (IOTs) and supply and use tables (SUTs) to incorporate firm heterogeneity, along with active discussions on potential approaches for doing so (OECD 2014a, b, 2018). The Organisation for Economic Co-operation and Development (OECD) encourages the extension of IOTs or SUTs to improve the accuracy of its Trade in Value Added (TiVA) indicators by reflecting differences in the ratio of imported to total intermediate goods across heterogeneous firms in an industry.

For the calculation of TiVA, it is important to estimate the amount of imported intermediate goods as accurately as possible, as this is essential for calculating foreign value added. In the OECD's expert group on extended input–output tables (EIOTs) established

in 2014, experts from various countries have discussed which elements of firm heterogeneity should be incorporated in EIOTs (Johnson and Noguera 2012; Ito et al. 2017). Thus far, the OECD has proposed assessing heterogeneity between exporters and non-exporters, domestically and foreign-owned, and large and small firms, in addition to firms with and without foreign subsidiaries (OECD 2015), as presented in Table 1.

In this context, this study considers the kind of firm heterogeneity that should be incorporated in Japan's EIOT. The research then examines the usefulness of such extension by estimating the vertical specialization (VS) indicator of Japan, which corresponds to TiVA's foreign value added included in Japan's exports.

The remainder of this paper is organized into three sections. Section 2 introduces methods, Subsection 3.1 discusses heterogeneity between exporters and non-exporters, and Subsection 3.2 that between large and small firms. Next, Subsection 3.3 focuses on domestically and foreign-owned firms, and Subsection 3.4 that firms with and without foreign subsidiaries. Subsection 3.5 describes the challenges of compiling Japan's EIOT, after determining an element of firm heterogeneity that produces the largest gap of imported intermediate ratio for each industry. In Subsection 3.6, Japan's VS indicators are calculated to examine the usefulness of the constructed EIOT. Section 4 concludes.

2 Methods

Using firm-level data from the Basic Survey of Japanese Business Structure and Activities (BSBSA) conducted by Japan's Ministry of Economy, Trade and Industry (METI), Hagino (2017) found the ratio of imported intermediates to output to be about 10% higher for exporters than non-exporters. To calculate the ratio, the author defined exporters as firms with non-zero exports. In contrast, studies for other countries often define exporters as firms that export at least 10% of their total sales. This research applied a different approach from Hagino's (2017), identifying exporters in terms of their export ratio (i.e., export/sales) in 10 percentage point increments, calculating the differences in intermediate import ratios between exporters and non-exporters.

The weight of distinctions between large and small firms and between exporters and non-exporters is assessed to determine differences in intermediate import ratios, using the firm-level data of the BSBSA. Two different methods are used to distinguish small and large firms. The first follows the Small and Medium-Sized Enterprise Act, which defines large firms as those with paid-in capital of more than 300 million yen. The second follows the Financial Statement Statistics of Corporations by Industry (FSSCI) of the Ministry of Finance, which defines large firms as those with paid-in capital of 1 billion yen or more.

The usefulness in distinguishing between foreign- and domestically owned firms in Japan is then examined, as in many developing and emerging economies, as well as highly internationalized developed economies, foreign-owned firms have a significant role in international trade.

The share of exports and imports accounted for by Japanese firms with foreign subsidiaries is also investigated. These shares for Japan are calculated from the BSBSA in comparison to corresponding shares for the U.K. and France from the OECD Trade by Enterprise Characteristics (TEC) database. Since the BSBSA does not cover very small firms, such firms are not included in this calculation; however, since very small firms

Table 1 Framework of extended input–output table

			Country A						**Country B**					
			Industry 1		**Industry 2**		**Industry 3**		**Industry 1**		**Industry 2**		**Industry 3**	
			Exporting	**Non-exporting**	**Large**	**Small**	**With foreign subsidiaries**	**Without foreign subsidiaries**	**Exporting**	**Non-exporting**	**Large**	**Small**	**With foreign subsidiaries**	**Without foreign subsidiaries**
Country A	Industry 1	Exporting												
		Non-exporting												
	Industry 2	Large												
		Small												
	Industry 3	With foreign subsidiaries												
		Without foreign subsidiaries												
Country B	Industry 1	Exporting												
		Non-exporting												
	Industry 2	Large												
		Small												
	Industry 3	With foreign subsidiaries												
		Without foreign subsidiaries												

Table 1 (continued)

			Country A						Country B					
			Industry 1		Industry 2		Industry 3		Industry 1		Industry 2		Industry 3	
			Exporting	Non-exporting	Large	Small	With foreign subsidiaries	Without foreign subsidiaries	Exporting	Non-exporting	Large	Small	With foreign subsidiaries	Without foreign subsidiaries
Country C	Industry 1	Exporting												
		Non-exporting												
	Industry 2	Large												
		Small												
	Industry 3	With foreign subsidiaries												
		Without foreign subsidiaries												
Value added														
Total output														

			Country C						Final demand		
			Industry 1		Industry 2		Industry 3		Country A	Country B	Country C
			Exporting	Non-exporting	Large	Small	With foreign subsidiaries	Without foreign subsidiaries			
Country A	Industry 1	Exporting									
		Non-exporting									
	Industry 2	Large									
		Small									
	Industry 3	With foreign subsidiaries									
		Without foreign subsidiaries									

Table 1 (continued)

			Country C						Final demand		
			Industry 1		Industry 2		Industry 3		Country A	Country B	Country C
			Exporting	Non-exporting	Large	Small	With foreign subsidiaries	Without foreign subsidiaries			
Country B	Industry 1	Exporting									
		Non-exporting									
	Industry 2	Large									
		Small									
	Industry 3	With foreign subsidiaries									
		Without foreign subsidiaries									
Country C	Industry 1	Exporting									
		Non-exporting									
	Industry 2	Large									
		Small									
	Industry 3	With foreign subsidiaries									
		Without foreign subsidiaries									
Value added											
Total output											

Source: authors' design based on OECD (2015)

are generally unlikely to have foreign subsidiaries, this is not considered to materially affect the results. The U.S. Bureau of Economic Analysis developed an EIOT incorporating heterogeneity between firms with and without foreign subsidiaries, since many U.S. firms with foreign subsidiaries import intermediate goods from subsidiaries and such firms have an important role in international trade in general.

Based on above analyses, the EIOT developed for this research incorporates aspects of firm heterogeneity. As for the details of the compilation procedure, Japan's IO table, which we will refer to as the Benchmark IO Table, is compiled every 5 years in joint work involving ten government ministries coordinated by the Ministry of Internal Affairs and Communications. The Benchmark IO Table is non-competitive and separates the import table from the domestic table. It is based on producer prices, which include subsidies and taxes, such as consumption taxes.

A domestic table is produced by deducting the import table from the transaction table of the Benchmark IO Table and converting 108 product/activity classifications into 18 industry classifications for consistency with the TiVA classification (Table 2). This research focuses on the extension of intermediate input and demand using elements of firm heterogeneity to quantify the effectiveness of the extension; thus, final demand and value added are not separated.

Extending the Benchmark IO Table to incorporate firm heterogeneity requires separating the total output based on the type of firm heterogeneity considered for each industry. To do so, firm-level data from the BSBSA are used and calculate the weights, for which output shares are used. An extended import table is then constructed by incorporating the differences in intermediate import ratios.

Finally, the usefulness of the EIOT is examined by comparing VS indicators based on the EIOT with that of the non-extended Benchmark IOT. For this purpose, VS coefficients are calculated by multiplying the import coefficient matrix using the Leontief inverse matrix. The coefficients for each industry are then aggregated, referring to the aggregated figure as each industry's total VS coefficient. Industries' total VS is then calculated by multiplying the industry total VS coefficient by the number of exports. After aggregating each industry's VS amount, the VS indicator is calculated by dividing the aggregate VS amount by total exports. Finally, two different VS indicators are calculated based on the extended and non-extended IOTs.

The roots of the development of TiVA indicators can be traced back to the estimation of VS indicators (Hummels et al. 2001), which are calculated as the ratio of imported intermediate goods included in exports and are estimated using OECD IOTs. The VS indicator corresponds to foreign value added included in exports in the TiVA.

VS indicators can be estimated using one country's IOT. Defining $\mathrm{VSI_d}$ as the direct imports deriving from exports, X as the $n \times 1$ vector of exports of each industry, X_t as a scalar of total exports of a country, A^m as the $n \times n$ imported input coefficient matrix, U as a $1 \times n$ vector of 1s used for aggregating industries, and n as the number of industries, $\mathrm{VSI_d}$ is given by:

$$\mathrm{VSI_d} = U \times A^m \times X \times X_t^{-1}. \tag{1}$$

However, imports may indirectly derive from exports. For example, automobile manufacturers may import chassis to export cars, or may alternatively purchase chassis from

Table 2 2015 domestic IO and import tables (in billion yen)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total output
Domestic IO table																			
1	1389	0	5827	0	239	3	0	0	0	0	7	0	42	1013	2	0	1	341	12,888
2	0	1	0	0	5	261	36	1	0	0	0	159	309	0	0	0	0	1	848
3	1367	0	5026	1	17	115	0	0	0	0	1	0	2	5532	8	0	0	807	38,341
4	52	3	25	539	42	79	25	31	79	62	21	14	54	300	111	43	113	421	3586
5	274	2	885	28	3615	646	98	125	351	121	182	120	460	1400	1814	687	714	2098	16,926
6	862	32	1128	328	1062	145,37	668	1174	2027	2700	448	1371	2968	846	5314	103	1190	7463	65,493
7	13	18	513	8	273	674	16,078	4720	2711	4197	236	19	3834	345	100	4	125	351	47,886
8	2	4	0	0	14	63	20	4196	346	408	7	33	121	93	13	0	1113	596	34,067
9	2	0	1	0	3	2	31	1340	6271	2084	47	1	162	53	57	6	917	252	35,055
10	51	0	0	0	0	0	0	8	0	22,788	0	0	0	0	747	0	1682	220	55,378
11	24	1	41	12	108	120	369	17	26	24	58	169	108	68	213	5	173	281	4614
12	132	36	610	117	665	1918	1411	415	609	718	62	3407	218	4765	1719	333	836	5719	34,081
13	30	3	18	8	49	167	126	53	79	34	6	504	19	320	529	87	812	787	60,837
14	843	17	2745	263	1276	2304	1344	1446	1598	2138	318	591	1626	4772	2094	188	1484	5572	128,109
15	771	182	1417	110	732	2121	1123	952	1084	1011	759	1765	1817	10,123	13,859	3051	7195	8295	104,984
16	72	33	213	63	155	339	277	253	209	232	96	642	405	1863	1255	738	6717	1981	35,448
17	269	47	1293	125	499	2285	739	1242	1443	1487	175	2503	3043	11,473	16,105	4344	14,717	12,674	155,508
18	21	3	44	3	17	69	27	66	40	20	8	91	55	371	837	111	336	2497	177,614
Total output	12,888	848	38,341	3586	16,926	65,493	47,886	34,067	35,055	55,378	4614	34,081	34,081	60,837	128,109	35,448	155,508	177,614	1,017,818
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Total Import**
Import table																			
1	178	0	1660	29	124	203	0	0	0	0	55	0	1	129	0	0	0	46	2808
2	0	1	11	1	48	10,130	1275	1	3	6	4	7459	7	1	0	0	1	4	20,293
3	118	0	1949	8	2	108	0	0	0	0	9	0	0	1626	1	0	0	101	7806

Table 2 (continued)

Import table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total Import
4	24	1	13	306	40	54	5	10	18	31	10	3	26	170	32	11	37	169	5155
5	8	0	36	2	762	41	8	6	14	6	30	42	122	126	137	21	38	86	2631
6	132	6	240	131	101	5796	77	118	259	289	76	371	137	145	680	17	94	3582	14,882
7	4	2	7	1	31	56	2640	307	867	600	15	5	229	23	6	0	10	27	5944
8	2	0	0	0	0	0	6	1420	15	93	1	16	3	12	6	0	376	287	5674
9	1	0	0	0	3	0	11	598	3898	604	32	0	77	6	54	1	352	86	15,310
10	21	0	0	0	0	0	0	1	0	2060	0	0	0	0	69	0	104	0	4588
11	4	0	5	31	7	7	7	21	11	13	112	1	23	35	23	3	104	257	2263
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	190	0	0	0	0	1234
15	5	1	18	3	17	64	24	47	60	22	4	81	18	424	3169	259	189	403	5931
16	10	1	7	2	5	25	7	8	7	9	1	2	9	28	278	898	76	14	1399
17	3	1	98	7	22	141	18	48	61	73	7	129	167	611	611	289	807	486	3785
18	1	0	8	0	2	15	6	15	30	7	1	17	6	30	216	14	32	53	2410
Total	491	10	3921	510	1118	16,394	4029	2482	5085	3704	345	7898	625	2274	1008	53	1115	4645	87,354

1: agriculture, 2: mining, 3: food, 4: textiles, 5: paper, 6: chemicals, 7: metal, 8: machinery, 9: electronics, 10: transport equipment, 11: other manufacturing, 12: electric, gas and water, 13: construction, 14: wholesale and retail, 15: transportation and warehouse, 16: finance and insurance, 17: real estate and leasing, 18: community, society and individual services

Source: authors' calculations based on the Benchmark IOT

domestic manufacturers, who may import intermediate goods for chassis. Therefore, VS indicators should cover all imports deriving from exports, including imports through increases in domestic demand spurred by exports. Domestic demand deriving from exports can be calculated using the Leontief inverse matrix. Defining A^d as the $n \times n$ input coefficient of domestic transactions matrix and $(I - A^d)^{-1}$ as the Leontief inverse matrix, VSI, which covers both direct and indirect imports from exports, is given by:

$$\mathrm{VSI} = U \times A^m \times \left(I - A^d\right)^{-1} \times X \times X_t^{-1}. \tag{2}$$

3 Results and discussion

3.1 Heterogeneity between exporting and non-exporting firms

The results of calculating the differences in intermediate import ratios between exporters and non-exporters are presented in Table 3.

The results indicate that, in the processing and assembly industries, the more a firm exports, the more it tends to import. In the electronic and optical equipment industry, the difference in the intermediate import ratio between exporters and non-exporters in 2011 was largest when focusing on exporters with an export ratio of 90%, while in 2015, it was largest for those with an export ratio of 50%. In the transport equipment industry, the difference in both years is largest for exporters with an export ratio of 100%. In the machinery equipment industry, the difference in the intermediate import ratio between exporters and non-exporters remains relatively stable as the export ratio increases. In contrast, no clear pattern between the export ratio and the difference between exporters and non-exporters can be observed in primary materials industries. For the metals industry, the difference is largest for an export ratio of 10%, both in 2011 and 2015. For the wood and paper products industry (hereafter, paper industry), the difference becomes larger as the export ratio increases. Conversely, for the textile industry, the difference is largest at an export ratio of 20% in 2011 and 10% in 2015 and then declines as the ratio increases. For the chemical industry, the difference is largest at an export ratio of 10% and then declines, even becoming negative, as the export ratio increases. These results indicate that other aspects of firm heterogeneity may be more crucial for identifying differences in the intermediate imports ratio.

The volume of transactions must be considered to determine the most appropriate export ratio to distinguish exporters from non-exporters. For example, in the transport equipment industry, a small number of export-intensive firms import, so the difference is largest for an export ratio of 100%. To take the volume of transactions into consideration and identify the magnitude of exports to the imported intermediate ratios, the gap was multiplied by the volume of total inputs to calculate indices (Fig. 1). In this figure, "> 0–100%", "≥ 10–100%", ..., "≥ 90–100%", 100% means the ranges of export intensities (export sales ratios). We calculated the differences of import intermediate ratios between exporters and non-exporters that belong to the certain range of export intensities, by subtracting non-exporters ratios from exporters ratios. The magnitude of "> 0–100%" is defined to equal 100 as reference index. (However, "> 0–100%" in 2015 of wood and paper products industry is defined as − 100 since it has a negative value.) Figure 1 demonstrates that the calculation for the export/sales ratio of "> 0–100%" for all

Table 3 Difference in intermediate import ratios between exporters and non-exporters, by export/sales ratios

	Industry/scope of exporters	>0–100%	≥10–100%	≥20–100%	≥30–100%	≥40–100%	≥50–100%	≥60–100%	≥70–100%	≥80–100%	≥90–100%	100%
2011	Food products	0.055	0.060	0.110	0.057	0.057	0.057	0.067	0.067	0.080	0.080	0.098
	Textiles	0.070	0.147	0.187	0.116	− 0.056	− 0.054	0.009	− 0.101	− 0.101	− 0.101	− 0.101
	Wood and paper products	0.027	0.064	0.366	0.444	0.509	0.540	0.762	0.967	0.967	0.967	0.967
	Chemicals	0.086	− 0.156	− 0.172	− 0.143	− 0.062	− 0.025	− 0.189	0.115	0.278	0.587	0.587
	Metals	0.034	0.104	0.125	0.194	0.295	0.428	0.239	0.262	− 0.039	− 0.011	− 0.011
	Machinery equipment	0.067	0.043	0.035	0.024	− 0.018	− 0.023	− 0.041	− 0.044	− 0.051	0.085	0.013
	Electronic and optical equipment	0.103	0.108	0.101	0.097	0.143	0.127	0.249	0.282	0.378	0.605	0.069
	Transport equipment	0.037	0.030	0.024	0.022	0.017	0.006	0.035	0.052	0.035	0.002	0.395
	Manufacturing n.e.c and recycling	0.188	0.092	0.274	0.273	0.280	0.302	0.099	0.140	0.540	0.572	0.815
2015	Food products	0.046	0.084	0.329	0.245	0.288	0.340	0.392	0.392	0.743	0.743	0.963
	Textiles	0.104	0.124	0.009	− 0.020	0.005	− 0.113	− 0.089	− 0.088	− 0.134	− 0.134	− 0.134
	Wood and paper products	− 0.007	0.058	0.098	0.339	0.352	0.503	0.627	0.627	0.961	0.961	0.961
	Chemicals	0.171	0.133	− 0.132	− 0.126	− 0.087	− 0.016	− 0.002	− 0.011	0.088	0.061	0.693
	Metals	0.055	0.092	0.110	0.030	0.241	0.545	0.577	0.595	0.715	0.849	0.870
	Machinery equipment	0.103	0.079	0.072	0.064	0.047	0.039	0.027	0.042	− 0.077	0.054	− 0.053
	Electronic and optical equipment	0.178	0.168	0.142	0.152	0.229	0.230	0.142	0.153	0.201	0.141	− 0.149
	Transport equipment	0.062	0.049	0.046	0.063	0.070	0.066	0.086	0.089	0.136	0.232	0.366
	Manufacturing n.e.c and recycling	0.189	0.081	0.030	0.122	0.110	0.161	0.206	0.418	0.217	0.069	− 0.038

Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

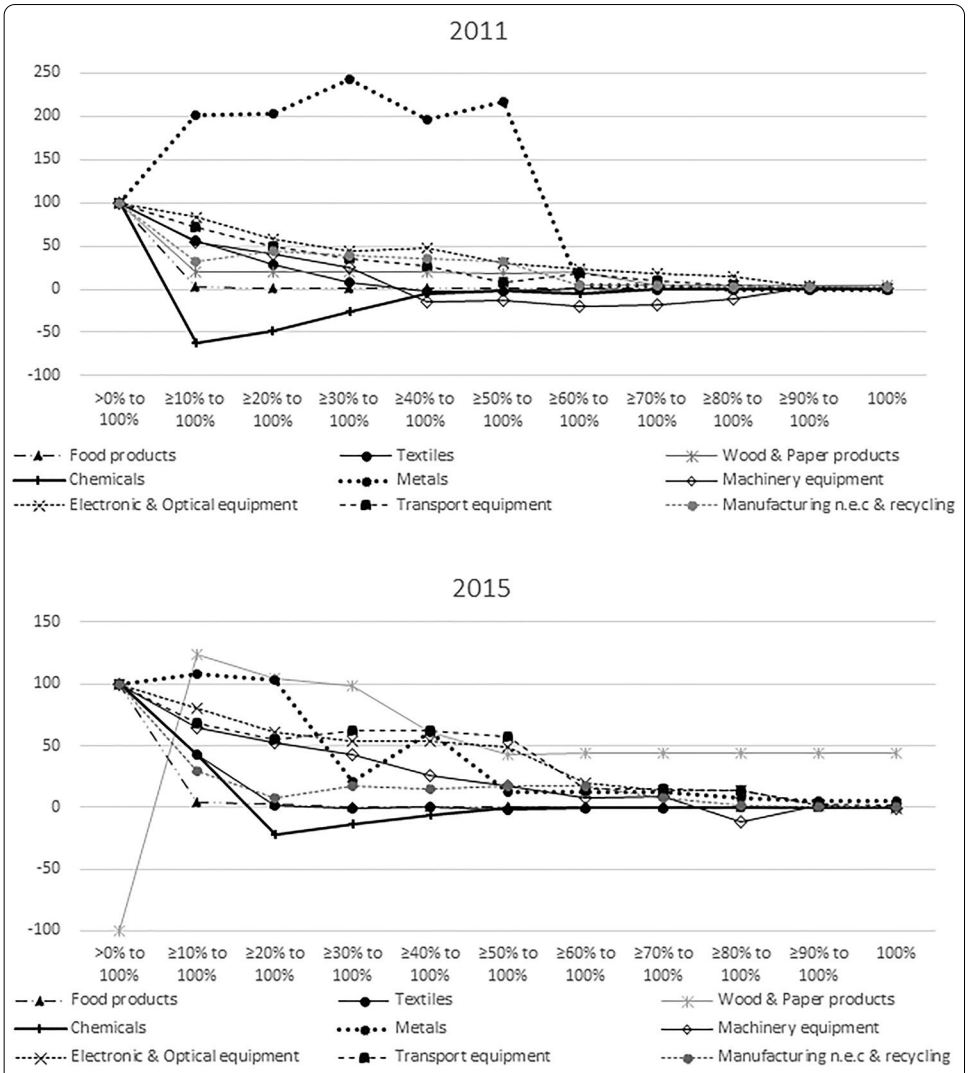

Fig. 1 Magnitude of export/sales ratios to imported intermediate ratios. Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

exporters produces the largest magnitude to the gap indices in all industries, the exception being the wood and paper products with the highest magnitude at "≥ 10–100%" in 2015 (124.31), the metal industry with the largest magnitude at "≥ 30–100%" in 2011 (243.06) and at "≥ 10–100%" in 2015 (108.22). Given than such exceptions are not numerous, we regard that all exporters should be covered in distinguishing exporters from non-exporters.

3.2 Heterogeneity between small and large firms

Figures 2 and 3 present the differences in the intermediate import ratio between small and large firms by industry, with Fig. 2 showing the results based on the first definition and Fig. 3 those based on the second definition, comparing the differences between exporters and non-exporters (where exporters are defined as firms with non-zero exports). In the processing and assembly industries, the differences in intermediate

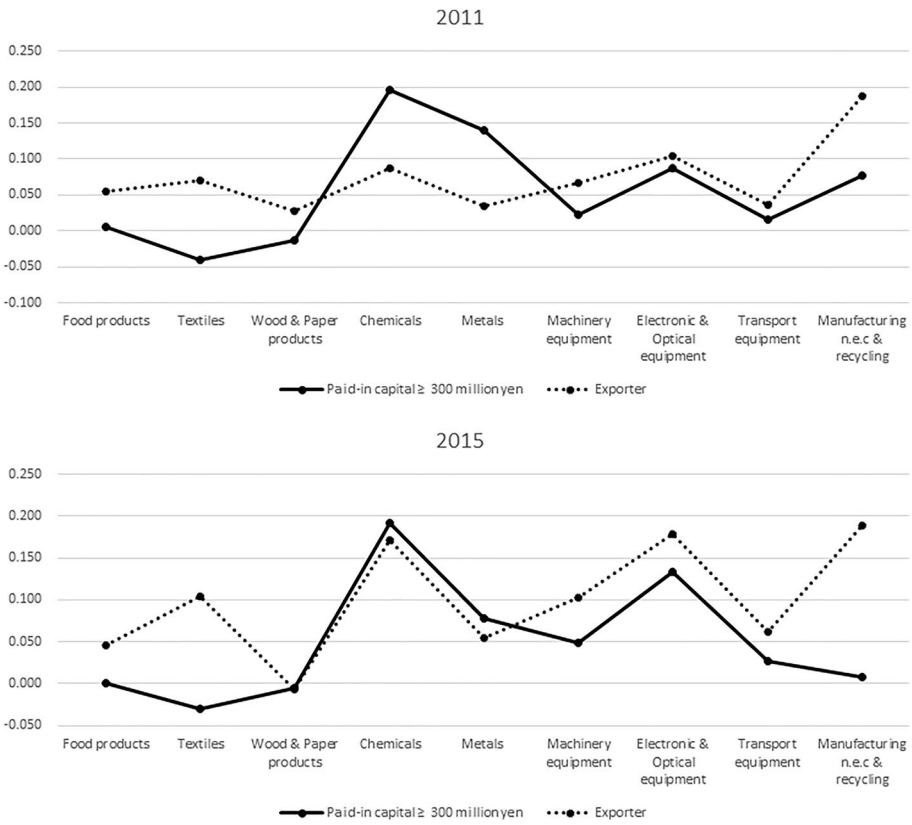

Fig. 2 Differences in intermediate import ratios (large firms = firms with paid-in capital of 300 million yen or more). Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

import ratios between exporters and non-exporters are found to be larger than those between small and large firms. Interestingly, for the electronic and optical equipment industry, the gap is larger when using the definition of the Small and Medium-Sized Enterprises Act (Fig. 2), which uses a lower capital threshold for large firms, than when using the definition of the FSSCI (Fig. 3), which uses a higher threshold. This indicates that there are a lot of medium-sized firms in the electronic and optical equipment industry between the two thresholds that engage in export.

The pattern for primary material industries differs considerably. For the chemical and metal industries, the differences in intermediate import ratios between small and large firms are larger than those between exporters and non-exporters. For the paper industry, the difference in 2015 between small and large firms was about the same as that between exporters and non-exporters. This indicates that heterogeneity regarding aspects other than exports may have a role for these industries. Interestingly, for the chemical industry, the difference is larger when using the definition of the FSSCI than when using the definition of the Small and Medium-Sized Enterprise Act. As discussed by Hagino (2017), this indicates that a small number of very large chemical firms operating integrated production systems, such as petroleum complexes, use large amounts of imported intermediates and materials.

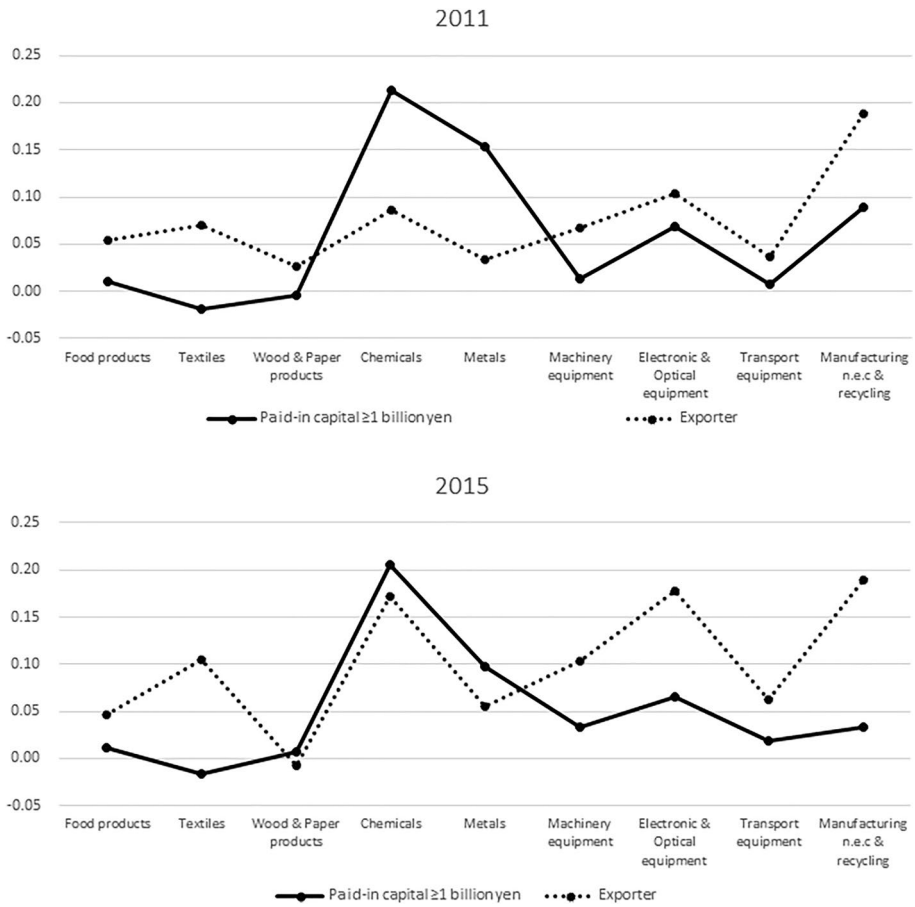

Fig. 3 Differences in intermediate import ratios (large firms = firms with paid-in capital of 1 billion yen or more). Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

Table 4 examines the differences in the chemical and metal industries in more detail. For this purpose, the chemical industry is subdivided into petrochemical and non-petrochemical industries, and the latter is further subdivided into chemical, rubber, and ceramic products industries. Similarly, the metal industry is subdivided into the pig iron, forged products, nonferrous products, nonferrous processing, and other metal industries.

In the chemical industry, the difference is larger in the petrochemical industry than the non-petrochemical industry. Large petrochemical firms are equipped with capital-intensive integrated manufacturing complexes, and the use of imported intermediates and materials increases with the size of such firms, resulting in the large difference. Within the non-petrochemical industry, the differences in rubber and ceramic products industries are small but positive, while in the chemical products industry the difference is even negative. As highlighted by Hagino (2017), a likely reason for the negative difference in the chemical industry is that production in the industry tends to be divided into multiple stages, so that importers provide processed products to domestic firms and exporters process domestically produced products.

Table 4 Differences in intermediate import ratios in the chemical and metal industries

Industry	2011		2015	
	Paid-in capital ≥ 1 billion yen	Paid-in capital ≥ 300 million yen	Paid-in capital ≥ 1 billion yen	Paid-in capital ≥ 300 million yen
Chemicals	0.214	0.196	0.206	0.191
Petrochemical products	0.335	0.314	0.397	0.344
Nonpetrochemical products	0.058	0.048	0.023	0.024
Chemical products	0.031	0.032	− 0.027	− 0.029
Rubber products	0.126	0.084	0.088	0.072
Ceramic products	0.044	0.038	0.062	0.054
Metal	0.153	0.141	0.098	0.078
Pig iron	0.269	0.26	0.19	0.188
Forged products	− 0.012	− 0.013	− 0.006	− 0.004
Nonferrous products	0.044	0.061	0.048	0.018
Nonferrous processing	0.004	0.006	− 0.009	− 0.05
Other metal	− 0.01	− 0.012	0.003	− 0.006

Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

In the metal industry, the difference is larger in pig iron and nonferrous products industries than in the other sub-industries. Large iron and nonferrous products firms are equipped with capital-intensive integrated manufacturing complexes, and the use of imported intermediates and materials increases with the size of such firms, resulting in the large difference. The differences in the other metal industries (forged products, nonferrous processing, and other metal industries) are positive but small or negative. The reason, once again, seems to be that production in these sub-industries tends to be divided into multiple stages.

3.3 Heterogeneity between domestic and foreign firms

Figures 4 and 5 demonstrate that foreign-owned firms do not play a pivotal role in international trade in Japan, and that this distinction is less relevant than in other countries. Figure 4 compares the export and import shares accounted for by domestic and foreign firms in Japan and major European economies, while Fig. 5 shows the share of domestic and foreign firms in the total number of exporting and importing firms. The data for European countries are from the OECD's Trade by Enterprise Characteristics (TEC) database, which provides trade data (exports and imports) categorized by firms' characteristics, including ownership structure. For Japan, corresponding figures are estimated using firm-level data from the BSBSA. Although the BSBSA does not cover very small firms with less than 50 employees and 30 million yen of paid-in capital, omitting such small firms is unlikely to skew the results in a meaningful way.

Starting with Fig. 4, the results demonstrate that the share of exports and imports in Japan accounted for by foreign firms is much smaller than in European countries, especially in the case of exports, at around 5%, it is almost negligible. A similar pattern is revealed in Fig. 5, which shows that the shares of foreign firms in the total number of exporting and importing firms in Japan are less than 3%. These findings suggest that, in

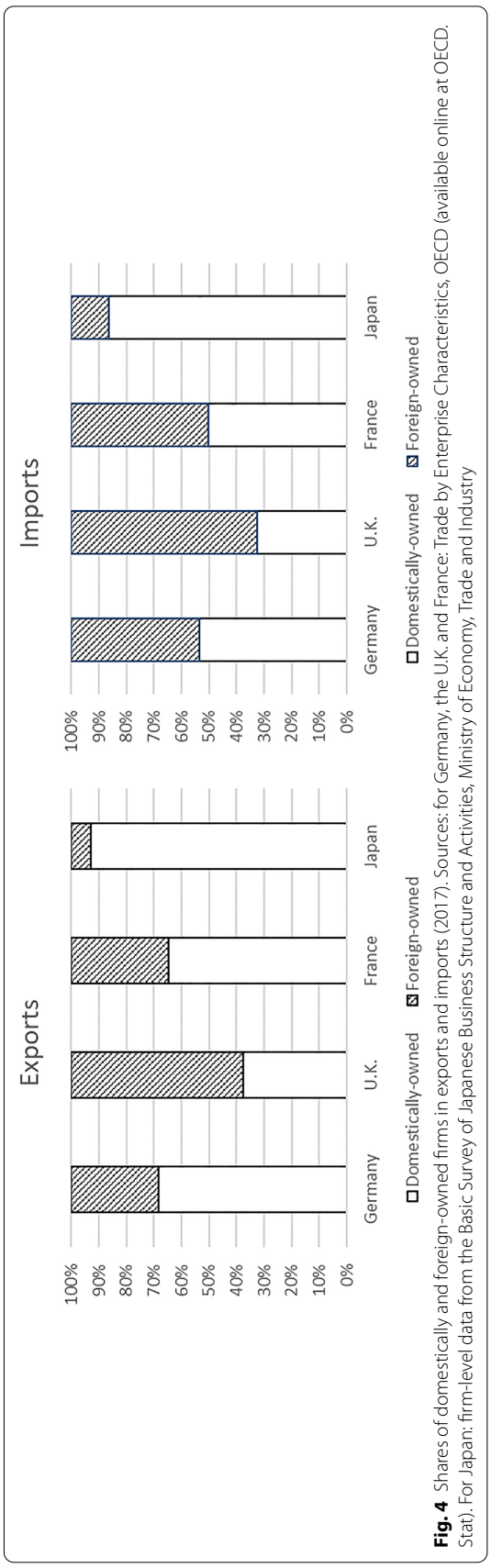

Fig. 4 Shares of domestically and foreign-owned firms in exports and imports (2017). Sources: for Germany, the U.K. and France: Trade by Enterprise Characteristics, OECD (available online at OECD. Stat). For Japan: firm-level data from the Basic Survey of Japanese Business Structure and Activities, Ministry of Economy, Trade and Industry

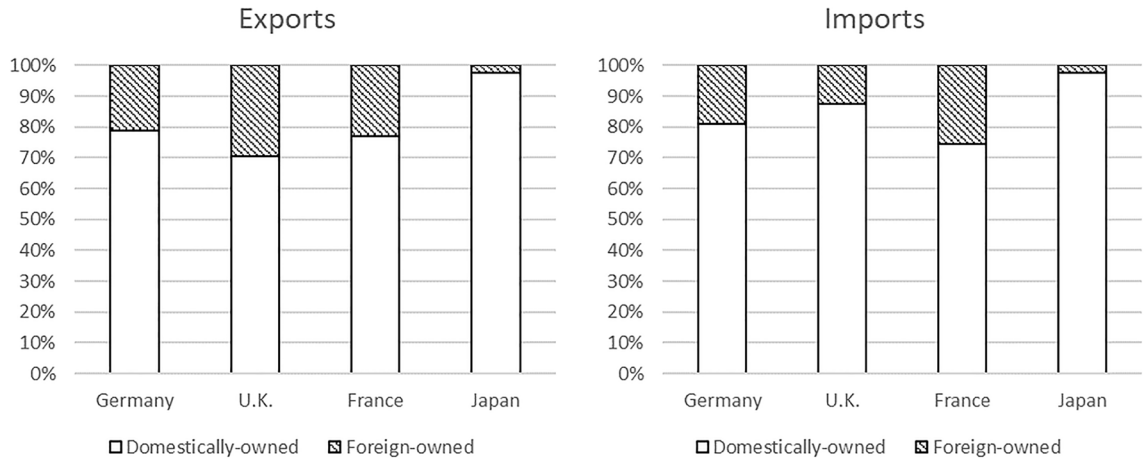

Fig. 5 Shares of domestically and foreign-owned firms in the number of exporting and importing firms (2017). Sources: for Germany, the UK and France: Trade by Enterprise Characteristics, OECD (available online at OECD.Stat). For Japan: firm-level data from the Basic Survey of Japanese Business Structure and Activities, Ministry of Economy, Trade and Industry

the case of Japan, distinguishing between domestically and foreign-owned firms is not a high priority when examining heterogeneity in intermediate imports.

3.4 Heterogeneity between firms with and without foreign subsidiaries

Figure 6 indicates that firms with foreign subsidiaries in Japan account for more than 95% of all exports and imports, which is considerably higher than in France and the UK.

Therefore, differences in the intermediate import ratio between firms with and without foreign subsidiaries are calculated. The results are presented in Fig. 7 and reveal that the difference between firms in the metal industry with and without foreign subsidiaries is larger than those between exporters and non-exporters as well as those between small and large firms. This suggests that metal corporations, which need to import materials, have established subsidiaries for the exploration and mining of raw materials abroad. Thus, distinguishing between firms with and without foreign subsidiaries in the EIOT for the metal industry appears to be appropriate.

Furthermore, in the textile industry and the paper industry, the differences between firms with and without foreign subsidiaries are as large as those between exporters and non-exporters. Wood and paper products firms, which must import wood products, have established foreign subsidiaries to grow and harvest wood abroad. Similarly, many textile firms have established subsidiaries abroad, especially for sewing processes, to take advantage of lower labor costs in developing countries and import intermediates to Japan. Since the reliance on foreign subsidiaries by firms in these industries is likely to grow in the future, distinguishing between firms with and without foreign subsidiaries in the EIOT also seems appropriate for the wood and paper products and textile industries.

3.5 Compiling Japan's EIOT

The analyses in subsections (3.1–3.4) regarding the types of heterogeneity to incorporate in the Japanese EIOT have several implications. For processing and assembly industries, such as machinery, electronics, transport equipment, food, and textile industries, heterogeneity between exporters and non-exporters should be incorporated. For the chemical industry, heterogeneity between small and large firms should be incorporated, and for paper and metal industries, heterogeneity between firms with and without foreign subsidiaries should be incorporated.

As for the textile industry, the difference in intermediate import ratios between firms with and without foreign subsidiaries is as large as that between exporting and non-exporting firms; however, the share of exports accounted for by firms with foreign subsidiaries is quite small (Table 5). As for the heterogeneity between small and large firms, the intermediate import ratio of small firms is larger than that of large firms, so incorporating such heterogeneity is not consistent with theoretical assumptions; therefore, the most appropriate approach appears to be the incorporation of heterogeneity between exporting and non-exporting firms.

An extended domestic table was constructed by applying the weights to the total output of each manufacturing industry (Table 4) in the domestic table. Total output was separated into the output of exporters and non-exporters for the food, textile, machinery, electronics, transport equipment, and other manufacturing industries; of small and large firms for the chemical industry; and of firms with and without foreign subsidiaries

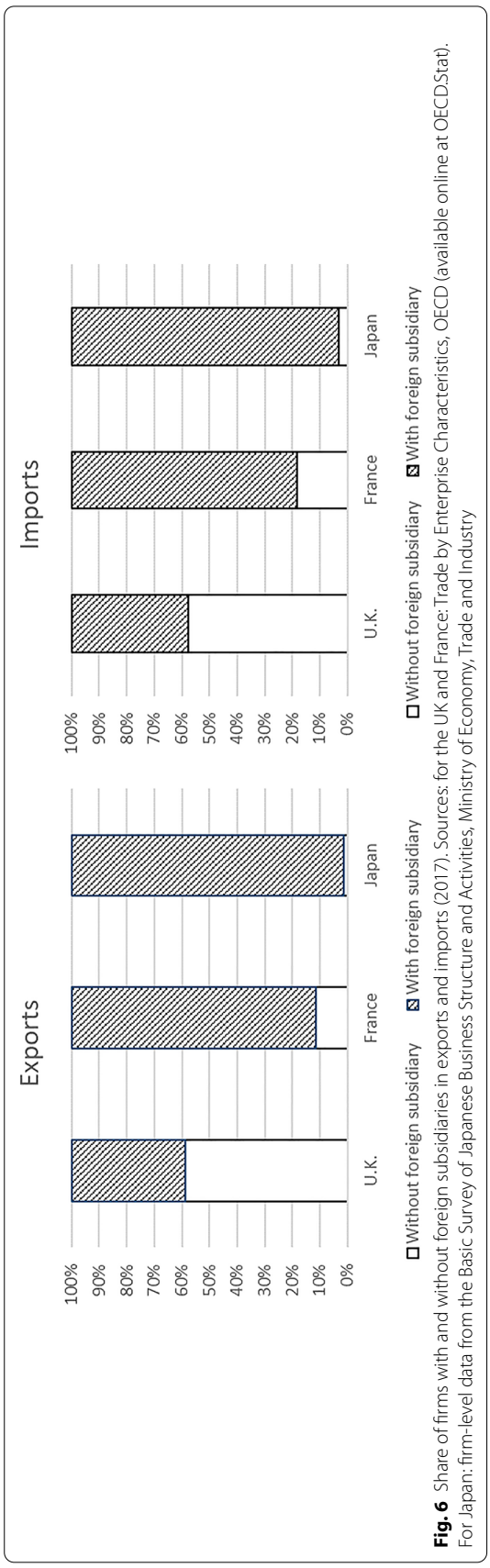

Fig. 6 Share of firms with and without foreign subsidiaries in exports and imports (2017). Sources: for the UK and France: Trade by Enterprise Characteristics, OECD (available online at OECD.Stat). For Japan: firm-level data from the Basic Survey of Japanese Business Structure and Activities, Ministry of Economy, Trade and Industry

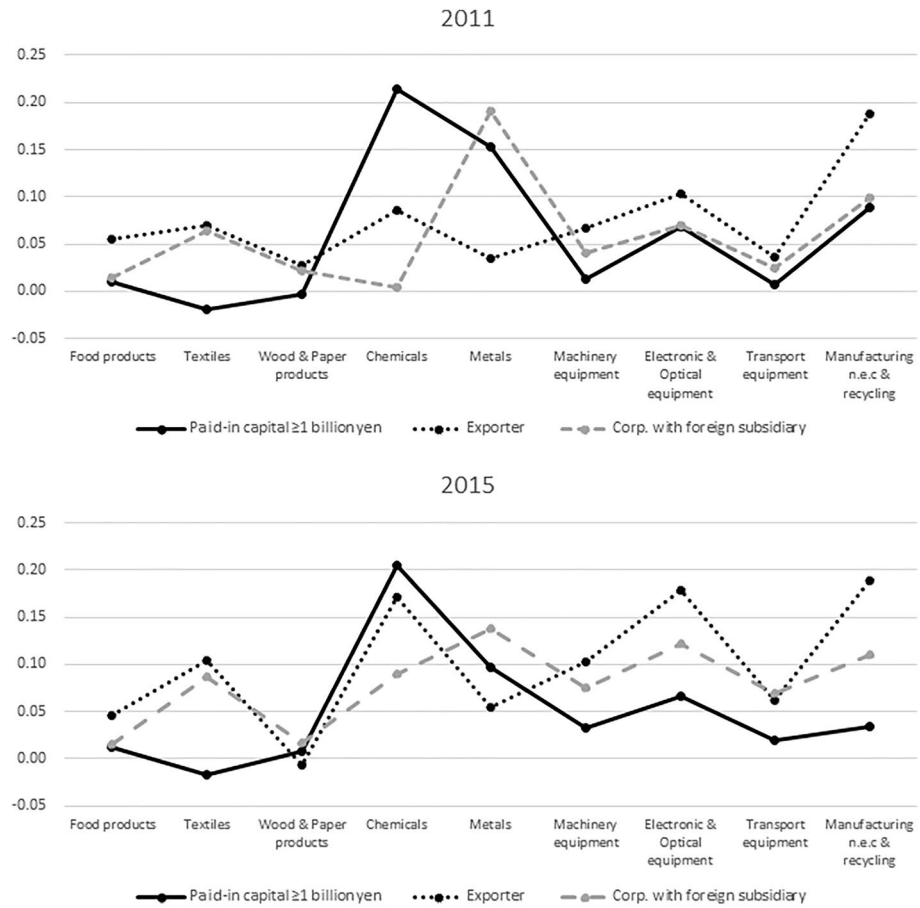

Fig. 7 Differences in intermediate import ratios between firms with and without foreign subsidiaries. Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

Table 5 Share in exports in 2015

	Food (%)	Textiles (%)	Paper (%)	Chemicals (%)	Metal (%)	Machinery (%)	Electronics (%)	Transport equipment (%)	Other manufacturing (%)
Export share of exporting firms	100.0	**100.0**	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Export share of large firms		**94.3**		90.5					
Export share of firms with foreign subsidiaries		**22.5**	77.1		63.2				

Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

Table 6 Output shares in 2015

	Food (%)	Textiles (%)	Paper (%)	Chemicals (%)	Metal (%)	Machinery (%)	Electronics (%)	Transport equipment (%)	Other manufacturing (%)
Output share of exporting firms	33.7	**63.6**	39.6	74.5	61.9	71.2	76.2	80.7	71.7
Output share of large firms		**82.5**		80.2					
Output share of firms with foreign subsidiaries		**29.4**	29.1		42.2				

Source: authors' calculations based on firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

for the paper and metal industries. For the textile industry, the output weight of firms with foreign subsidiaries is relatively small (bold text in Table 6), justifying the use of exporting and non-exporting as the heterogeneity consideration for the textile industry.

Table 6 is the extended import table incorporating the differences in intermediate import ratios (only manufacturing industries are shown). Based on Hagino's (2017) analysis demonstrating that differences in industries' intermediate import ratios are mainly due to the import of goods that an industry needs to produce, such differences are assumed to derive from differences in within-industry imports. For example, exporting automobile firms in the transport equipment industry import a large number of automobile parts, whereas non-exporting automobile firms mainly procure such parts from domestic firms. As a result, the transport equipment industry's difference in import intermediate ratio becomes largest in the import of transport equipment. Such a result is assumed to be reasonable, and therefore, reflect differences in intermediate import ratios in the diagonal cells (bold text in Table 7).

3.6 Usefulness of the EIOT

Table 8 presents the VS coefficients for the non-extended IOT and Table 9 those for the EIOT.

Table 10 reveals the VS indicator based on the EIOT (34.3%) is 70% larger than that based on the non-extended IOT (20.5%). This implies that the extension of IOTs incorporating differences in intermediate import ratios makes it possible to more comprehensively capture VS, and potentially, foreign value added.

OECD TiVA indicators show that Japan's foreign value added included in exports is about 15%. Despite the similarity of the underlying concept of the VS indicator and foreign value added, the former is 30% larger than the latter. This gap may be caused by the fact that the VS indicator calculated in this research is based on one country's IOT and does not exclude the domestic value added included in imported intermediate goods (APEC 2019, De Becker and Yamano 2012), which is not negligible in machinery industries. If the domestic value added included in imported intermediate goods is deducted

Table 7 2015 Extended domestic IO and import tables (in billion yen)

	3		4		5		6		7	
	Exporting	**Non-exporting**	**Exporting**	**Non-exporting**	**With foreign subsidiaries**	**Without foreign subsidiaries**	**Large firms**	**Small firms**	**With foreign subsidiaries**	**Without foreign subsidiaries**
Extended domestic table										
1	1964	3864	0	0	69	169	3	1	0	0
2	0	0	0	0	2	4	210	52	15	21
3	1694	3332	0	0	5	12	92	23	0	0
4	8	17	159	380	12	30	63	16	11	15
5	298	587	18	10	1052	2563	518	128	41	57
6	380	748	209	119	309	753	11,666	2872	282	387
7	173	340	5	3	80	194	541	133	6781	9297
8	0	0	0	0	4	10	51	12	9	12
9	0	0	0	0	1	2	1	0	13	18
10	0	0	0	0	0	0	0	0	0	0
11	14	27	8	4	32	77	96	24	156	213
Total output	12,920	25,421	2281	1305	4926	12,001	52,557	12,937	20,197	27,690
Extended import table										
1	559	1101	18	11	36	88	163	40	0	0
2	4	7	1	0	14	34	8129	2001	538	737
3	**1065**	**884**	5	3	1	2	87	21	0	0
4	4	9	**175**	**131**	12	28	43	11	2	3
5	12	24	1	1	**390**	**372**	33	8	3	5
6	81	159	84	48	29	71	**4582**	**1213**	32	44
7	2	4	1	0	9	22	45	11	**1598**	**1042**
8	0	0	0	0	0	0	0	0	3	4
9	0	0	0	0	1	2	0	0	5	7
10	0	0	0	0	0	0	0	0	0	0
11	2	4	20	11	2	5	5	1	3	4
Total	1730	2191	305	205	494	624	13,087	3307	2184	1845

Table 7 (continued)

	8		9		10		11	
	Exporting	**Non-exporting**	**Exporting**	**Non-exporting**	**Exporting**	**Non-exporting**	**Exporting**	**Non-exporting**
Extended domestic table								
1	0	0	0	0	0	0	5	2
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	1	0
4	22	9	61	19	50	12	15	6
5	89	36	267	84	97	23	130	52
6	836	339	1544	483	2178	522	321	127
7	3359	1361	2065	646	3385	812	169	67
8	2986	1210	264	82	329	79	5	2
9	954	387	4777	1494	1681	403	33	13
10	6	2	0	0	18,379	4409	0	0
11	12	5	20	6	20	5	42	16
Total output	24,244	9823	26,705	8350	44,663	10,715	3307	1307
Extended import table								
1	0	0	0	0	0	0	40	16
2	1	0	2	1	5	1	3	1
3	0	0	0	0	0	0	7	3
4	7	3	14	4	25	6	7	3
5	4	2	10	3	5	1	21	8
6	84	34	197	62	233	56	55	22
7	218	88	661	207	484	116	11	4
8	**838**	**582**	11	3	75	18	1	0
9	426	173	**2403**	**1495**	487	117	23	9
10	0	0	0	0	**1145**	**915**	0	0
11	15	6	8	3	10	2	**89**	**23**
Total	1593	889	3307	1778	2471	1233	255	89

3: food, 4: textiles, 5: paper, 6: chemicals, 7: metal, 8: machinery, 9: electronics, 10: transport equipment, 11: other manufacturing

Source: authors' calculations based on the Benchmark IOT and firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

Table 8 VS coefficients of the 2015 Benchmark IOT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0.02	0.00	0.06	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
2	0.03	0.03	0.02	0.04	0.04	0.21	0.06	0.03	0.03	0.04	0.04	0.26	0.03	0.03	0.02	0.01	0.01	0.02
3	0.02	0.00	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00
6	0.03	0.02	0.02	0.06	0.02	0.12	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.03
7	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.03	0.04	0.03	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.14	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.02	0.03	0.01	0.00	0.01
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
17	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.12	0.07	0.18	0.24	0.16	0.36	0.16	0.16	0.25	0.21	0.16	0.30	0.10	0.15	0.08	0.06	0.04	0.07

1: agriculture, 2: mining, 3: food, 4: textiles, 5: paper, 6: chemicals, 7: metal, 8: machinery, 9: electronics, 10: transport equipment, 11: other manufacturing, 12: electric, gas and water, 13: construction, 14: wholesale and retail, 15: transportation and warehouse, 16: finance and insurance, 17: real estate and leasing, 18: community, society and individual services

Source: authors' calculations based on the Benchmark IOT

Table 9 VS coefficients of the 2015 extended IOT

	1	2	3–1	3–2	4–1	4–2	5–1	5–2	6–1	6–2	7–1	7–2	8–1
1	0.02	0.00	0.05	0.05	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2	0.03	0.03	0.02	0.02	0.07	0.03	0.04	0.04	0.21	0.21	0.06	0.06	0.02
3–1	0.01	0.00	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3–2	0.01	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4–1	0.00	0.00	0.00	0.00	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4–2	0.00	0.00	0.00	0.00	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5–1	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.00
5–2	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.00
6–1	0.02	0.01	0.01	0.01	0.08	0.02	0.01	0.01	0.09	0.10	0.00	0.00	0.01
6–2	0.01	0.01	0.01	0.01	0.04	0.01	0.01	0.01	0.02	0.03	0.00	0.00	0.00
7–1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.04	0.02
7–2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.01
8–1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
8–2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
9–1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
9–2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
10–1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10–2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11–1	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11–2	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.01	0.00	0.02	0.02	0.09	0.04	0.06	0.06	0.04	0.04	0.05	0.05	0.02
13	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.02	0.01	0.09	0.09	0.19	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.06
15	0.02	0.02	0.05	0.05	0.09	0.05	0.07	0.07	0.05	0.05	0.04	0.04	0.05
16	0.00	0.00	0.01	0.01	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
17	0.01	0.01	0.05	0.05	0.10	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.05
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.17	0.10	0.43	0.38	0.96	0.41	0.47	0.42	0.54	0.55	0.35	0.31	0.34

	8–2	9–1	9–2	10–1	10–2	11–1	11–2	12	13	14	15	16	17	18
1	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.26	0.02	0.02	0.02	0.01	0.01	0.02
3–1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
3–2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
4–1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4–2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5–1	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5–2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6–1	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.02
6–2	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01
7–1	0.02	0.03	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
7–2	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8–1	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8–2	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9–1	0.02	0.07	0.13	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9–2	0.01	0.04	0.08	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10–1	0.00	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10–2	0.00	0.00	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11–1	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11–2	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9 (continued)

	8–2	9–1	9–2	10–1	10–2	11–1	11–2	12	13	14	15	16	17	18
12	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.00	0.01	0.01	0.01	0.00	0.00	0.01
15	0.05	0.05	0.05	0.05	0.05	0.19	0.19	0.01	0.01	0.01	0.04	0.01	0.01	0.01
16	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.00	0.00
17	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.36	0.43	0.52	0.42	0.48	0.52	0.51	0.31	0.08	0.09	0.12	0.08	0.05	0.09

1: agriculture, 2: mining, 3: food, 4: textiles, 5: paper, 6: chemicals, 7: metal, 8: machinery, 9: electronics, 10: transport equipment, 11: other manufacturing, 12: electric, gas and water, 13: construction, 14: wholesale and retail, 15: transportation and warehouse, 16: finance and insurance, 17: real estate and leasing, 18: community, society and individual services

For industries 3–11, the subnumbers (e.g., 3–1 and 3–2) denote elements of the extension

Source: authors' calculations based on the Benchmark IOT and firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI

using corresponding data from the OECD TiVA indicators, the VS indicator is reduced slightly to 20.1%. To calculate the foreign value added included in imported intermediate goods in this way, data from Japan's trade partners must be considered and made endogenous in the analysis, which requires an international EIOT.

4 Conclusion

This paper discussed the various aspects of firm heterogeneity that should be incorporated into Japan's EIOT. Based on the analysis using firm-level data, it was concluded that processing and assembly industries, such as the machinery, electronics, transport equipment industries, food, and textile industries, heterogeneity between exporters and non-exporters should be incorporated. For the chemical industry, heterogeneity between small and large firms should be incorporated, while for paper and metal industries, heterogeneity between firms with and without foreign subsidiaries should be incorporated. Based on these results, an EIOT was constructed for Japan. To examine the usefulness of this table, Japan's VS indicator was estimated, finding the VS indicator based on the EIOT to be 70% larger than that based on the non-extended IOT. This implies that the foreign value added could be more comprehensively captured by the extension of an IOT. For more precise calculation of the foreign value added, however, Japan's EIOT should be incorporated into an international IOT. For this purpose, we would like to work with the OECD. Doing so may enable verification of the reliability of the input structure method proposed in this study.

A future research challenge is the construction of an EIOT incorporating different elements of heterogeneity. Specifically, capturing the impact of firms' globalization on the SNA, identifying multinational corporations could be useful. For this purpose, the OECD has proposed to incorporate the distinction between domestically owned firms without foreign subsidiaries, domestically owned firms with foreign subsidiaries, and foreign-owned firms in the EIOT. Following this proposal will present an opportunity to extend the work in this paper and present a potential research task for next research stage.

Table 10 VS indicators calculated from the extended and non-extended IOTs

Industry	Extension elements	Calculation based on extended IOT				Calculation based on non-extended IOT						
		Industry total of VS coefficient	Exports (billion of yen)	Amount of VS (billion of yen)	VS indicator	Industry total of VS coefficient	Exports (billion of yen)	Amount of VS (billion of yen)	VS indicator	Domestic value added included in imported intermediates (%)	Amount of VS after deducting domestic value added (billion of yen)	VS indicator after deducting domestic value added
Agriculture		0.17	0	0		0.12	0	0		0.6	0.0	
Mining		0.10	33	3		0.07	33	2		0.5	2	
Food	Exporting	0.43	155	66		0.18	155	29		1.2	28	
	Non-exporting	0.38	0	0								
Textile	Exporting	0.96	131	126		0.24	131	32		1.6	31	
	Non-exporting	0.41	0	0								
Paper	With foreign subsidiaries	0.47	289	135		0.16	375	60		0.9	59	
	Without foreign subsidiaries	0.42	86	36								
Chemical	Large	0.54	6811	3673		0.36	7521	2679		1.8	2630	
	Small	0.55	711	388								
Metal	With foreign subsidiaries	0.35	2866	1014		0.16	4535	739		1.9	725	
	Without foreign subsidiaries	0.31	1669	521								

Table 10 (continued)

Industry	Extension elements	Calculation based on extended IOT				Calculation based on non-extended IOT						
		Industry total of VS coefficient	Exports (billion of yen)	Amount of VS (billion of yen)	VS indicator	Industry total of VS coefficient	Exports (billion of yen)	Amount of VS (billion of yen)	VS indicator	Domestic value added included in imported intermediates (%)	Amount of VS after deducting domestic value added (billion of yen)	VS indicator after deducting domestic value added
Machinery	Exporting	0.34	8685	2943		0.16	8685	1348		7.1	1253	
	Non-exporting	0.36	0	0								
Electronics	Exporting	0.43	14,294	6200		0.25	14,294	3536		8.2	3245	
	Non-exporting	0.52	0	0								
Transport equipment	Exporting	0.42	22,919	9644		0.21	22,919	4756		4.3	4552	
	Non-exporting	0.48	0	0								
Other manufacturing	Exporting	0.52	526	275		0.16	526	86		7.9	79	
	Non-exporting	0.51	0	0								
Electric, gas and water		0.31	23	7		0.30	23	7		0.8	7	
Construction		0.08	23	2		0.10	23	2		1.5	2	
Wholesale and retail		0.09	18,051	1602		0.15	18,051	2650		1.2	2618	
Transportation and warehouse		0.12	158	20		0.08	158	13		2.7	13	
Finance and insurance		0.08	0	0		0.06	0	0		1.1	0	
Real estate and leasing		0.05	16	1		0.04	16	1		1.0	1	
Community, society and individual services		0.09	278	25		0.07	278	21		2.4	20	
Total		9.50	77,725	26,680	**34.3%**	2.87	77,725	15,961	**20.5%**	2.1	15,632	**20.1%**

Source: authors' calculations based on the Benchmark IOT, firm-level data of the Basic Survey of Japanese Business Structure and Activities, METI, and OECD TiVA indicator

Abbreviations
BSBSA: Basic Survey of Japanese Business Structure and Activities; EIOT: Extended input–output table; FSSCI: Financial Statement Statistics of Corporations by Industry; METI: Japan's Ministry of Economy, Trade and Industry; OECD: Organisation for Economic Co-operation and Development; TiVA: Trade in value added; VS: Vertical specialization.

Acknowledgements
Not applicable.

Authors' contributions
SH designed the work and Kim made calculations. SH interpreted the results and made the first draft. JK revised the manuscript. Both authors read and approved the final manuscript.

Funding
Not applicable.

Availability of data and materials
The Japanese benchmark input–output table used in this study is available on the website of the Ministry of Internal Affairs and Communication of Japan. Firm-level data of the Basic Survey of Japanese Business Structure and Activities are available through requests to the Ministry of Economy and Industry of Japan.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Senior Research Fellow, Economic and Social Research Institute, Cabinet Office (ESRI), 1-6-1 Nagata-cho, Chiyoda-ku, Tokyo 100-8914, Japan. [2]Graduate School of Humanities and Social Sciences, Okayama University, 3-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530, Japan.

Received: 3 August 2021 Revised: 11 November 2021 Accepted: 14 November 2021
Published online: 04 December 2021

References
APEC Committee on Trade and Investment, 2019. Methodologies of Constructing the APEC TiVA Database for Better Understanding Global Value Chains in the APEC Region.
De Becker K, Yamano N (2012) 'International Comparative Evidence on Global Value Chains, OECD Science,' Technology and Industry Working Papers 2012/03.
Hagino S (2017) Identifying Firm Heterogeneity in Japan by Developing TEC and TEC Plus Data. Fukuyama University Journal of Economics
Hummels D, Ishii J, Yi K-M (2001) The nature and growth of vertical specialization in world trade. Journal of International Economics 54:75–96
Ito K, Deseatnicov I, Fukao K (2017) 'Japanese Plants' heterogeneity in sales, factor inputs, and participation in global value chains. RIETI Discussion Paper Series, 17-E-117
Johnson RC, Noguera G (2012) Accounting for intermediates: production sharing and trade in value added. Journal of International Economics 86(2):224–236
OECD Expert Group on Extended Supply-Use Tables (2014a) Draft: Terms of Reference
OECD (2014b) Extending OECD's Work on Measuring Trade in Value-Added, STD/CSSP(2014)7
OECD (2015) Firm Heterogeneity and Trade in Value-Added, STD/CSSP/WPTGS(2015)23
OECD (2018) Addressing the Challenges of Globalisation in National Accounts, COM/SDD/DAF(2018)6

Publisher's Note