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Abstract

Recent research has emphasized the importance of global value chains (GVCs) in inter-country linkages and international production fragmentation. Several initiatives have attempted to construct multi-country input-output tables (MIOTs) to analyze these trends. However, heterogeneity in export and domestic activities among firms within the same industry may cause biases in analyses that rely on MIOTs.

This paper has two main objectives. First, we use matched employer-employee data for Japan to split output in each industry in Japan's manufacturing sector in the Organisation for Economic Co-operation and Development (OECD) Inter-Country Input-Output (ICIO) table into output for export or domestic sale. Second, using our split ICIO table, we compute trade in value added (TiVA) indicators to examine the participation of Japanese manufacturing plants in GVCs and compare our results with the OECD-WTO TiVA indicators.

Our estimates suggest that Japan's forward participation in GVCs is lower than in the original OECD-WTO TiVA indicators when we take plant heterogeneity within industries into account. We infer that this result is due to higher cross-border production fragmentation as well as the large presence of multinational companies and intra-industry trade in the manufacturing sector.

Keywords: Global value chains (GVCs), Firm heterogeneity, Input-output table, Export intensity, Factor inputs
JEL classification: F12, F14, C67, C81

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1 Introduction

The role of global value chains (GVCs) has recently become an important topic due to the increased fragmentation of production across countries and industries. Multi-country input-output tables (MIOTs) have been extensively used to measure the significance of GVCs (e.g., Koopman et al., 2014). Several initiatives, such as the joint initiative by the Organisation for Economic Cooperation and Development (OECD) and the World Trade Organization (WTO) on Measuring Trade in Value Added (TiVA) (Piacentini and Fortanier, 2015) and the World Input–Output Database (WIOD) initiated at the University of Groningen within the framework of a European Commission project, have attempted to construct such tables (Timmer et al., 2015). The idea underlying these databases is to link national supply–use tables (SUTs) via international trade flows. Furthermore, recent research has sought to elucidate firm heterogeneity across firms and their export activities, which theoretical and empirical evidence suggests (Melitz, 2003; Bernard et al., 2007), by splitting industries of some countries in MIOTs taking firm heterogeneity in terms of firm size, ownership, trade mode, etc., into account (Ahmad et al., 2013; Ma et al., 2014; Fetzer and Strassner, 2015). Regarding Japan, however, few similar studies have been conducted.

Our study attempts to contribute to this new trend using unique Japanese manufacturing plant-level data. Specifically, using matched data from the Economic Census for Business Activity (ECBA) and the Basic Survey on Wage Structure (BSWS), we split output in each industry of Japan's manufacturing sector in the OECD Inter-Country Input–Output (ICIO) table into output for export and domestic sale, and examine the GVC participation of Japanese manufacturing plants, which can be computed from our split ICIO table. Details of our definitions and accounting framework are presented in Section 3. Methodologically, our accounting framework is similar to the one implemented by Ma et al. (2015). Using information on exports and domestic sales from our data, we split output in each manufacturing industry in Japan in the ICIO table into output for export and domestic sale. We then employ quadratic programming and compute all elements of the extended ICIO table. Finally, we compute TiVA indicators and factor inputs induced by foreign demand for Japan from our extended ICIO table and compare them to indicators computed from the original OECD ICIO table.

The methodology we use to compute the domestic and foreign value added shares in a country's exports follows the approach developed by Hummels et al. (2001), which is widely used for computing TiVA indicators. One of their key assumptions is that the intensity of intermediate input use is the same for production for export and production for domestic sale. Clearly, this simplification may lead to under-estimation of GVC participation indicators if production for export extensively relies on foreign intermediate inputs. Our data allows us to identify Japanese plants' production for export and domestic sale. This makes it possible to re-examine Japan's GVC participation by relaxing the assumption made by Hummels et al. (2001).

Employing the split ICIO table, we can measure backward and forward linkages in Japanese manufacturing sector GVCs more accurately than analyses based on the non-split version of the ICIO table. Since Hummels et al. (2001), several other studies have examined GVC participation measures (e.g., Johnson and Noguera, 2012; Koopman et al., 2014). Of particular interest as a measure of inter-country linkages and involvement in GVCs is countries' backward and forward linkages in GVCs (Kowalski et al., 2015). Analysis of these linkages has been also increasingly important in the trade theory literature (Costinot et al., 2013; Grossman and Rossi-Hansberg, 2008; Baldwin and Venables, 2015). In the case of Japan, it has been argued that the manufacturing sector has strong forward linkages, so that foreign final demand shocks may have a considerable impact on the Japanese economy (Fukao and Yuan, 2007, 2009). To confirm this point, we calculate the domestic value added in exports (DVA), the foreign value added in exports (FVA), the domestic value added embodied in foreign final demand (FFD_DVA), and the factor inputs induced by foreign final demand (FFD_F), and compare these statistics with TiVA estimates based on the non-split version of the ICIO table.[2]

Our analysis indicates that Japan's manufacturing plants' forward linkages (DVA, FFD_DVA and FFD_F) in GVCs are lower, and backward linkages (FVA) are higher, than suggested by estimates that do not take firm heterogeneity into account, implying that cross-border fragmentation is higher if we consider firm heterogeneity in exporting activity. In fact, in recent years, the importance of intermediate input imports (backward linkages) has increased, suggesting that Japan, as well as other countries, are becoming more globally integrated (see, e.g., Timmer et al., 2014).

We also find that the intensity of factor use induced by foreign final demand varies significantly across and within industries. The differences between the split and non-split versions of the ICIO table imply that firm heterogeneity in terms of export activity plays an important role in understanding Japan's manufacturing sector involvement in GVCs.

The remainder of this study is organized as follows. Section 2 provides a brief review of the literature. Section 3 then describes the data and estimation method employed, which is

[2] In this study, we distinguish between sectors and industries. The term "sector" refers to broad classifications such as the manufacturing sector and service sector. The term "industry" is used for categories within the sectors, such as the textile industry in the manufacturing sector.

followed by the presentation and discussion of the main findings in Section 4. Extended Input-Output (IO) table is presented in Section 5. Section 6 provides a summary of the results.

2 Literature review

This section presents the most recent findings of studies that have attempted to identify within-industry heterogeneity in the MIOT framework. Most studies produced extended IO tables using micro-level data and revealed the benefits of such extension. Table 1 provides a summary of selected studies.

Table 1: Overview of Major Studies and Their Findings

Ahmad et al. (2013)	MNEs vs Non-MNEs, Large vs SMEs	Turkey, 2006	VA share of output larger for domestic firms/non-MNEs in several industries (e.g., textiles, apparel)
Piacentini and Fortanier (2015)	MNEs vs Non-MNEs, Large vs SMEs	27 Europe + US, Mexico, 2011	Large firms and foreign firms dominate in exports and imports, SMEs provide intermediates for exports
Ma et al. (2015)	Processing trade, Traditional export, Domestic	China, 2007	Higher imported inputs for foreign-owned processing firms
Fetzer and Strassner (2015)	US MNEs, Foreign-owned affiliates, Domestic firms	US, 2011	VA as a share of output is lower for foreign-owned firms
Hagino and Tokoyama (2016)	Exporting and non-exporting firms	Japan, 2011	The method to reflect the difference of the ratio of imported to total intermediate goods between exporting and non-exporting firms in extended IO table is examined.

Several important studies have been conducted at the OECD. The study by Ahmad et al. (2013) was the first attempt to consider firm heterogeneity within the IO framework using Turkish micro-data for 2006. They examined the correlation and distribution of several statistics, namely, export intensity (the export/output ratio), the intermediate import ratio (the intermediate imports/intermediate consumption ratio), value added per unit of output, value added, and exporting firms' share in total output. Considered firm ownership heterogeneity –

foreign or domestic – and firm size heterogeneity, they found that, on average, the observed statistics increase with firm size and are greater for foreign firms.

As a follow up, Ahmad and Ribarsky (2014) suggested various ways to consider heterogeneity, using trade statistics from the OECD Trade by Enterprise Characteristics (TEC) database and TiVA database to support their argument. They discuss firm size and firm ownership heterogeneity, and present their preliminary findings for European countries and the US. They also mention that for some countries it may be more optimal to consider another type of heterogeneity, such as between firms engaged and not engaged in processing trade in the case of China, global manufacturers and domestic firms in the case of Mexico, or firms operating inside and outside of export zones in the case of Costa Rica.

Piacentini and Fortanier (2015) extended this work to a larger number of countries (mainly European countries, as well as the US and Latin American countries, but only a small number of countries in Asia and Africa) by linking several micro databases (namely, the TEC OECD Structural and Demographic Business Statistics and the OECD Activity of Multinational Enterprises databases). They consider firm size and firm ownership heterogeneity, and find that large, foreign-owned firms generally have higher export/turnover, import/turnover, and VA/employment ratios.[3] In addition, they identify the important role of small and medium enterprises (SMEs) as providers of intermediate inputs for exports.

Another trend in the literature is an increasing focus on China. Chen et al. (2012) present an input–output methodology to distinguish between processing exports, non-processing exports, and output for final use in production activity within sectors in 2002 and 2007 and argue that domestic final demand in China induced higher domestic value added and employment than final demand generated by exports. Similarly, dividing production activities in China into processing exports, normal exports, and production for the domestic market, Koopman et al. (2012) conclude that DVA in exports increased after China joined the WTO. Furthermore, extending previous studies using micro-data and taking trade regimes and firm ownership heterogeneity (Chinese-owned enterprises and foreign-invested enterprises) within industries in China into account, Ma et al. (2014) argue that foreign-owned enterprises made the largest contribution to domestic VA in exports (about 45%), while Chinese-owned processing firms accounted for a much smaller share of domestic content in exports (less than 5%). They also found that the income share captured by foreign factor owners was about 52.6%. In sum, the main concern of these studies was to examine how processing trade production

[3] Piacentini and Fortanier (2015) also compare VA/turnover ratios, but the results are mixed.

activities affect the domestic value added distribution within industries in China, and how capital and labor income is captured by Chinese or foreign factor owners.

Extended input–output tables to consider firm heterogeneity were created at the US Bureau of Economic Analysis (BEA). Fetzer and Strassner (2015) proposed an alternative way to consider firm heterogeneity within industries in supply–use/IO tables by distinguishing multinational enterprises (MNEs) headquartered in the US, foreign MNEs' affiliates operating in the US, and domestic non-MNE firms. Comparing trade in value added (TiVA) statistics derived from extended and non-extended SUTs, they argue that the variance in TiVA statistics is higher if the proposed firm heterogeneity is taken into account.

Another study that attempts to construct an extended IO table taking exporting and non-exporting firms into account is that by Hagino and Tokoyama (2016). They extend Japan's system of national accounts (SNA) input–output table to reflect the difference in the ratio of imported to total intermediate goods between exporting and non-exporting firms.

Overall, these studies suggest various alternative ways to consider firm heterogeneity within industries in the SU/IO tables. They mainly focus on firm heterogeneity in terms of firm ownership, size, and trade mode.

Against this background, our study introduces heterogeneity within industries in the ICIO table by distinguishing production for foreign markets (export) and production for the domestic market (domestic sale). To consider such heterogeneity, we split the output of each industry in the IO table into exports and domestic sales following the methodology introduced by Koopman et al. (2012) to compute input–output linkages in a split IO table. This allows us to identify how much domestic value in production for export and domestic sale is induced directly and indirectly by foreign final demand.

In addition, our study has several advantages over previous studies using micro-level data. First, previous studies used firm-level data and to the best of our knowledge there are no studies using plant-level data. In contrast, in our study we are able to use plant-level data, which allows us to more clearly distinguish between production for export and for domestic sale. Second, we rely on detailed labor data from the BSWS, which allows us to compute labor input captured by foreign final demand. Our dataset allows us to make inference about the participation of Japan's manufacturing sector in GVCs and the consequences for domestic factor input demand. Third, our unique employer–employee matched data makes it possible to estimate factor content in manufacturing plants' output for export and domestic sale induced by foreign final demand.

In sum, our study shows the benefits of taking firm heterogeneity in terms of whether firms are engaged in exports or not into account by means of calculating TiVA statistics and comparing the results between the split and non-split IO table. In the following sections, we present our data, accounting framework, and a discussion of our results.

3 Data and method of estimating the split IO table

3.1 Data description

For our analysis, we construct an employer–employee matched dataset for Japan's manufacturing sector using micro-data from the following public data sources published by various Japanese government ministries.

3.1.1 2012 Economic Census for Business Activity (ECBA)

The Economic Census for Business Activity (ECBA), conducted for the first time in 2012 by the Ministry of Internal Affairs and Communications (MIC) and the Ministry of Economy, Trade and Industry (METI), aims to identify the structure of establishments and enterprises in all industries on a national and regional level and to obtain basic information for conducting various statistical surveys. The first survey targeted almost all establishments and enterprises (hereafter we refer to these as plants for short) in Japan as of February 1, 2012.[4] Note that the ECBA data we use only covers the manufacturing sector and thus does not provide any service sector data.

The ECBA data covers basic information such as the sales, capital, and number of employees of all plants with four or more employees in the manufacturing sector, comprising a total of 332,360 plants.[5] It also includes data on the share of the value of direct exports to sales, which we use to distinguish plants' exports and domestic sales in our analysis.

3.1.2 Basic Survey on Wage Structure 2012 (BSWS)

[4] The following establishments are not included in the ECBA:
(i) establishments of national and local public entities; (ii) establishments of individual proprietorships that fall under Division A "agriculture and forestry" of the Japan Standard Industrial Classification; (iii) establishments of individual proprietorships that fall under Division B "fisheries" of the Japan Standard Industrial Classification; (iv) establishments that fall under Group 792 "domestic services" in Division N "living-related and personal services, and amusement services" of the Japan Standard Industrial Classification; and (v) establishments that fall under Major Group 96 "foreign governments and international agencies in Japan in Division R services, nec" of the Japan Standard Industrial Classification.

[5] We exclude data of establishments with three or fewer employees, following the Census of Manufacturer conducted annually by the Ministry of Economy, Trade and Industry (METI).

The purpose of the Basic Survey on Wage Structure (BSWS), implemented by the Ministry of Health, Labour and Welfare (MHLW), is to clarify the wage structure of employees in major industries, i.e., the wage distribution by type of employment, type of work, occupation, gender, age, educational attainment, etc.

From the survey implemented in 2012, we use 273,377 employee data points extracted from 10,616 manufacturing plants.

To connect the ECBA and BSWS data, we employ three identification numbers for prefecture, city, and plant. We can link these identification numbers to identify each plant. Fortunately, both datasets use the same identification numbers. We are therefore able to merge the ECBA and BSWS data and generate an employer–employee matched dataset covering 256,301 employee data points extracted from 9,979 plants.[6]

Unlike the ECBA, the BSWS is a sample survey. Thus, it is possible to estimate population variables related to employee data (i.e., the ratio of non-regular workers and the share of university graduates) using a sampling ratio. The sampling method of the BSWS involves stratified two-stage sampling, where plants are the primary sampling unit and employees are the secondary sampling unit. Plants are stratified by prefecture, industry, and size.[7] The sampling ratio for each plant is set within one of these three categories. The sampling ratios for employees are determined in accordance with the industry and size of the plant (for plants with 100 employees or more and plants with up to 99 employees).

The sampling ratios for employees are disclosed while those for plants are not. However, the employee data we use includes both sampling ratios, making it possible to estimate population variables. The variables in the table and figures in Section 4 provide an indication of the estimated parent population.

3.1.3 Inter-Country Input–Output Database (ICIO)

The ICIO table issued by the OECD consists of 62 countries/areas and 34 sectors based on the International Standard Industrial Classification of All Economic Activities (ISIC), rev.3, released by the United Nations Statistics Division. Our aim is to split the table for Japanese manufacturing industries, of which there are 16 in the ICIO table. Note that we use the ECBA,

[6] The merged data covers 93.8% of the employee data and 94.0% of the establishment data in the original BSWS data.
[7] The BSWS aims at making the standard error of scheduled cash earnings of a regular employee by prefecture, industry, and size of enterprise less than 5%.

which covers almost all manufacturing plants in Japan, to split value added, output, and input-output linkages. We use employer–employee matched data only for computing labor input.

3.2 Estimation method to split the output of each industry in the manufacturing sector into production for export and domestic sale

Next, we explain the procedure to split the output of each industry in Japan's manufacturing sector into production for export and domestic sale in the ICIO table.

3.2.1 Reason why we split output into production for *export* and *domestic sale* in our split IO table

While previous studies trying to divide IO tables split production in each industry into production by exporting and non-exporting firms, in this paper we split production in each industry in Japan's manufacturing sector into production for export or domestic sale.

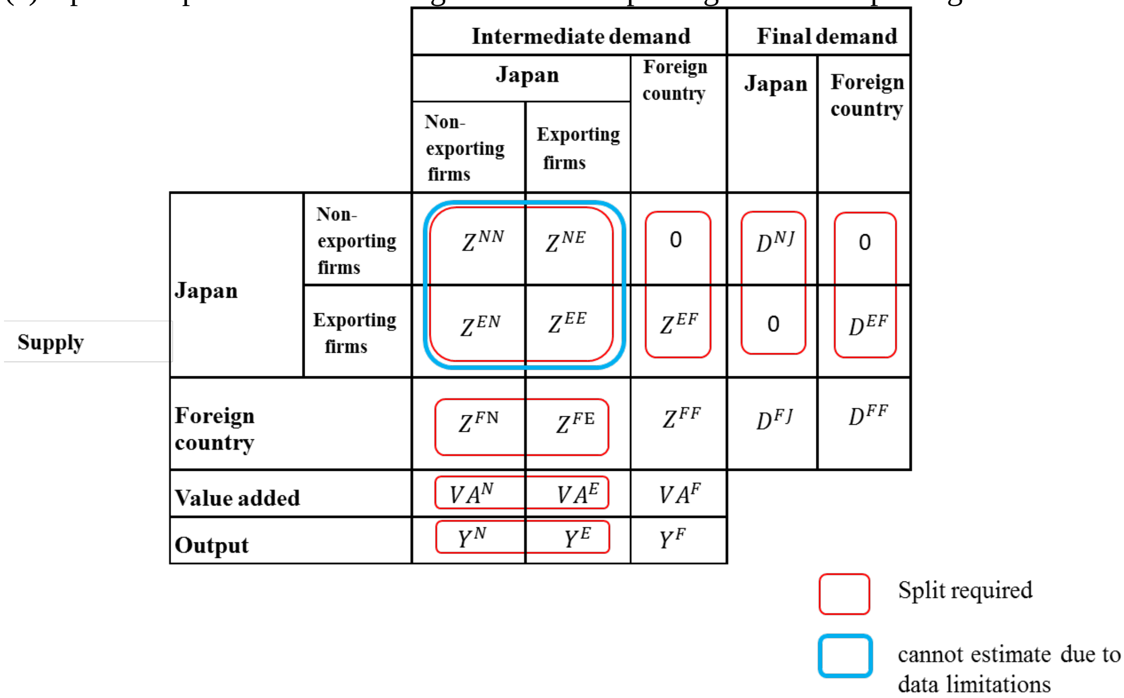
In previous studies, the output of manufacturing industries is divided into output by exporting and non-exporting firm (Figure 1 (a)). In order to carry out this division accurately, we need data on the share of exporting firms' sales to exporting and non-exporting firms and, similarly, of non-exporting firms' sales to exporting and non-exporting firms. However, the lack of information in our data makes it impossible to split the coefficients (indicated by the blue frame in Figure 1 (a)).

Therefore, we divide the output of each industry into production for export and for domestic sale, not into production by exporting and non-exporting firms (see Figure 1 (b)). By definition, production for export involves no sales to domestic firms.[For production for domestic sale, the share of output used for production for domestic sale is needed but this information is not included in our data. Therefore, we calculate the share from other conditions of the input-output table.[8]

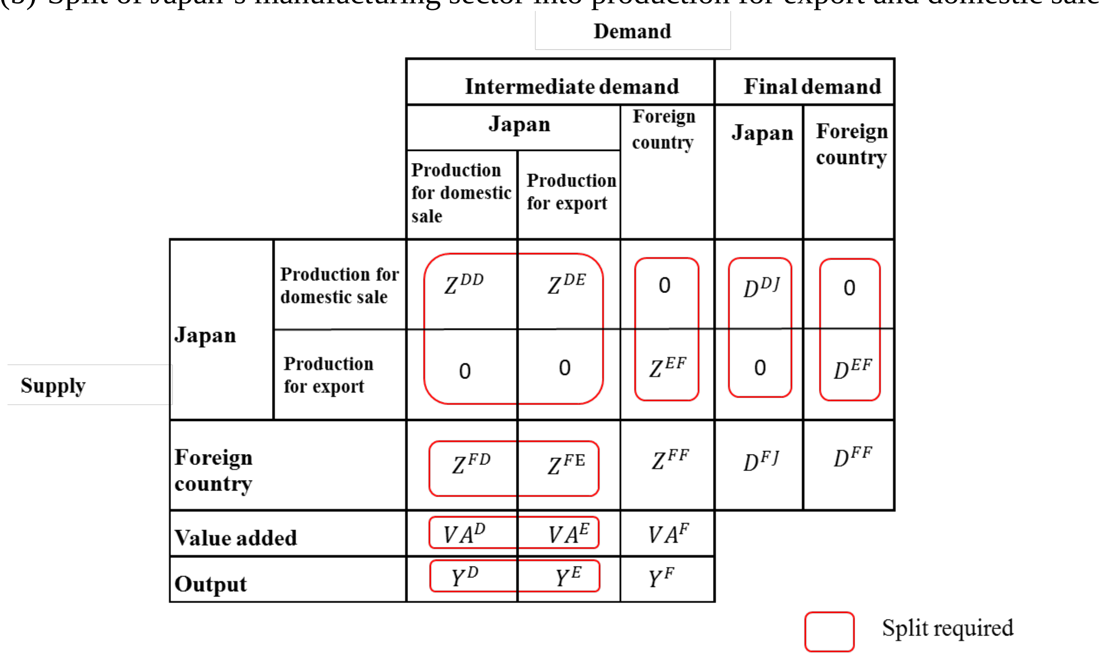
[8] We assume that activity within firms is homogenous and the same technology is used for production for export and domestic sale.

Figure 1: Split of Japan's manufacturing sector in a multinational IO table

(a) Split of Japan's manufacturing sector into exporting and non-exporting firms



(b) Split of Japan's manufacturing sector into production for export and domestic sale



3.2.2 Sequence of estimation

The sequence of our estimation is as follows.

a) We harmonize the industry classifications of the ICIO table and our micro-data.

While the ICIO table uses ISIC rev.3, the ECBA uses the Japan Standard Industry Classification (JSIC, ver.11),[9] which has more detailed categories. The concordance of ISIC rev.3 and JSIC ver.11 is used to aggregate our micro-data into the 16 manufacturing industries for Japan in the ICIO table.

b) We aggregate domestic sales, exports, value added and intermediate input into the 16 manufacturing industries using the concordance in a) as follows.

i) Domestic sales and exports

In each industry, the sales of exporting plants are divided into exports and domestic sales. The aggregated exports of exporting plants will be treated as the total exports of the industry. The aggregated domestic sales of exporting plants are added to the aggregate sales of non-exporting plants, and the sum represents the total domestic sales of the industry.

ii) Value added

The value added of exporting plants is divided into the value added derived from exporting and the value added derived from domestic sales based on the share of exports and domestic sales in total output.[10] The industry-level value added derived from exports is the aggregated value added derived from exporting of all exporting plants. The industry-level value added derived from domestic sales is the sum of the value added of non-exporting plants and the value added derived from domestic sales of exporting plants.

iii) Intermediate goods

The methodology for calculating intermediate goods input for production for export and for domestic sale is similar to the calculation of value added. We divide intermediate goods input of exporting plants into intermediate goods use for export and for domestic sale based on the share of exports and domestic sales in total output. We then aggregate the intermediate goods use for export of all plants to obtain the industry-level intermediate goods use for export. For the intermediate goods use for domestic sale, the aggregated intermediate goods use for domestic sale of exporting plants is added to the aggregated intermediate goods use of non-exporting plants.

We estimate the split IO table using the quadratic programming method. The purpose of

[9] In JSIC rev.11, there are 637 sectors to which three-digit codes are allocated.

[10] This calculation is based on the assumption that technology is homogenous within firms producing for export and domestic sale.

this estimation is twofold. The first is to ensure that the balance conditions in the aggregated ICIO table are always satisfied, and that the estimated ICIO table is consistent with the original ICIO table. The second is to ensure that the estimated split ICIO table is consistent with the structure of production for export and domestic sale. Our estimation framework closely follows Ma et al. (2015). Details of the estimation framework are provided in Appendix 1.

4 Differences in Production for Export and Domestic Sale: Empirical Findings

Before we start with the analysis of the split ICIO table, we examine the differences between production for export and domestic sale in the Japanese manufacturing sector. In addition, we present some basic data on plants' performance and factor content in production using our micro-data.

4.1 Share of exporting plants

Table 2 shows the distribution of manufacturing plants in the ECBA micro-data in terms of their export intensity. First, non-exporting plants (plants with a 0% export/sales ratio) make up 97.4% of our sample, indicating that exporting plants are extremely rare (2.6%). The table further shows that the number of plants decreases with the degree in export intensity.

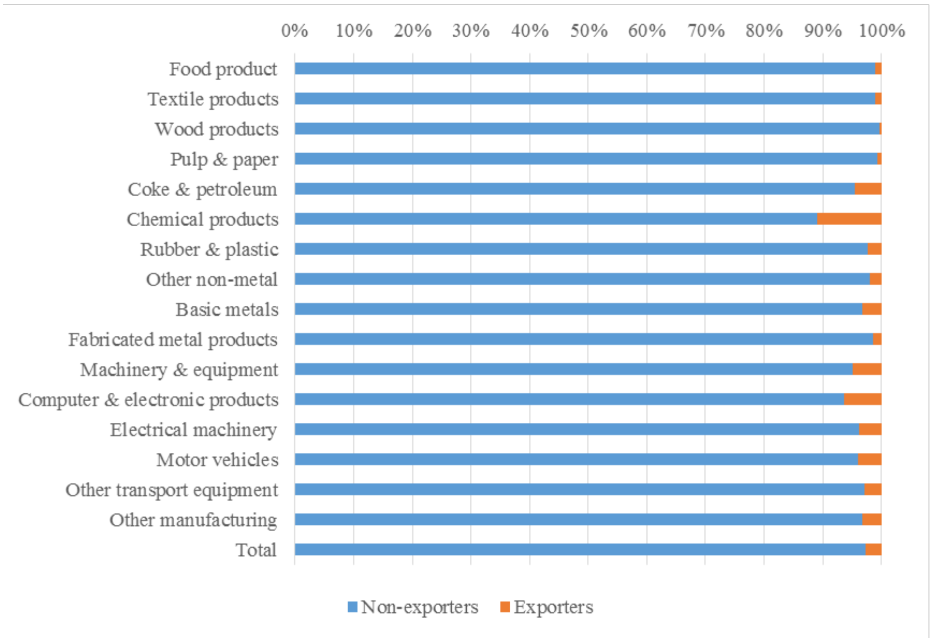
Table 2: Number of observations by export/sales ratio

Export-sales ratio	Observations	Share
0%	323,784	97.4%
More than 0% to 10%	4,667	1.4%
More than 10% to 20%	1,290	0.4%
More than 20% to 30%	733	0.2%
More than 30% to 40%	481	0.1%
More than 40% to 50%	410	0.1%
More than 50% to 60%	271	0.1%
More than 60% to 70%	225	0.1%
More than 70% to 80%	174	0.1%
More than 80% to 90%	126	0.0%
More than 90% to 100%	199	0.1%
Total	332,360	100.0%

Note: Authors' calculations based on ECBA micro-data.

Figure 2 shows the share of exporting and non-exporting plants in each manufacturing industry. As can be seen, the share varies across industries, but is generally less than 10% for most (with the chemical products industry being the exception).[11]

Figure 2: Share of non-exporters and exporters by industry



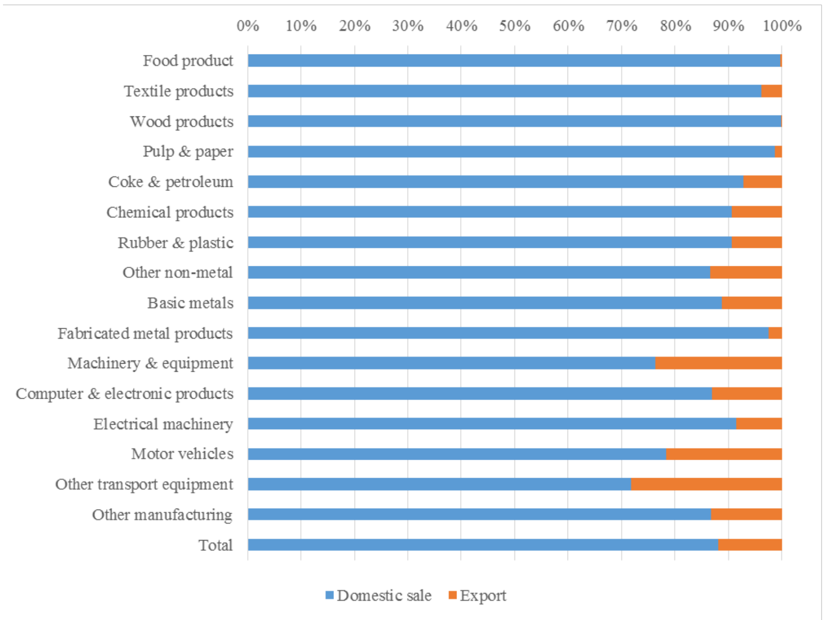
Note: Authors' calculations based on ECBA micro-data

4.2 Share of exports and domestic sales

Next, we aggregate exports and domestic sales in each industry (Figure 3). While the share of exports exceeds 20% in three industries (machinery & equipment, motor vehicles, and other transport equipment), domestic sales make up the overwhelming part in most industries. Comparing Figure 3 with Figure 2, we find that the share of exports is larger than the share of exporters, implying that exporters must be large in size in terms of sales.

[11] For the aggregation, we exclude plants with no record of sales as well as plants with no record of intermediate goods input.

Figure 3: Share of domestic sales and exports by industry



Note: Authors' calculations based on ECBA micro-data.

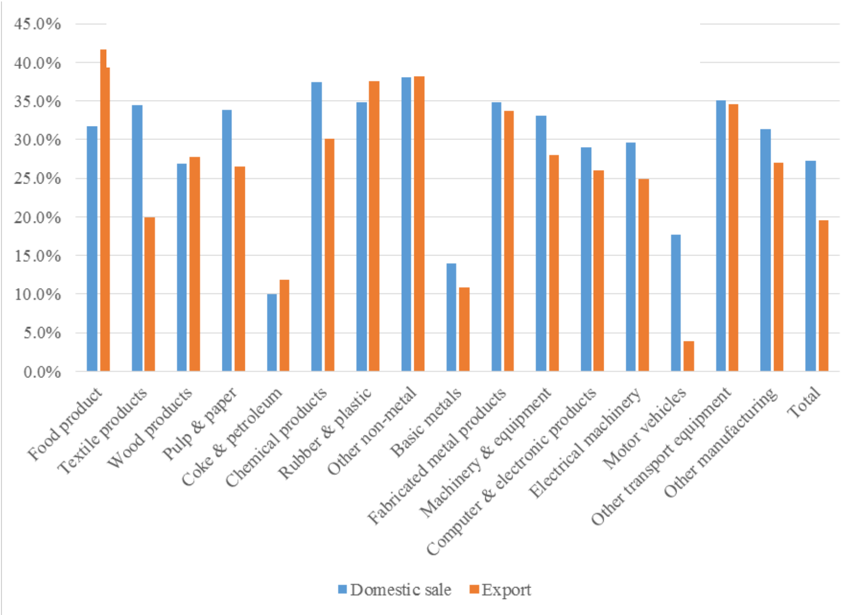
4.3 Heterogeneity in value added/sales ratio and labor productivity

To examine the heterogeneity in firms' production for export and domestic sale, we present here the value added/sales ratio and labor productivity computed as described in Section 3.2. As explained, we split the total value added in each industry into the valued added of production for export and for domestic sale using the shares of exports and domestic sales in the total output of each industry. We use the same approach to aggregate the number of workers involved in production for export and domestic sale for each industry. This allows us to compute the value added/sales ratio and labor productivity.

The data presented in Figure 4 indicates that in most industries, the difference between the value added/sales ratios of production for export and for domestic sale is small. Although on average the ratio is higher in the case of production for domestic sale, in most industries the ratios are quite similar.

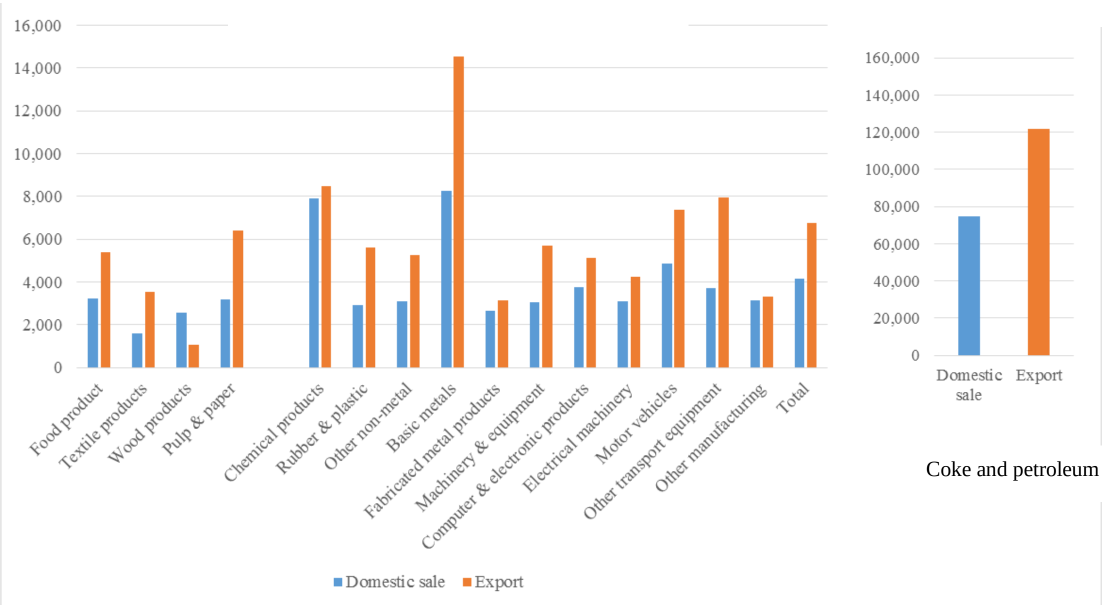
On the other hand, Figure 5 shows that there is significant heterogeneity in labor productivity and a clear size relationship of the two variables in each industry: labor productivity of production for export tends to exceed that of production for domestic sale. This fact is an important reason to relax the Hummels et al. (2001) assumption of identical intensity of imported intermediate input use in production for export and production for domestic sale.

Figure 4: Value added/sales ratios of production for export and domestic sale



Note: Authors' calculations based on ECBA micro-data.

Figure 5: Labor productivity of production for exports and domestic sale

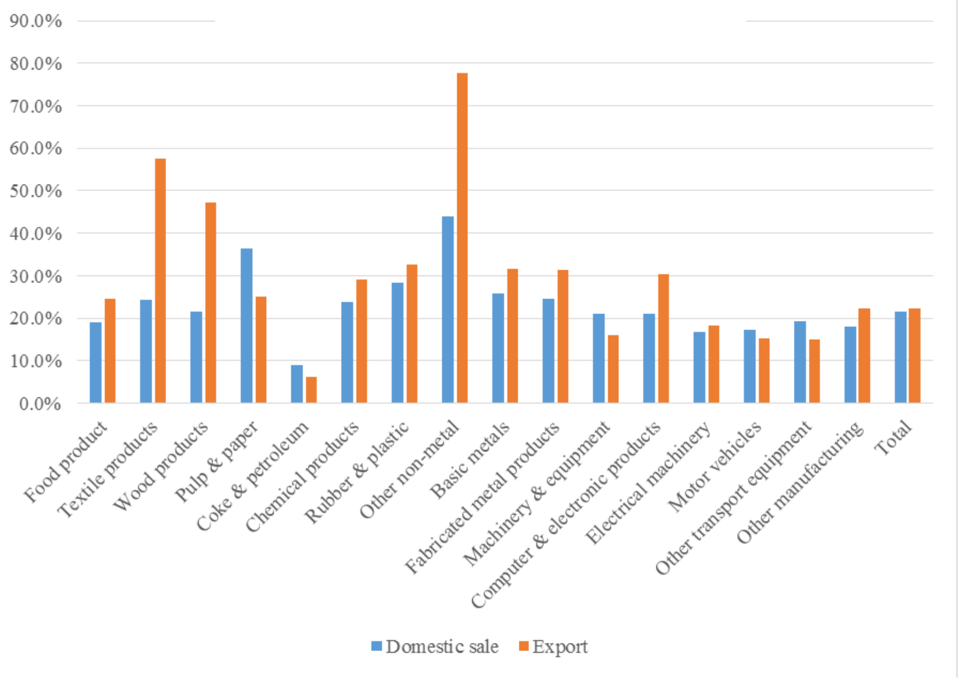


Notes: Authors' calculations based on ECBA micro-data. Labor productivity = output (10 thousand yen) / number of regular workers.

4.4 Heterogeneity of factor content in production for export and domestic sale

A comparison of factor content in production for export and domestic sale reveals a clear difference. Figure 6 shows that production for export is more capital-intensive than production for domestic sale, as predicted by trade theories (such as the Hecksher-Ohlin framework).[12] A particularly high capital intensity of production for export is observed for textile products, wood products, and other non-metal industries.

Figure 6: Capital/sales ratio of production for export and domestic sale



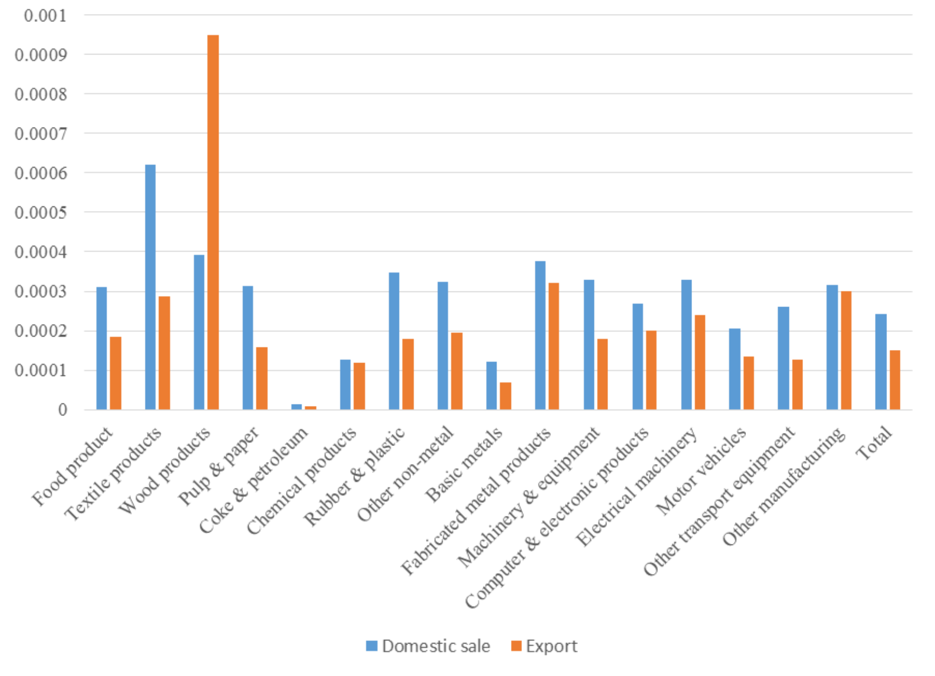
Notes: Authors' calculations based on ECBA micro-data. Capital/sales ratio = tangible fixed assets (10 thousand yen)/ sales (10 thousand yen).

Next, we discuss labor input differences for production for export and production for domestic sale. As labor inputs, we focus on regular workers, university graduates and non-regular workers. Figure 7 compares the "regular worker-intensity" of production for export and domestic sale and shows that this is higher in the case of the latter. The highest regular worker-intensity is observed in the production for domestic sale of textile products. The only exception where production for export is more regular worker intensive is the wood products industry.

The combined ECBA and BSWS employer–employee matched data includes the numbers of university graduates and non-regular workers in each plant. We use the same approach to aggregate the number of workers involved in production for export and domestic sale for each industry as described for value added in Section 3.2. Figure 8 shows that production for export is more skilled labor-intensive than production for domestic sale: in all industries, the share of university graduates is higher in production for export.

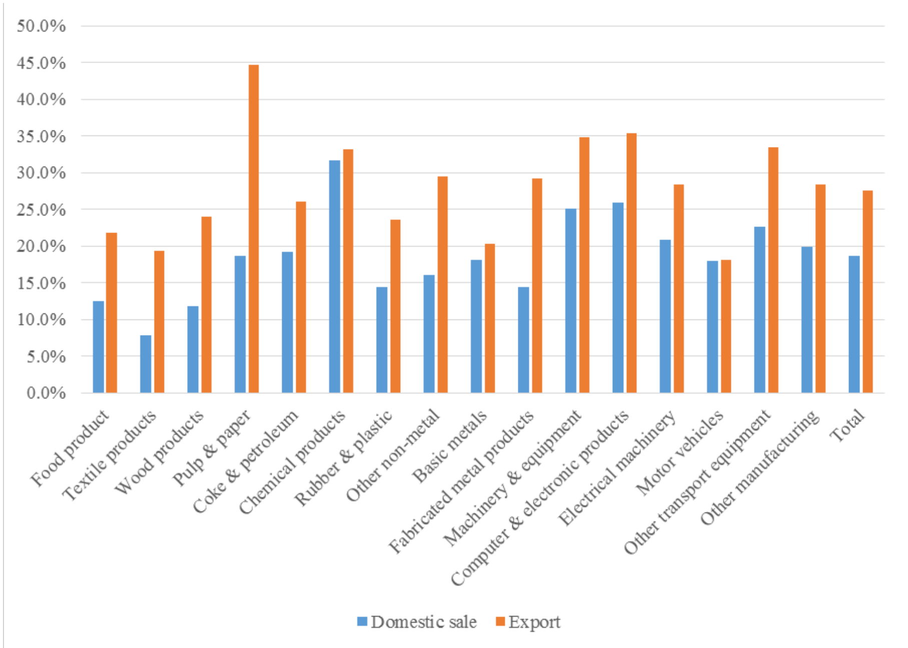
[12] Capital (physical fixed assets except land) used for production for export and domestic sale is calculated in the same way as value added derived from production for export and domestic sale.

Figure 7: Labor/sales ratio of production for export and domestic sales



Notes: Authors' calculations based on ECBA micro-data. Labor/sales ratio = number of regular workers / sales (10 thousand yen).

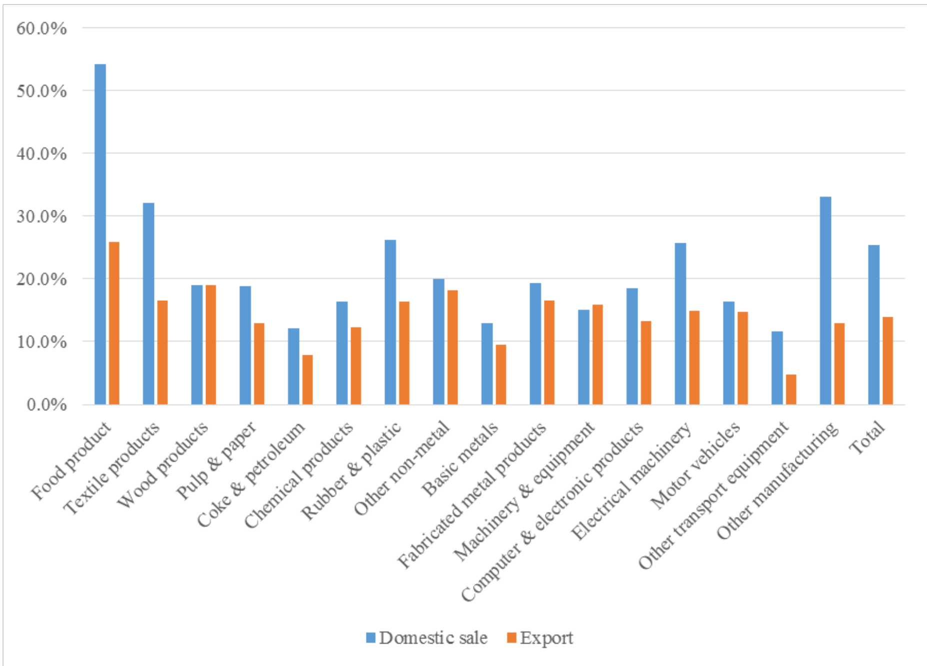
Figure 8: Share of university graduates in production for exports and domestic sale



Note: Authors' calculations based on ECBA and BSWS employer–employee matched data.

Further, as shown in Figure 9, in most industries production for export requires less non-regular workers than production for domestic sale.

Figure 9: Share of non-regular workers in production for export and domestic sale



Note: Authors' calculations based on ECBA and BSWS employer–employee matched data.

Overall, the figures presented here show that there is considerable heterogeneity in production for export and domestic sale from a variety of perspectives.

5. Extended Input–Output Table

5.1 Main indicators

We are now ready to identify how heterogeneity in production for export and domestic sale affects domestic and foreign value added embodied in Japanese exports and final demand, as well as factor input use induced by final demand. The indicators we calculate are described below.

We start by computing a global Leontief inverse matrix L of dimension C*S x C*S (where C stands for country and S stands for industry), the global value added share of output row vector V' (C*S x 1), and the factor input/output share vector F'_{JP} for Japan (S x 1) as follows:

$$L = (I - Z/Y')^{-1} \qquad (1)$$

$$V' = VA'/Y' \qquad (2)$$

$$F'_{JP} = FactorInput'_{JP}/Y'_{JP} \qquad (3)$$

where Z is a global technical coefficient matrix (C*S x C*S). The block of Japan's technical coefficient matrix is split into production for export and domestic sale as explained in Section 3.2; Y' a is row vector of global output (C*S x 1); VA' is a row vector of global value added

(C*S x 1); and $FactorInput'_{JP}$ is a row vector of factor input. We examine the following factor inputs: capital, regular workers, non-regular workers, and university graduates. Capital (tangible fixed assets) is derived from the ECBA data. Labor input is derived from the employer–employee matched data. For the purpose of our analysis, we employ only information on Japanese factor inputs.

To allow a comparison, the indicators we use are identical to those of the OECD TiVA database.[13] Below, we provide short definitions of the indicators used.

(1) Domestic value added in exports of each industry (DVA_{JPWOR})

DVA_{JPWOR} includes both direct exports (production for export) and indirect exports, that is, goods produced for domestic sale used as input for production for export, and is defined as follows. It serves as a measure of forward participation in GVCs.

$$DVA_{JPWOR} = V'_{JP} L_{JP} \widehat{EX'_{JP}} \tag{4}$$

where V'_{JP} is a row vector of the value added to output ratio for Japanese industries; L_{JP} is a diagonal block matrix for Japan of the global Leontief inverse matrix representing total domestic gross output required for one-unit increase in Japan's demand; and $\widehat{EX'_{JP}}$ is a diagonalized matrix of vector EX'_{JP} representing Japanese industries' exports.

(2) Foreign value added in exports of each of Japan's industries (FVA_{JPWOR})

FVA_{JPWOR} includes the direct and indirect inputs of all other countries' industries into Japan's industries' exports. It serves as a measure of backward participation in GVCs.

$$FVA_{JPWOR} = V' L_{JP\_zero} \widehat{EX'_{JP}} \tag{5}$$

where V' is a row vector of the global value added to output ratio; L_{JP_zero} is a column block of the global Leontief inverse matrix corresponding to Japan, with the row block corresponding to Japan equal to zero; $\widehat{EX'_{JP}}$ is a diagonalized matrix of vector EX'_{JP} representing Japanese industries' exports.

(3) Japanese industries' domestic value added component in country C's final demand ($FFD\_DVA_{JP,C}$)

[13] We use version 2 of the definitions of TiVA 2015 indicators. Retrieved from https://www.oecd.org/sti/ind/tiva/TIVA_2015_Indicators_Definitions.pdf (as of June 19, 2017).

$FFD\_DVA_{JP,C}$ includes both the direct and indirect contribution of Japanese industries to country C's final demand via all global input–output linkages. It serves as a measure of forward participation in GVCs.

$$FFD\_DVA_{JP,C} = \widehat{V'_{JP}} L_{JP,global} D_{global,C} \qquad (6)$$

where $\widehat{V'_{JP}}$ is a diagonal matrix of the value added to output ratio for Japanese industries on the diagonal; $L_{JP,global}$ is row block of the global Leontief inverse matrix corresponding to Japan; $D_{global,C}$ is a vector of country C global final demand for goods and services from each industry in other countries. We examine $FFD\_DVA_{JP,C}$ for the United States, Korea, China, and global final demand.

(4) Japanese industries' factor component in country C's final demand ($FFD\_F_{JP,C}$)

$FFD\_F_{JP,C}$ shows the factor input generated by country C's final demand via all global input–output linkages. It serves as a measure of forward participation in GVCs. The definition is as follows:

$$FFD\_F_{JP,C} = \widehat{F'_{JP}} L_{JP,global} D_{global,C} \qquad (7)$$

where $\widehat{F'_{JP}}$ is a diagonal matrix of factor input required per unit of output in Japanese industries; $L_{JP,global}$ is a row block of the global Leontief inverse matrix corresponding to Japan; $D_{global,C}$ is a vector of country C global final demand for goods and services from each industry in other countries. We examine $FFD\_F_{JP,C}$ for the United States, Korea, China, and global final demand.

5.2 Results and discussion

5.2.1 Results

We now examine our input–output tables taking heterogeneity in production for export and domestic sale into account. Table 3 presents such a table for the whole manufacturing sector for 2011 based on our micro-data.[14] The table allows the following observations:

(1) Production for domestic sale is greater than production for export.

(2) Total value added in production for domestic sale is greater than in production for export.

(3) The total capital stock per worker is higher in production for export than for domestic sale.

(4) Overall labor productivity is higher in production for export.

[14] A global ICIO table analysis is presented in the next section.

(5) The number of workers employed in production for domestic sale is considerably higher than that employed in production for export.

(6) The share of university graduates is higher in production for export.

(7) The share of non-regular workers is higher in production for domestic sale.

Table 3: Extended input–output table for the whole manufacturing sector, 2011

	Production for domestic sale	**Production for export**	**Exports (billion yen)**	**Total sales (billion yen)**
Production for domestic sale			0	20,744.65
Production for export			2,809.53	2,809.53
Total value added (billion yen)	6,936.99	559.65		
Total capital stock per worker (mil. yen/worker)	887.38	1494.56		
Labor productivity (mil. yen/worker)	4137	6757		
Number of workers	5,032,637	419,737		
Share of university graduates	0.19	0.28		
Share of non-regular workers	0.26	0.14		
Total sales (billion yen)	20,744.65	2,809.53		

A more detailed picture can be obtained if we examine the input–output table for individual industries. Table 4 presents the example of two industries (machinery and equipment; computer, electronic, and optical products), which are export-oriented industries in Japan. The above presented observations hold for these two industries as well.

Note that in the machinery and equipment industry the share of non-regular workers is similar in production for export and production for domestic sale, while in the computer, electronic, and optical products industry it is higher for production for domestic sale.

These observations imply heterogeneity of factor inputs in production for export and domestic sale, which may vary considerably between and within industries. Thus, our findings suggest that taking heterogeneity in production for export in the split input–output table into account may provide a better picture of the factor inputs and value added distribution within industries.

Table 4: Example of input–output table for two industries, 2011

		Machinery and equipment		Computer, electronic, and optical products		Exports (billion yen)	Sales (billion yen)
		Production for domestic sale	Production for export	Production for domestic sale	Production for export		
Machinery and equipment	Production for domestic sale					0	1586.49
Machinery and equipment	Production for export					492.51	492.51
Computer, electronic and optical products	Production for domestic sale					0	22667.63
Computer, electronic and optical products	Production for export					423.19	2812.32
Value added (Billion yen)		524.50	137.82	815.65	110.05		
Total capital stock per worker (mil. yen/worker)							
Labor productivity (mil. yen/worker)			5,712	3,738	5,123		
Number of workers			87,796	757,495	84,120		
Share of university graduates			0.35	0.26	0.35		
Share of non-regular workers			0.159	0.18	0.13		
Sales (billion yen)			492.51	22667.63	423.19		

Next, we discuss the differences between the main indicators presented in Section 3.3 that arise when we split Japan's industries' output in the ICIO table into production for export and production for domestic sale. We start by examining the domestic and foreign value added in Japanese industries' exports. To allow a comparison, we sum up the results for *DVA* and *FVA* when splitting production into that for export and for domestic sale to derive industries' total DVA and FVA and compare these totals with the corresponding OECD TiVA statistics. Table 5 shows our findings. However, to more clearly illustrate the results, Figure 10 shows the difference visually for textiles, fabricated metal products, machinery & equipment, computer, electronic and optical equipment, electrical machinery and total manufacturing.

Table 5: Domestic and foreign value added in Japan's gross exports (ten thousand yen)

	DVA Split IO (A)	TiVA_ DVA (B)	Deviation (%) {(A-B)/[(A+B)/2]}*100	FVA Split IO (C)	TiVA_ FVA (D)	Deviation (%) {(C-D)/[(C+D)/2]}*100	Exports
Food products, beverages, and tobacco	2540.0	2662.4	-4.7	511.7	389.3	27.2	3051.7
Textiles, textile products, leather, and footwear	4167.3	4931.6	-16.8	2318.8	1554.5	39.5	6486.1
Wood and products of wood and cork	54.1	58.1	-7.2	18.1	14.1	25.0	72.2
Pulp, paper, paper products, printing, and publishing	3242.7	3407.1	-4.9	569.6	405.2	33.7	3812.4
Coke, refined petroleum products, and nuclear fuel	7996.4	5893.9	30.3	5636.7	7739.3	-31.4	13633.1
Chemicals and chemical products	47411.2	49264.1	-3.8	17222.0	15369.2	11.4	64633.3
Rubber and plastics products	17033.4	17302.1	-1.6	4147.5	3878.8	6.7	21180.9
Other non-metallic mineral products	8968.2	9403.1	-4.7	1974.3	1539.5	24.7	10942.5
Basic metals	48930.0	51885.7	-5.9	17893.3	14937.7	18.0	66823.4
Fabricated metal products	6064.8	6527.1	-7.3	1529.5	1067.2	35.6	7594.3
Machinery and equipment	82796.8	85238.0	-2.9	16741.0	14299.8	15.7	99537.8
Computer, electronic, and optical equipment	103276.5	110970.1	-7.2	30705.1	23011.5	28.6	133981.7
Electrical machinery and apparatus, nec	20100.9	21332.8	-5.9	5148.8	3917.0	27.2	25249.8
Motor vehicles, trailers, and semi-trailers	100491.2	102636.5	-2.1	18722.6	16576.4	12.2	119212.9
Other transport equipment	26742.3	28148.7	-5.1	6526.5	5120.1	24.2	33268.8
Manufacturing nec; recycling	9558.1	9913.2	-3.6	2624.4	2269.4	14.5	12182.5
Total	489374	509574.2	-4.0	132290	112088.9	16.5	609480.9

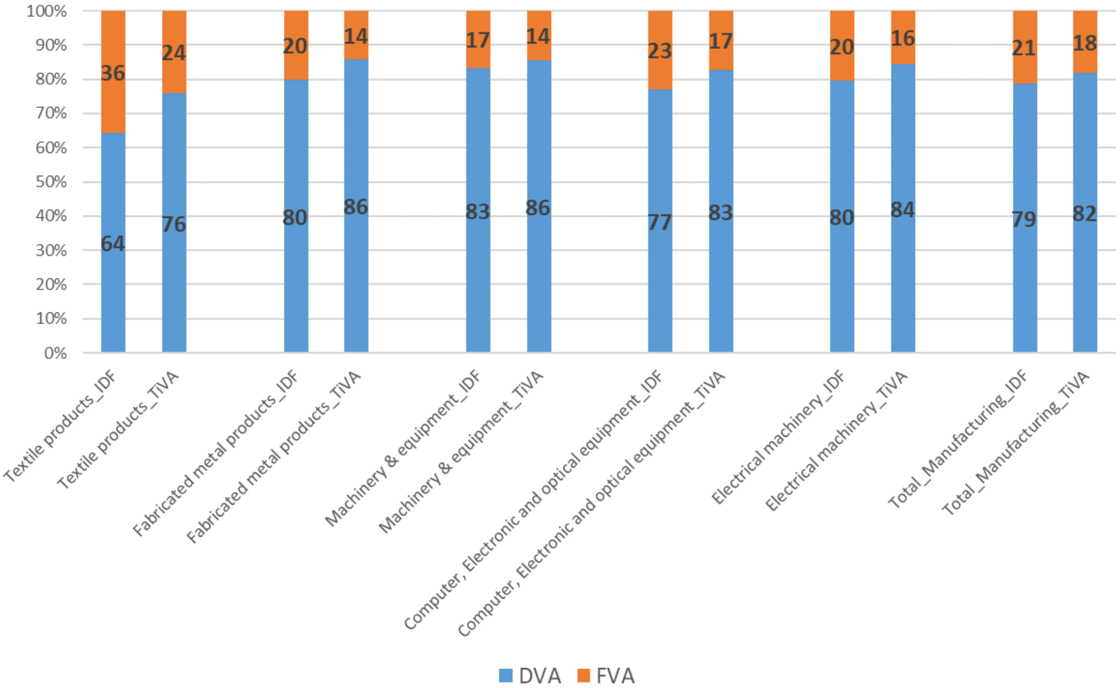
We find that the DVA computed from the extended ICIO table is lower in most industries as well as overall than the DVA computed from the original ICIO table.[15] The lower level of domestic value added means that foreign value added is higher than in the original ICIO table. Differences in FVA of more than 15% are observed in many industries.[16] This

[15] Note that DVA is higher for the coke and petroleum industry. This industry is somewhat exceptional. In total, the number of plants is smaller in this industry and the share of exporters is relatively high (around 30%). Higher labor productivity of exporters could explain this result of higher DVA.

[16] Exceptions are chemicals and chemical products, rubber and plastics products, motor vehicles, trailers and semi-trailers, and manufacturing recycling industries.

implies that Japanese production for export relies more on foreign value added than estimates not taking firm heterogeneity into account suggest.

Figure 10: Domestic and foreign value added in Japan's gross exports



Note: IDF stands for Ito, Deseatnicov, and Fukao. OECD represents the TiVA results computed by the OECD using the non-split IO table.

This finding suggests that Japan's forward participation in GVCs has not been as high (at least in 2011) as implied by previous studies (e.g., Fukao and Yuan, 2009), suggesting that Japanese manufacturing firms' production induced by foreign final demand is lower than previously argued. We infer that this result is caused by the low domestic value/added sales ratio of production for export, implying a higher reliance on foreign inputs in production. For instance, several large assemblers (such as Toyota) purchase parts and components, and some of them come from abroad. This generates a leakage of VA abroad. Part of this process consists of intra-industry trade by multinationals. As GVCs proliferate, an increasing number of parts and components are being imported from abroad. The production of intermediate inputs abroad reduces the domestic value added/sales ratio, meaning that the Japanese manufacturing sector relies on backward linkages. In this context, Ito and Fukao (2010) suggest that Japanese multinationals' affiliates develop their suppliers abroad, which then provide intermediate inputs to firms in Japan. Hagino and Tokoyama (2016) also document that processing and assembly industries in Japan, many of which are export-oriented, import relatively more intermediate inputs than other industries. Note that Japan is not the only country with increased reliance on backward linkages. Timmer et al. (2014), examining the period from 1995 to 2008, show that there has been a global increase in foreign value added shares in most industries in developed countries. Ma et al. (2014) observe a similar pattern for China. To reinforce our argument, we compute the simple correlation between domestic value added in exports and foreign value added in exports for the machinery and equipment, computer, electronic, and optical equipment, and electrical machinery and apparatus industries (Table 6). The results suggest that these manufacturing industries have indeed become more globally integrated recently.

Table 6: Correlation between domestic value added in exports and foreign value added in exports

	Machinery and equipment	Computer, electronic, and optical equipment	Electrical machinery and apparatus
1995	0.9286	0.6597	0.7760
2000	0.9034	0.6564	0.7164
2005	0.9351	0.6849	0.7892
2008	0.9759	0.8345	0.9011
2009	0.9676	0.8381	0.8758
2010	0.9665	0.8453	0.9026
2011	0.9709	0.8645	0.9066

Note: Authors calculation based on the original OECD TiVA indicators.

However, note that domestic value added still represents a major part of Japanese exports. In sum, these findings imply that cross-border fragmentation is greater than suggested based on measures that do not take firm heterogeneity in production for export and domestic sale into account.

Next, in Table 7 we compare our estimates of value added in foreign final demand with those reported in the TiVA database.[17] Again, to more clearly bring out the results, Figure 11 shows the difference visually for textiles, machinery & equipment, computer, electronic and optical equipment, electrical machinery, other transport equipment, and total manufacturing.

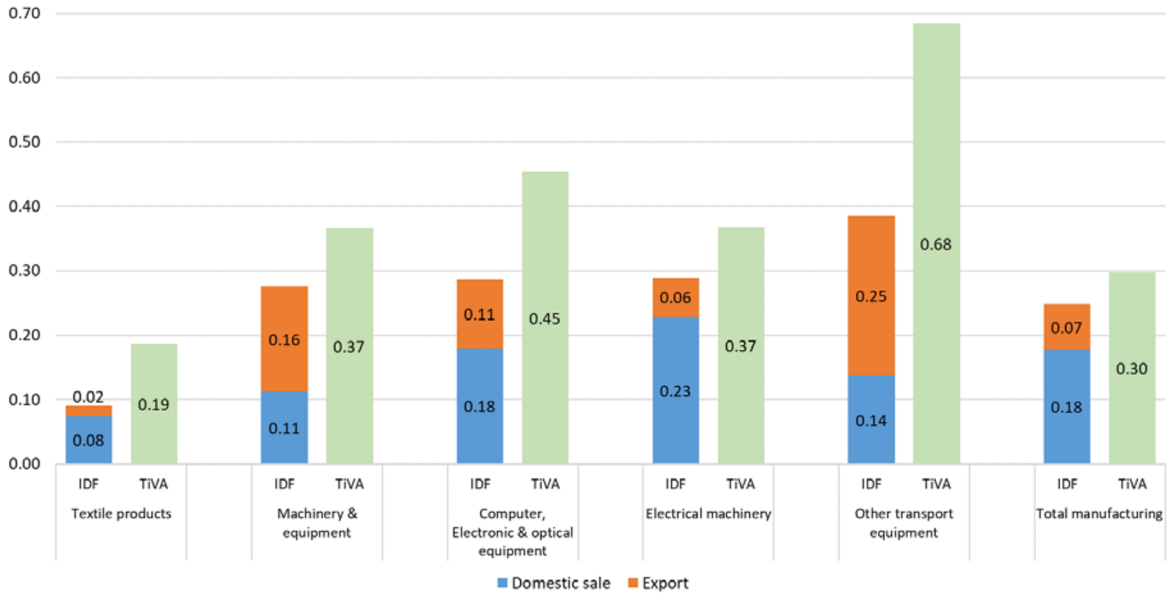
[17] Detailed results are given in Appendix Table 1.

Table 7: Comparison of results for domestic value added embodied in foreign final demand between the original and split IO table

	United States	China	Korea	World
	Deviation from TiVA, %	Deviation from TiVA, %	Deviation from TiVA, %	Deviation from TiVA, %
Food products, beverages, and tobacco	-4.74	6.05	-9.89	-5.66
Textiles, textile products, leather, and footwear	-66.77	-68.78	-72.95	-69.48
Wood and products of wood and cork	15.42	18.86	16.48	11.67
Pulp, paper, paper products, printing and publishing	8.82	15.34	11.22	7.27
Coke, refined petroleum products, and nuclear fuel	20.62	30.10	31.80	24.93
Chemicals and chemical products	-11.72	-10.31	-15.14	-13.99
Rubber and plastics products	9.01	11.52	1.14	5.41
Other non-metallic mineral products	1.16	7.18	-19.15	-6.36
Basic metals	12.48	9.94	1.37	1.70
Fabricated metal products	1.83	8.56	-1.22	-3.80
Machinery and equipment	-21.60	-26.25	-29.14	-28.33
Computer, electronic, and optical equipment	-44.09	-43.06	-32.56	-45.00
Electrical machinery and apparatus, nec	-19.05	-29.00	-23.50	-23.96
Motor vehicles, trailers, and semi-trailers	-29.57	-25.02	-17.68	-29.36
Other transport equipment	-48.45	-16.00	-25.76	-55.85
Manufacturing nec; recycling	-3.88	8.57	-20.30	-11.15
Total for industries	-0.60	1.73	2.09	-3.38

Note that our results are more than 15% lower than the TiVA results for the textiles, textile products, leather and footwear, machinery and equipment, computer, electronic and optical equipment, electrical machinery and apparatus, motor vehicles, trailers and semi-trailers, and other transport equipment industries. As is well known, companies in these industries tend to rely on outsourcing as well as outward FDI and intra-industry trade. Thus, when we consider manufacturing plant heterogeneity in production for export and production for domestic sale, we find that the DVA embodied in foreign final demand is lower than the results based on the ICIO table not taking such heterogeneity into account. This is a surprising finding, because a widespread perception is that the Japanese manufacturing sector has much stronger forward than backward linkages, i.e., Japanese companies' value added represents an important share of foreign final demand (e.g., Fukao and Yuan, 2009). However, we find that Japanese companies are strongly involved in GVCs via backward linkages as well. Thus, they rely on foreign intermediate input to a higher extent, and therefore depend less on foreign final demand, than suggested in previous studies.

Figure 11: Domestic value added embodied in world final demand, share in industries' total value added



Note: IDF stands for Ito, Deseatnicov, and Fukao. OECD represents the TiVA results computed by the OECD using non-split IO table.

In fact, exporters' share in outsourcing is higher in the machinery and equipment, computer, electronic, and optical equipment, electrical machinery and apparatus, motor vehicles, trailers and semi-trailers, other transport equipment, manufacturing, and recycling industries than other industries. We also found lower DVA and factor inputs embodied in exports and foreign final demand in these industries.

5.2.2 Discussion of factor input differences between production for export and production for domestic sale

Tables 8 and 9 present the factor inputs embodied in foreign final demand. Again, to bring out the results more clearly, Figure 12 shows the difference visually for machinery & equipment, computer, electronic and optical equipment, and total manufacturing. The tables and the figure show the following.

First, we find that production for domestic sale contributes relatively high factor content to production for exports. This means that a significant part of production for domestic sale is used as inputs for production for export. Thus, production for domestic sale benefits from foreign final demand via indirect linkages.

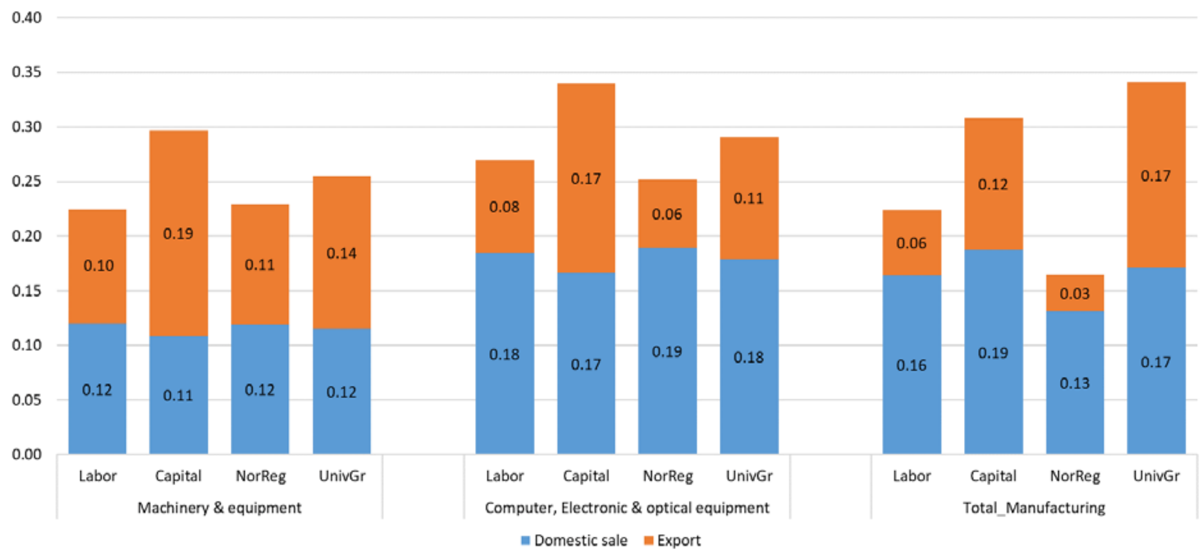
Table 8: Factor inputs embodied in global foreign final demand for products for export and domestic sale

	Labor (workers)		Capital (ten thousand yen)		Non-regular workers (workers)		University graduates (workers)	
	Production for export	Production for domestic sale	Production for export	Production for domestic sale	Production for export	Production for domestic sale	Production for export	Production for domestic sale
Food products, beverages, and tobacco	2431.3	25407.9	2086750.0	10157127.1	449.6	9864.9	379.2	2277.8
Textiles, textile products, leather, and footwear	3875.0	35207.2	5373035.0	4667732.7	296.1	5204.8	345.3	1266.9
Wood and products of wood and cork	44.3	26156.7	187005.2	4265338.7	3.3	1958.8	4.2	1217.9
Pulp, paper, paper products, printing and publishing	3021.1	133099.3	2825151.8	55764792.7	158.1	10179.2	545.9	10092.2
Coke, refined petroleum products, and nuclear fuel	525.8	3772.7	6685973.2	16959165.3	20.7	227.4	68.3	361.1
Chemicals and chemical products	27199.0	79077.8	61600094.5	105285963.5	2427.0	9405.7	6553.3	18184.6
Rubber and plastics products	21400.4	163228.1	33161053.1	80058456.6	2232.0	27222.3	3217.3	14937.5
Other non-metallic mineral products	14775.0	47579.8	44160619.8	27493974.1	1471.4	5216.6	2397.6	4201.5
Basic metals	24613.7	177182.7	79531634.7	263876268.3	1521.9	14861.8	3229.0	20756.0
Fabricated metal products	9730.4	144101.7	6580418.3	34730643.5	737.8	12706.6	1300.2	9468.0
Machinery and equipment	134380.5	154164.8	77268428.6	44606526.3	10953.9	11916.9	24004.5	19814.7
Computer, electronic, and optical equipment	119145.4	260054.0	124360595.8	119268474.5	7667.8	23207.6	20346.3	32640.2
Electrical machinery and apparatus, nec	11488.8	104174.9	13115824.2	32157668.9	1022.4	16095.3	1956.6	13018.1
Motor vehicles, trailers, and semi-trailers	159286.8	231317.7	122792961.2	133388850.8	16544.2	26712.7	20343.0	29152.2
Other transport equipment	50504.6	36839.2	24824404.6	14959095.9	1016.6	1812.8	7109.0	3506.5
Total	582422.1	1621364.5	604553949.9	947640078.8	46522.9	176593.5	91799.6	180895.3
Minimum	44.3	3772.7	187005.2	4265338.7	3.3	227.4	4.2	361.1
Maximum	159286.8	260054.0	124360595.8	263876268.3	16544.2	27222.3	24004.5	32640.2
Median	14775.0	104174.9	24824404.6	34730643.5	1022.4	10179.2	2397.6	10092.2

Table 9: Factor inputs embodied in global foreign final demand for products for export and domestic sale (Share in industries' total factor inputs)

	Labor (workers)			Capital (ten thousand yen)			Non-regular workers (workers)			University graduates (workers)		
	Ex	DS	Total	Ex	DS	Total	Ex	DS	Total	Ex	DS	Total
Food products, beverages, and tobacco	0.02	0.002	0.02	0.02	0.004	0.02	0.02	0.001	0.02	0.02	0.003	0.02
Textiles, textile products, leather, and footwear	0.08	0.01	0.08	0.07	0.08	0.15	0.08	0.004	0.08	0.07	0.02	0.09
Wood and products of wood and cork	0.09	0.0002	0.09	0.09	0.004	0.10	0.09	0.0002	0.09	0.09	0.0003	0.09
Pulp, paper, paper products, printing and publishing	0.16	0.004	0.17	0.16	0.01	0.17	0.16	0.003	0.16	0.16	0.01	0.17
Coke, refined petroleum products, and nuclear fuel	0.13	0.02	0.15	0.12	0.05	0.17	0.13	0.01	0.14	0.13	0.02	0.15
Chemicals and chemical products	0.19	0.07	0.26	0.19	0.11	0.29	0.20	0.05	0.25	0.19	0.07	0.26
Rubber and plastics products	0.27	0.04	0.31	0.25	0.10	0.36	0.28	0.02	0.30	0.27	0.06	0.32
Other non-metallic mineral products	0.16	0.05	0.21	0.13	0.21	0.34	0.16	0.04	0.20	0.15	0.09	0.24
Basic metals	0.46	0.06	0.53	0.43	0.13	0.56	0.47	0.05	0.52	0.46	0.07	0.53
Fabricated metal products	0.17	0.01	0.18	0.16	0.03	0.20	0.17	0.01	0.18	0.17	0.02	0.19
Machinery and equipment	0.12	0.10	0.22	0.11	0.19	0.30	0.12	0.11	0.23	0.12	0.14	0.25
Computer, electronic, and optical equipment	0.18	0.08	0.27	0.17	0.17	0.34	0.19	0.06	0.25	0.18	0.11	0.29
Electrical machinery and apparatus, nec	0.24	0.03	0.26	0.22	0.09	0.31	0.24	0.02	0.25	0.23	0.04	0.27
Motor vehicles, trailers, and semi-trailers	0.22	0.15	0.38	0.21	0.20	0.41	0.23	0.14	0.37	0.22	0.16	0.38
Other transport equipment	0.15	0.20	0.35	0.14	0.23	0.37	0.17	0.09	0.26	0.13	0.27	0.40
Total	0.16	0.08	0.24	0.15	0.16	0.30	0.17	0.03	0.20	0.16	0.11	0.26
Minimum	0.16	0.06	0.22	0.19	0.12	0.31	0.13	0.03	0.17	0.17	0.09	0.26
Maximum	0.02	0.0002	0.02	0.02	0.004	0.02	0.02	0.0002	0.02	0.02	0.0003	0.02
Median	0.46	0.20	0.53	0.43	0.23	0.56	0.47	0.14	0.52	0.46	0.27	0.53

Figure 12: Factor inputs embodied in world final demand (Share in industries' total factor input)



Second, the input of capital and high-skilled labor (university graduates) in production for domestic sale benefits more from foreign final demand than in production for export in the manufacturing sector as a whole and in most industries.

Third, in most industries capital and high-skilled labor (university graduates) are embodied in foreign final demand to a higher extent than labor of regular and non-regular workers. Thus, most industries rely more on capital and high-skilled labor as factor inputs for foreign final demand production than on regular and non-regular workers as labor input. Interestingly, there are a few exceptions, such as the machinery and equipment and other transport equipment industries, which are usually regarded as being capital- and high-skilled labor-intensive. These industries do not show a high reliance on capital and high-skilled labor for production induced by foreign final demand.

In sum, we observe a high variation in factor inputs across different industries. However, note that forward linkages are capital and skilled-labor intensive for most of industries. Thus, we would expect an increase in foreign demand to induce a higher increase in demand for capital and skilled workers than for non-skilled workers.

Finally, we discuss the difference between factor inputs embodied in global final demand calculated from the split and non-split ICIO tables. The comparison of the results is presented in Table 10.[18]

[18] Detailed results are provided in Appendix Table 2.

Table 10: Comparison of results for factor inputs embodied in global final demand between original and extended IO tables

	Labor	Capital (10000 yen)	Non-Regular Workers	University Graduates
	Deviation	Deviation	Deviation	Deviation
Food products, beverages, and tobacco	-13.01	-3.70	-17.57	-6.91
Textiles, textile products, leather, and footwear	-75.90	-21.63	-79.71	-65.07
Wood and products of wood and cork	11.96	15.66	11.96	12.11
Pulp, paper, paper products, printing and publishing	6.15	8.38	5.57	8.65
Coke, refined petroleum products, and nuclear fuel	-3.34	13.54	-7.05	0.29
Chemicals and chemical products	-15.87	-4.16	-20.69	-15.00
Rubber and plastics products	-4.02	10.68	-7.07	0.83
Other non-metallic mineral products	-19.68	29.82	-21.40	-5.74
Basic metals	-0.15	5.66	-1.64	0.50
Fabricated metal products	-5.46	3.27	-6.19	-0.33
Machinery and equipment	-47.83	-20.85	-46.01	-35.76
Computer, electronic, and optical equipment	-50.85	-28.66	-57.07	-43.65
Electrical machinery and apparatus, nec	-33.12	-16.64	-36.18	-30.62
Motor vehicles, trailers, and semi-trailers	-7.86	-0.06	-10.48	-7.52
Other transport equipment	-65.29	-58.67	-89.96	-51.37
Manufacturing nec; recycling	-12.57	11.93	-29.17	-3.12
Total for industries	-3.75	-6.23	-27.64	-22.43

Again, a significant negative deviation is observed for most sectors. Thus, we can conclude that analyses using a non-split IO table overestimate the level of factor inputs induced by foreign final demand. Note that there are a few exceptions that can be explained by differences in factor input/output ratios. [19]

6. Conclusion

In this study, we examined the role of heterogeneity between Japanese manufacturing plants producing for export and for domestic sale using data from the Economic Census for Business Activity (2012) and the Basic Survey on Wage Structure (2012) and a unique employer–employee matched dataset constructed from these two sources. We examined the differences in value added and factor inputs in production for export and production for domestic sale.

Our main findings are generally consistent with the theoretical expectations and several previous studies. They can be summarized as follows:

[19] In this paper, we did not calculate TiVA indicators for other countries. If we assume that our conclusion is valid i.e., high backward linkages of local firms, then we could expect similar overshooting of forward linkage in other countries. At least Timmer et. al (2014) document that foreign value added in output increased from 1998 to 2008 for most of manufacturing industries in their sample countries.

- Most of Japan's manufacturing production for export is conducted by a relatively small number of large plants, which employ approximately only 8% of workers in the manufacturing sector.
- Production for export is larger and more capital-intensive (in terms of both physical and human capital) than production for domestic sale.
- The labor productivity of production for export is much higher than that of production for domestic sale.
- No clear pattern in terms of the VA/sales ratio across and within industries can be observed.

Based on our results, we also presented an extended input–output table taking plant heterogeneity in production for export and production for domestic sale into account, where we reported factor input statistics for the entire manufacturing sector and for two industries: transportation equipment and electronic machinery.

Finally, using the shares from the micro-data, we derived Japan's input–output table as part of the OECD Inter-Country Input–Output table. We computed TiVA indicators and compared the results between the split and non-split ICIO tables. We found several differences.

- Domestic value added in exports, domestic value added embodied in foreign final demand, and factor inputs embodied in foreign final demand computed from the split IO table are lower than the results computed from the non-split IO table. This implies that Japanese companies benefit less from foreign final demand than is often argued. We infer that this result is due to high cross-border production fragmentation as well as the intensive presence of multinational companies and intra-industry trade in the manufacturing sector.
- Production for domestic sale benefits relatively more from exports and foreign final demand than production for export.
- Capital and high-skilled labor benefit to a higher extent from exports and foreign final demand than less skilled labor (regular workers and non-regular workers).
- There is a high variation in factor inputs embodied in foreign final demand in between industries. Our findings suggest that taking production for export and production for domestic sale within industries into account may provide a more complete and better picture of firm heterogeneity in the ICIO table. Moreover, the resulting TiVA indicators will show a more realistic picture of countries' interconnectedness.

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Appendix 1. Framework of Estimation of Split IO Table Using Quadratic Programming

The following is the framework for the quadratic programming we implement.

1. Set initial elements of the split IO table

We start by deciding the initial value of each element of the split IO table. While some parts are described from the original IO table, some need to be based on information from the micro-data.

Thus, we set the initial data in the following way (Appendix Figure 1):

a) Japanese manufacturing sector output used as Japanese manufacturing sector input

The original element is divided into output for domestic sale used in production for export and in production for domestic sale, proportional to the share of exports and domestic sales calculated in Section 3.2.2).

b) Japanese manufacturing sector output used as input by other countries

The original element is described in production for export, and zero is recorded for production for domestic sale.

c) Japanese manufacturing sector output used in Japanese final demand

The original element is described in production for domestic sale, and zero is recorded for production for export.

d) *Japanese manufacturing sector output used in final demand by other countries*

The original element is described in production for export, and zero is recorded for production for domestic sale.

e) Foreign countries' output used as Japanese manufacturing sector input

The original element is split proportional to the share of exports and domestic sales calculated in Section 3. 2. 2.

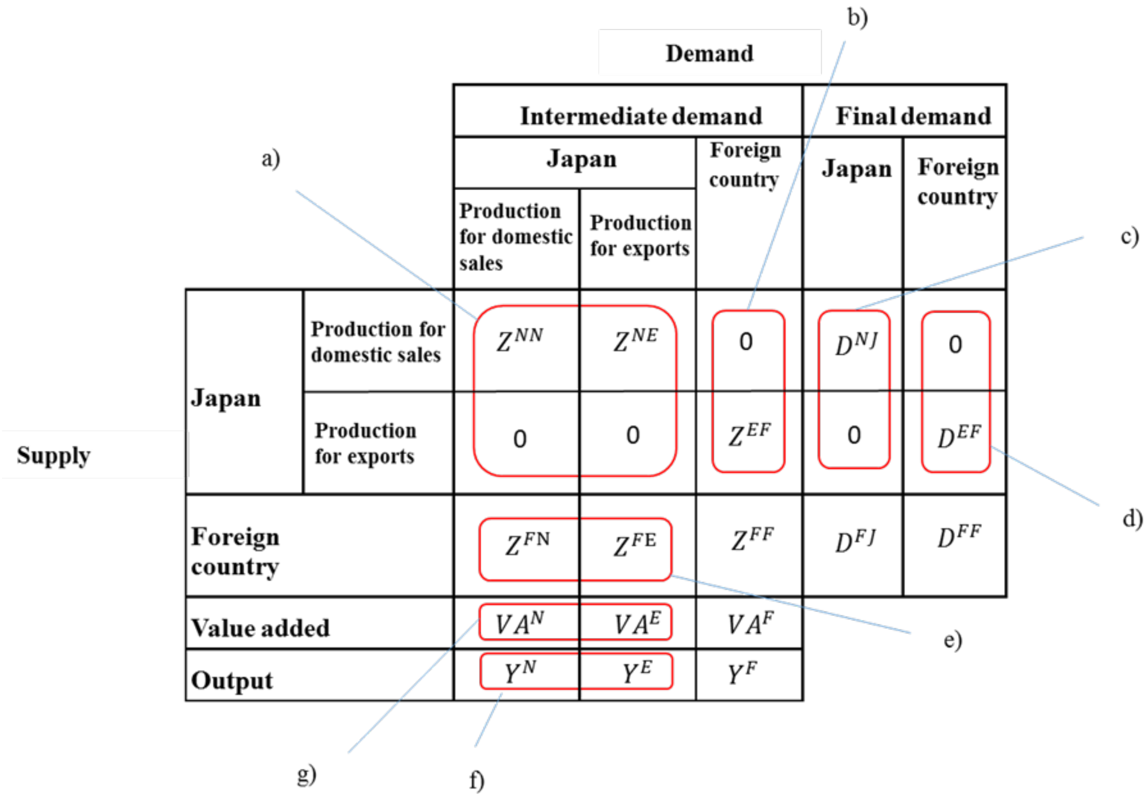
f) Output for export and output for domestic sale of Japanese manufacturing sector

Output is equal to the sum of the elements in the row of production for export and production for domestic sale of the Japanese manufacturing sector, calculated in a) to d). In the case of Appendix Figure 1, $Y^E = Z^{EF} + D^{EF}$ and $Y^N = Z^{NN} + Z^{NE} + D^{NJ}$.

g) Value added of production for export and production for domestic sale of the Japanese manufacturing sector

Value added is equal to output minus the sum of inputs, the sum of elements in the column for production for export and production for domestic sale.

Appendix Figure 1: Split of input-output table



Note: *N and E mean* production for domestic sale and production for export, respectively. *F* and *J* mean foreign countries and Japan, respectively.

2) Z^{mn} is a matrix of intermediate goods supply from sector *m* to *n* (*m* = *N, E, F*, *n* = *N, E, F, J*).
3) D^{mn} is a matrix of *m's* final demand for goods supplied by sector *n* (*m* = *N, E, F*, *n* =*J, F*).
4) Y^m and VA^m are matrixes of sector *m's* output and value added, respectively (*m* = *N, E, F*).

2. Implement quadratic programming

Quadratic programming is a method to estimate a variable subject to constraints. We need to estimate:

z_{ij}^{NE} : Elements of matrix Z^{NE} (*i*: index of industries on the supply side, *j* : index of industries in the Japanese manufacturing sector on the demand side)

z_{ij}^{NN} : Elements of matrix Z^{NN}

z_{ij}^{FE} : Elements of matrix Z^{FE}

z_{ij}^{FN} : Elements of matrix Z^{FN}

va_{ij}^{E} : Elements of matrix VA^E

va_{ij}^{N} : Elements of matrix VA^{N}

The estimated elements should satisfy the following constraints:

For all $i \in J$,

$z_{ij}^{NE} + z_{ij}^{NN} = z_{ij}^{O,J}$ where *o* refers to the "original" element of the IO table before the split

$\sum_j \left(z_{ij}^{NE} + z_{ij}^{NN}\right) = D_i^{O,J} + \sum_f D_{if}^{O,F} - \sum_j \sum_f Z_{ij}^{O,F}$

For all $i \in F$,

$z_{ij}^{FE} + z_{ij}^{FN} = z_{ij}^{O,F}$

$\sum_j \left(z_{ij}^{FE} + z_{ij}^{FN}\right) = D_i^{O,J} + \sum_f D_{if}^{O,F} - \sum_j \sum_f Z_{ij}^{O,F}$

For all j,

$\sum_i \left(z_{ij}^{NE} + z_{ij}^{FE}\right) = Y_j^{E} - va_{ij}^{E} = \alpha_j (\sum_i z_{ij}^{O,J} + \sum_i \sum_f Z_{ij}^{O,F})$

$\sum_i \left(z_{ij}^{NN} + z_{ij}^{FN}\right) = Y_j^{N} - va_{ij}^{N} = (1-\alpha_j)(\sum_i z_{ij}^{O,J} + \sum_i \sum_f Z_{ij}^{O,F})$

where α_j is the share of production for export of total production in industry j, calculated from the micro-data.[20, 21]

Under these constraints, quadratic programming estimates the elements by minimizing the following objective function:

$$S = \sum_i \sum_j \frac{(z_{ij}^{NE} - z0_{ij}^{NE})^2}{z0_{ij}^{NE}} + \sum_i \sum_j \frac{\left(z_{ij}^{NN} - z0_{ij}^{NN}\right)^2}{z0_{ij}^{NN}} + \sum_i \sum_j \frac{(z_{ij}^{FE} - z0_{ij}^{FE})^2}{z0_{ij}^{FE}} + \sum_i \sum_j \frac{(z_{ij}^{FN} - z0_{ij}^{FN})^2}{z0_{ij}^{FN}}$$

[20] We assume that α_j holds after the estimation process. We also implemented the quadratic programming to estimate variables without fixed α_j, but the solutions have implausible elements (e.g., in some industries, sectors' production for export is larger than production for domestic sale).

[21] It is also possible to use the share of value added from the micro-data. However, we avoid making any assumptions on value added. We therefore use the share of total inputs and, as a result, value added va_{ij}^{E} and va_{ij}^{N} are calculated indirectly from the estimated output and total input.

Appendix Table 1: Comparison of results for VA embodied in foreign final demand between original and extended IO table (mil. USD; current prices)

	United States			China			Korea			World		
	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)
Food products, beverages, and tobacco	761.84	798.82	-4.74	653.43	615.06	6.05	260.13	287.18	-9.89	3683.85	3898.43	-5.66
Textiles, textile products, leather, and footwear	303.67	608.03	-66.77	300.88	616.29	-68.78	91.74	197.09	-72.95	1530.58	3160.30	-69.48
Wood and products of wood and cork	163.22	139.86	15.42	147.61	122.17	18.86	53.87	45.67	16.48	902.63	803.10	11.67
Pulp, paper, paper products, printing and publishing	2871.63	2629.03	8.82	2622.43	2248.81	15.34	757.28	676.84	11.22	13573.04	12621.15	7.27
Coke, refined petroleum products, and nuclear fuel	2145.56	1744.47	20.62	2585.90	1909.37	30.10	988.85	717.53	31.80	14848.80	11557.35	24.93
Chemicals and chemical products	4208.49	4732.50	-11.72	4288.39	4754.40	-10.31	1596.14	1857.55	-15.14	22178.24	25515.08	-13.99
Rubber and plastics products	3617.16	3305.38	9.01	3081.70	2745.90	11.52	992.37	981.13	1.14	17918.59	16974.03	5.41
Other non-metallic mineral products	1522.20	1504.61	1.16	1529.61	1423.55	7.18	814.47	986.93	-19.15	8408.75	8961.36	-6.36
Basic metals	8424.36	7434.51	12.48	9585.01	8677.19	9.94	3671.87	3622.02	1.37	53564.24	52659.60	1.70
Fabricated metal products	1869.87	1835.93	1.83	1878.79	1724.52	8.56	526.05	532.53	-1.22	9814.79	10195.16	-3.80
Machinery and equipment	5978.14	7425.55	-21.60	7063.60	9197.61	-26.25	2365.73	3172.83	-29.14	33443.86	44484.21	-28.33
Computer, electronic, and optical equipment	8974.59	14050.36	-44.09	10602.68	16421.09	-43.06	1643.54	2282.74	-32.56	39420.07	62309.57	-45.00
Electrical machinery and apparatus, nec	2491.61	3016.30	-19.05	2601.83	3484.33	-29.00	498.81	631.64	-23.50	11839.03	15061.50	-23.96
Motor vehicles, trailers, and semi-trailers	8976.43	12091.87	-29.57	4170.38	5363.09	-25.02	467.78	558.49	-17.68	33829.47	45471.82	-29.36
Other transport equipment	706.53	1158.23	-48.45	274.75	322.55	-16.00	107.16	138.84	-25.76	7700.49	13667.49	-55.85
Manufacturing nec; recycling	1134.88	1179.79	-3.88	907.55	832.99	8.57	374.50	459.11	-20.30	5903.37	6600.54	-11.15
Total for industries	146663.27	147544.6	-0.60	130140.85	127910.9	1.73	37688.271	36909.42	2.09	718307.92	743034.1	-3.38

Appendix Table 2: Comparison of results for factor inputs embodied in world final demand between original and extended IO tables

	Employment (workers)			Capital (ten thousand yen)			Non-regular workers			University graduates		
	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)
Food products, beverages, and tobacco	27839.3	31713.4	-13.0	12243877.1	12705631.3	-3.7	10314.5	12300.7	-17.6	2657.1	2847.1	n-6.9
Textiles, textile products, leather, and footwear	39082.3	86888.4	-75.9	10040767.7	12475577.1	-21.6	5500.9	12790.5	-79.7	1612.2	3167.2	-65.1
Wood and products of wood and cork	26200.9	23245.0	12.0	4452343.9	3805758.5	15.7	1962.1	1740.8	12.0	1222.1	1082.5	12.1
Pulp, paper, paper products, printing and publishing	136120.4	127995.8	6.2	58589944.6	53876610.6	8.4	10337.2	9777.2	5.6	10638.0	9756.0	8.7
Coke, refined petroleum products, and nuclear fuel	4298.5	4444.5	-3.3	23645138.5	20646723.3	13.5	248.0	266.2	-7.1	429.5	428.2	0.3
Chemicals and chemical products	106276.7	124602.4	-15.9	166886058.0	173980238.7	-4.2	11832.8	14563.3	-20.7	24737.8	28748.4	-15.0
Rubber and plastics products	184628.6	192205.8	-4.0	113219509.6	101739002.0	10.7	29454.3	31614.5	-7.1	18154.8	18004.1	0.8
Other non-metallic mineral products	62354.8	75963.5	-19.7	71654593.9	53059076.8	29.8	6688.1	8290.4	-21.4	6599.1	6989.0	-5.7
Basic metals	201796.3	202107.9	-0.2	343407903.0	324511947.9	5.7	16383.7	16654.9	-1.6	23985.0	23865.4	0.5
Fabricated metal products	153832.1	162474.3	-5.5	41311061.7	39982753.3	3.3	13444.4	14303.3	-6.2	10768.2	10803.8	-0.3
Machinery and equipment	288545.2	469930.0	-47.8	121874954.9	150237387.8	-20.8	22870.8	36536.0	-46.0	43819.2	62902.0	-35.8
Computer, electronic, and optical equipment	379199.4	637789.7	-50.9	243629070.3	325148095.0	-28.7	30875.5	55529.4	-57.1	52986.6	82575.4	-43.7
Electrical machinery and apparatus, nec	115663.7	161575.4	-33.1	45273493.1	53492194.8	-16.6	17117.7	24679.5	-36.2	14974.8	20388.0	-30.6
Motor vehicles, trailers, and semi-trailers	390604.6	422554.0	-7.9	256181811.9	256333188.1	-0.1	43256.9	48039.2	-10.5	49495.1	53363.0	-7.5
Other transport equipment	87343.7	172015.2	-65.3	39783500.5	72814246.8	-58.7	2829.4	7455.6	-90.0	10615.5	17954.2	-51.4
Manufacturing nec; recycling	53880.6	61108.7	-12.6	15644723.1	13882821.8	11.9	6913.4	9273.9	-29.2	5872.0	6058.3	-3.1
Total for industries	7343644.5	7630072.1	-3.8	1567838751.9	1668691253.8	-6.2	230029.7	303815.2	-27.6	278566.9	348932.7	-22.4