Value Added Trade and Structure of China's High-technology Exports

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1. Introduction

Technological level of industry in a country is reflected in the structure of trade, especially in exports. It is obvious that as the technological level of industry goes up, the technology intensity of exports also rises, and simultaneously more sophisticated products are exported from the country, so that its export structure may approach that of more advanced economies.

The above relationship, however, becomes less straightforward, when we consider the reverse causality—that is, whether the country with a high share of high-technology exports holds strong technological capabilities. This proposition has become increasingly inscrutable, as many developing countries are engaged in vertical fragmentation of production (Lall 2000, Srholec 2006). For example, if a highly export-oriented economy, such as China, constitutes a part of production networks organized by multinational enterprises and is engaged in assembling of high-technology products with heavy dependence on imported inputs, the technology intensity of exports that is measured by trade statistics will be raised accordingly. But does it actually reflect the technological capabilities of the host country?

In recent years, many studies have been conducted to estimate the technological intensity of China's exports. The above fact, however, raises a serious concern about an appropriate measure. Trade statistics, which has been used to measure the technology intensity of exports, may not be appropriate, given the rapid progress of vertical fragmentation.

In this study, an alternative approach will be presented. Instead of export values, domestic content of exports will be used as a measure of the technological intensity of exports. Note that, in estimating the domestic content of exports, foreign content is separated from export values, so that only the value added that is produced by domestic factors of production is captured with the use of the measure. The Asian input-output tables (hereafter called the AIO tables) will be used to estimate the domestic content of exports. The AIO tables cover inter-industry transactions of nine East Asian economies plus the USA, and other economies are treated exogenously as the "Rest of the World (ROW)."[1]

Second, value added exports is also used as an alternative measure of the

[1] Nine East Asian economies covered in the AIO table are as follows: China, Japan, Korea, Taiwan, Singapore, Malaysia, the Philippines, Thailand, and Indonesia.

technological intensity of exports. Value added exports indicate the flow of value added between countries and is conceptually different from the domestic content of exports: The relationship between the three measures—gross exports, domestic content of exports, and value added exports—will be shown in a systematic manner with particular reference to the AIO tables.

Third, the indices of vertical specialization, which were originally developed by Hummels et al. (2001), will be applied to the AIO tables. These indices will provide invaluable information on how respective economies were involved in East Asian production networks and how they procured intermediate inputs that are used for exports.

The study focuses on the technological intensity of China's exports, but it also refers to the inter-industry linkages with neighboring countries, in particular Japan and Korea. Since Chinese industries, especially a high-technology industry, have shaped a close and complementary relationship with neighboring countries, it is critically important to examine the issue from a regional perspective.

The paper is organized as follows. Section 2 reviews previous empirical works on the export structure of China. Section 3 presents the methods of analysis. Section 4 discusses the results of analysis. Section 5 concludes.

2. Export structure of China

In this section, we first look at major characteristics of China's involvement in vertical production networks, which are then followed by the previous studies on the sophistication of China's exports.

(1) Triangular trade structure

China's rapid economic growth is closely related to its involvement in East Asian production networks. For example, it is shown clearly that China has emerged—replacing Southeast Asian economies—as a final manufacturing assembler in East Asia after its accession to the WTO in 2001. More specifically, China's role is most aptly expressed from the viewpoint of the triangular trade, whereby China imports intermediate inputs from neighboring East Asian economies, such as Japan and Korea, and then assemble them and export final products to the US and EU markets (kuroiwa and Kuwamori, 2011). In particular, such a triangular trade structure is prominent in electrical appliances, office and telecommunication equipment (Haddad 2007: Tong and Zheng 2008).

(2) Sophistication of exports

Another important characteristic of China is its rapid sophistication of the export structure. Sophistication of exports can be measured in a variety of ways. For example, Rodrik (2006) and Hausmann, et al. (2007) estimate the degree of export sophistication using PRODY and EXPY. PRODY is a weighted sum of the per capita GDP of the countries exporting a given product and, therefore, represents the income level associated with each of these products, whereas EXPY is the weighted sum of PRODY, where the weight is given by the share of each product in the country's total exports. Therefore, EXPY represents the income level associated with the country's overall export bundle. As a consequence, Rodrik (2006) shows that China has exported a wide range of highly sophisticated products, and its export bundle is similar to that of a country with an income per-capita level three times higher than China's (Rodrik 2006). Moreover, empirical studies conducted by Jarreau and Poncet (2009) reveal that the sophistication of exports has positively influenced the export and growth performance of Chinese provinces.

An alternative approach to measure export sophistication is to use a measure of export similarity developed by Finger and Kreinin (1979). Export similarity index (ESI) is defined by the formula, $ESI_{\mathrm{tcd}} = \sum_{\mathrm{p}} \min(S_{\mathrm{tpc}}, S_{\mathrm{tpd}})$, where S_{tpc} is the share of country c's exports in manufacturing product p in year t. ESI is a bilateral measure bound by zero and unity: ESI_{tcd}= 0 if countries c and d have no products in common in year t and ESI_{tcd}= 1 if their exports are distributed identically across products. Using FSI, Schott (2006) examines the relative sophistication of China' exports to the United States, and shows that China's export overlap with more developed (OECD) countries has increased dramatically over time, jumping from a rank of 21 among non-OECD U.S. trading partners in 1972 to a rank of 3 in 2001, just behind Mexico and Korea and ahead of Taiwan.

(3) Technological intensity of exports

The other group of scholars, on the other hand, criticized the rather optimistic conclusion regarding the upgrading of export composition in developing countries including China. Lall (2000), for example, investigates the technology structure and performance of developing country's manufactured exports, and notes that a significant part of the high-technology industry growth in developing countries might be "something of a statistical illusion", as they are specializing in labor intensive processes within technology-intensive activities. Srholec (2007), on the other hand, argues that specialization in high-technology exports can be mere reflection of high-technology component imports: his econometric analysis reveals that while domestic technological capabilities are associated with export performance in electronics—which occupies a dominant share of high-technology exports in developing countries—it is the propensity to import electronics components that accounts for the largest portion of cross-country differences in specialization in electronics exports. In a similar vein, Amiti and Freund (2010) examine the skill content of manufacturing exports in China. They find that although there has been a significant increase in the skill content of China's total manufacturing exports, it is mainly due to the increased imported inputs used for processing trade.

The above discussions reveal the necessity to separate the influences of imported inputs from those of domestic factor inputs. The following section introduces the method of input-output analysis that meets this requirement.

3. Methodology

In this section, a simple method of input-output analysis is presented for analyzing the technological structure of exports. First, gross exports are decomposed into several elements with focus on the relationship between gross exports, value added exports and domestic content of exports. Then, measures of the technological intensity of exports are introduced, with reference to the above three export measures. Finally, the indices of the vertical specialization are presented.

3.1 Decomposition of gross exports in the Asian input-output tables

The input-output analysis has been used frequently to estimate induced outputs, when final demand is given exogenously. In the analysis of domestic content of exports induced value added is estimated for given exports demand. Recently Koopman et al. (2012) developed a method of decomposition of gross exports for the global Inter-Country Input-Output (ICIO) tables. This paper, on the other hand, attempts to apply a similar method to input-output tables of a different format, namely the Asian input-output (AIO) tables. Note that a major difference between the global Inter-Country Input-Output (ICIO) tables and the Asian Input-Output (AIO) tables lies in the treatment of the "imports from the Rest of the World (ROW)" and the "exports to the Rest of the World (ROW)": these two trade-related transactions are treated endogenously in the ICIO tables, while they are treated exogenously in the AIO tables.

First, from the equality of demand and supply of outputs, it holds that

$$x^r = A^{r1}x^1 + A^{r2}x^2 \dots A^{rG}x^G + f^{r1} + f^{r2} \dots + f^{rG} + r^r \qquad \text{for } r = 1,2,\dots G \qquad (1)$$

where x^r is a country r's $n \times 1$ vector of output (n and G are respectively a number of industrial sectors and endogenous countries in the AIO tables): A^{rs} is a $n \times n$ matrix which indicates the flows of intermediate inputs provided by country r to country s: f^{rs} is a $n \times 1$ vector of final goods provided by country r to country s: and r^r is a country r's $n \times 1$ vector of exports to the Rest of the World (ROW). Note that, unlike the ICIO tables which were used by Koopman et al. (2012), the AIO tables cover transactions (both intermediate inputs and final goods) between the nine Asian countries plus the USA only, so that Country r's exports to the ROW are summed up and included in a single exports to the ROW vector, r^r. Next, Eq. (1) can be rewritten, in a matrix form, as

$$\begin{bmatrix} x^1 \\ \vdots \\ x^G \end{bmatrix} = \begin{bmatrix} A^{11} & \cdots & A^{1G} \\ \vdots & \ddots & \vdots \\ A^{G1} & \cdots & A^{GG} \end{bmatrix} \begin{bmatrix} x^1 \\ \vdots \\ x^G \end{bmatrix} + \begin{bmatrix} f^{11} + f^{12} \dots + f^{1G} + r^1 \\ \vdots \\ f^{G1} + f^{G2} \dots + f^{GG} + r^G \end{bmatrix} \quad (2)$$

Solving Equation (2) for x yields

$$\begin{bmatrix} x^1 \\ \vdots \\ x^G \end{bmatrix} = \begin{bmatrix} I - A^{11} & \cdots & -A^{1G} \\ \vdots & \ddots & \vdots \\ -A^{G1} & \cdots & I - A^{GG} \end{bmatrix}^{-1} \begin{bmatrix} f^{11} + f^{12} \dots + f^{1G} + r^1 \\ \vdots \\ f^{G1} + f^{G2} \dots + f^{GG} + r^G \end{bmatrix}$$

$$= \begin{bmatrix} B^{11} & \cdots & B^{1G} \\ \vdots & \ddots & \vdots \\ B^{G1} & \cdots & B^{GG} \end{bmatrix} \begin{bmatrix} \sum_{s=1}^{G} f^{1s} + r^1 \\ \vdots \\ \sum_{s=1}^{G} f^{Gs} + r^G \end{bmatrix} \quad (3)$$

where B^{rs} is a $n \times n$ sub-matrix of the Leontief inverse matrix. Then value added in country r $(= va^r)$ that is induced by the final demand vector is obtained by pre-multiplying Eq. (3) by a value added coefficient matrix.

$$\begin{bmatrix} va^1 \\ \vdots \\ va^G \end{bmatrix} = \begin{bmatrix} \hat{V}^1 & \cdots & O \\ \vdots & \ddots & \vdots \\ O & \cdots & \hat{V}^G \end{bmatrix} \begin{bmatrix} B^{11} & \cdots & B^{1G} \\ \vdots & \ddots & \vdots \\ B^{G1} & \cdots & B^{GG} \end{bmatrix} \begin{bmatrix} \sum_{s=1}^{G} f^{1s} + r^1 \\ \vdots \\ \sum_{s=1}^{G} f^{Gs} + r^G \end{bmatrix}$$

$$= \begin{bmatrix} \sum_{r=1}^{G} \hat{V}^1 B^{1r} (\sum_{s=1}^{G} f^{rs} + r^r) \\ \vdots \\ \sum_{r=1}^{G} \hat{V}^G B^{Gr} (\sum_{s=1}^{G} f^{rs} + r^r) \end{bmatrix} \qquad (4)$$

where $\hat{V}^r$ is a country r's $n \times n$ diagonal matrix of value added coefficients (value added coefficients are ratios of value added relative to total output). From Eq. (4) total value-added exports from country s to country r can be calculated as

$$vt^{sr} = u' \widehat{V}^S \sum_{g=1}^{G} B^{sg} f^{gr}$$

$$= v^{s\prime} \sum_{g=1}^{G} B^{sg} f^{gr} \qquad (5)$$

where vt^{sr} represents the value added produced in source country s but absorbed (or consumed as final products) in destination country r, and u' is a 1 x n row vector consisting of all ones. Note that Eq. (5) is conceptually equivalent to the "value added (VA) exports" defined by Johnson and Noguera (2012). By summing over the destination countries, country s' value added exports to the world are given by

$$vt^{s*} = u' \widehat{V}^{s} \sum_{g=1}^{G} B^{sg} \left(\sum_{r \neq s}^{G} f^{gr} + r^{g}\right)$$

$$= v^{s\prime} \sum_{g=1}^{G} B^{sg} \left(\sum_{r \neq s}^{G} f^{gr} + r^{g}\right) \qquad (6)$$

Note that, unlike Koopman et al. (2012), Eq. (6) includes r^{g}, which indicates country r' value added exports to the ROW.

From the relationship between the value added coefficient matrix, the imports from the ROW matrix, and the Leontief inverse matrix, it holds that [2]

$$\sum_{r=1}^{G} u'(\widehat{V}^{r} + \widehat{M}^{r})B^{rs} = \sum_{r=1}^{G} (v^{r\prime} + m^{r\prime})B^{rs} = u' \qquad (7)$$

where $\widehat{M}^{r}$ is an import coefficient matrix that indicates the flows of intermediate inputs provided by the ROW to country r. On the other hand, country s'exports to the world by industrial sector can be calculated as

[2] The first term in the LHS of Eq. (7) indicates how much value added and imports from the ROW are induced, when one unit of final demand is given to all sectors in country *s.* Since final demand induces not only value added in endogenous countries but also imports from the ROW, the sum of value added and imports from the ROW always equals one unit as indicated by Eq. (7).

$$e^{s*} = \sum_{r\neq s}^{G} e^{sr} = \sum_{r\neq s}^{G}(A^{sr}x^{r} + f^{sr}) + r^{s} \qquad (8)$$

Note that $A^{sr}x^{r}$ and f^{sr} respectively represent exports of intermediate inputs and final goods from country *s* to country *r*. Inserting Eq. (7) into Eq. (8), country *s*' gross exports can be calculated as

$$u'e^{s*} = \sum_{r=1}^{G}(v^{r\prime} + m^{r\prime})B^{rs}e^{s*}$$

$$= (v^{s\prime} + m^{s\prime})B^{ss}e^{s*} + (v^{r\prime} + m^{r\prime})\sum_{r\neq s}^{G} B^{rs}e^{s*} \qquad (9)$$

Rearranging Eq. (6) and Eq. (8), the first term of Eq. (9) can be expressed as

$$(v^{s\prime} + m^{s\prime})B^{ss}e^{s*} = vt^{s*} + m^{s\prime}\sum_{g=1}^{G} B^{sg}\left(\sum_{r\neq s}^{G} f^{gr} + r^{g}\right) + (v^{s\prime} + m^{s\prime})B^{ss}\left[\sum_{r\neq s}^{G}(A^{sr}X^{r} + f^{sr}) + r^{s}\right] - (v^{s\prime} + m^{s\prime})\sum_{g=1}^{G} B^{sg}\left(\sum_{r\neq s}^{G} f^{gr} + r^{g}\right) \qquad (10)$$

Since $x^{s} = \sum_{r=1}^{G}(A^{sr}x^{r} + f^{sr}) + r^{s}$ and simultaneously $x^{s} = \sum_{g=1}^{G} B^{sg}\left(\sum_{r=1}^{G} f^{gr} + r^{g}\right)$ (see Eq. (2) and (3)), the third and fourth terms of Eq. (10) are rewritten as

$z^s = (v^{s\prime} + m^{s\prime})[B^{ss}(x^s - A^{ss}x^s - f^{ss}) - (x^s - \sum_{g=1}^{G} B^{sg} f^{gs})]$

$= (v^{s\prime} + m^{s\prime})\{[B^{ss}(I - A^{ss}) - I]x^s + \left(\sum_{g=1}^{G} B^{sg} f^{gs} - B^{ss} f^{ss}\right)\}$ (11)

Then, substituting $B^{ss}(I - A^{ss}) - I$ in Eq.(11) by $\sum_{r\neq s}^{G} B^{sr} A^{rs}$, [3] we get

$z^s = (v^{s\prime} + m^{s\prime})[\sum_{r\neq s}^{G} B^{sr} (A^{rs} x^s + f^{rs})]$ (12)

Inserting Eq. (12) into Eq. (9) and Eq.(10) yields

$u' e^{s*} = vt^{s*} + m^{s\prime} \sum_{g=1}^{G} B^{sg} (\sum_{r\neq s}^{G} f^{gr} + r^g) + (v^{s\prime} + m^{s\prime})[\sum_{r\neq s}^{G} B^{sr} (A^{rs} x^s + f^{rs})]$

$+ (v^{r\prime} + m^{r\prime}) \sum_{r\neq s}^{G} B^{rs} e^{s*}$

$= vt^{s*} + v^{s\prime} (\sum_{r\neq s}^{G} B^{sr} e^{rs}) + v^{r\prime} \sum_{r\neq s}^{G} B^{rs} e^{s*}$

$+ m^{s\prime} \sum_{g=1}^{G} B^{sg} (\sum_{r\neq s}^{G} f^{gr} + r^g) + m^{s\prime} (\sum_{r\neq s}^{G} B^{sr} e^{rs}) + m^{r\prime} \sum_{r\neq s}^{G} B^{rs} e^{s*}$ (13)

In Eq. (13), the gross exports of source country s are now decomposed into four elements,

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[3] From Eq. (3), it holds that

$$\begin{bmatrix} B^{11} & \cdots & B^{1G} \\ \vdots & \ddots & \vdots \\ B^{G1} & \cdots & B^{GG} \end{bmatrix} \begin{bmatrix} I - A^{11} & \cdots & -A^{1G} \\ \vdots & \ddots & \vdots \\ -A^{G1} & \cdots & I - A^{GG} \end{bmatrix} = \begin{bmatrix} I & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & I \end{bmatrix}$$

Thus, we obtain $B^{ss}(I - A^{ss}) - I = \sum_{r\neq s}^{G} B^{sr} A^{rs}$.

namely (i) value added exports, which are produced in source country s and absorbed outside the source country (=$vt^{s*} = v^{s\prime} \sum_{g=1}^{G} B^{sg} \left(\sum_{r \neq s}^{G} f^{gr} + r^{g}\right)$), (ii) re-imports, which are initially exported but eventually returned and absorbed in the source country ($= v^{s\prime} \left(\sum_{r \neq s}^{G} B^{sr} e^{rs}\right)$); (iii) foreign content, which is generated in the endogenous countries other than the source country and embodied (as imported inputs) in the source country's exports (=$v^{r\prime} \sum_{r \neq s}^{G} B^{rs} e^{s*}$), and (iv) imports from the ROW, which are induced by the source country's exports ($= m^{s\prime} \sum_{g=1}^{G} B^{sg} \left(\sum_{r \neq s}^{G} f^{gr} + r^{g}\right) + m^{s\prime} \left(\sum_{r \neq s}^{G} B^{sr} e^{rs}\right) + m^{r\prime} \sum_{r \neq s}^{G} B^{rs} e^{s*}$).

Note that Eq. (13) corresponds to Eq. (34) in Koopman et al. (2012), but the former is more complicated than the latter, because it includes the terms relevant to (iv) imports from the ROW.[4]

3.2 Measures of the technological intensity of exports

As discussed in the previous section, the decomposition of gross exports demonstrates the following relationship:

Gross exports= (i) value added exports + (ii) re-imports + (iii) foreign content

[4] It is shown that gross exports are finally decomposed into nine elements in Koopman et al. (2012). In our method of decomposition, using the AIO tables, gross exports are further decomposed into 18 elements.

+ (iv) imports from the ROW (14)

In Eq. (14), both (iii) foreign content and (iv) imports from the ROW represent the value added that is generated outside the exporting country. Thus they should be separated from export values in examining the technology intensity of exports: note that only the value added that is generated by domestic factors of production should be included in the measure.

In this regard, (i) value added exports should be included in the measure, because it represents the factor content that is embodied in exports and actually traded between countries. (ii) Re-imports are more nuanced. The re-imports contain the factor content that is initially exported but eventually returned and consumed in the exporting country. Therefore, its factor content is not actually traded (if we follow the definition of value added trade), although it is still a part of the domestic value added that is generated by the exports. Thus, if we include the re-imports as a part of the domestic content (DC) of exports, DC contains both (i) the value added exports and (ii) the re-imports.

Note that the above treatment is in line with the previous empirical studies on the Heckscher-Ohlin model. Since Leontief (1953) used a single country input-output table to measure the factor content of US trade, many studies have been conducted to test the Heckscher-Ohlin theorem with the use of input-output tables: further, in recent years, Trefler and Zhu (2010) used an international input-output table to estimate the (Vanek-consistent) factor content of trade. These studies focus on the factor content of trade (such as labor and capital inputs embodied in trade), because international trade is viewed as indirect or disguised means of trading factor inputs embodied in trade. Since value added is obtained by multiplying factor inputs by factor rewards, these studies implicitly calculated the value added content of trade.

Originally, the technological intensity of exports was measured by the share of high-technology industry in exports. Now, there are two additional measures: one is the share of high-technology industry in value added exports, and the other is the corresponding share in domestic content (DC) of exports.[5]

3.3 The indices of vertical specialization

[5] However, it is shown by Koopman et al. (2012) that a pure double-counted portion is included in the intermediate transactions of the re-imports. Thus, the domestic value added that is actually induced by exports (DV) is less than domestic content (DC) of exports. The author calculated the DVs for China, Japan, and Korea, and found that a pure double counted portion is very small, so that it does not affect in any significant manner the export structure of the countries. The author, therefore, decides to use only the value added (VA) exports and DC of exports as a measure of the technology intensity of exports. The other reason for using DC (not DV) is that DC is methodologically consistent with the VS and VS1 indices that do not exclude a pure double-counted portion in their formulas.

The indices of vertical specialization are instrumental in demonstrating how a country is engaged in vertical production networks. There are two kinds of vertical specialization indices—VS and VS1—which were originally proposed by Hummels el al. (2001). The VS index indicates foreign content (embodied as imported inputs) of exports, and is given by

$$VS^s = \sum_{t \neq s}^{G} v^t B^{ts} e^{s*} = \sum_{t \neq s}^{G} \sum_{r \neq s}^{G} v^t B^{ts} \left[\left(A^{sr} x^r + f^{sr} \right) + r^s \right] \qquad (15)$$

On the other hand, the VS1 index represents the domestic content of exports that are used as imported inputs by other countries to produce their exports, and is given by

$$VS1^s = v^s \sum_{r \neq s}^{G} B^{sr} e^{r*} = v^s \sum_{r \neq s}^{G} \sum_{t \neq r}^{G} B^{sr} \left[\left(A^{rt} x^t + f^{rt} \right) + r^r \right] \qquad (16)$$

Note that, given the characteristics of these two indices, VS and VS1 are instrumental in obtaining insight for a country's position in the vertical production networks. Since a country located in a downstream depends very much on imported inputs to be used for its exports, it tends to have a high ratio of VS relative to gross exports (VS/EX). A country in an upstream, on the other hand, exports a large amount of intermediate inputs that are used by other countries to produce their exports, so that it tends to have a high ratio of VS1 relative to gross exports (VS1/EX).

4. Results of Empirical Analysis

In this section, we first look at major characteristics of East Asian production networks with particular focus on China, Japan, and Korea. Then China' technology structure of exports is examined in greater detail.

4.1 China's position in East Asian production networks

Figure 1 shows the result of the decomposition of gross exports for China, Japan, and Korea. As shown in Eq. (13) and (14), gross exports are fully decomposed into four elements, namely value added exports, re-imports, foreign content, and imports from the ROW. Figure 1 shows that shares of value added exports continued to fall in all the three countries, while those of import content—i.e. foreign content and imports from the ROW—moved in the opposite direction. The increase in the share of import content obviously reflects deepening integration and fragmentation of production in East Asia. In particular, following Korea, China increased sharply foreign content, as well as imports from the ROW, in the subsequent periods. As a result, China's share of value added exports became significantly lower than that of Japan in 2005.

[Figure 1]

The other important finding is that the shares of re-imports were generally low except in Japan. This is due to the fact that Japanese firms actively invested in East Asian countries and re-imported their products back to home, while such a linkage was relatively weak in other countries.

Figure 2 reveals the relative positions of the three countries in East Asian production networks. As discussed in the previous section, countries located in a downstream tend to have a high VS/EX ratio, while those in an upstream have a high VS1/EX ratio. In 1990, China had a relatively low VS/EX and VS1/EX ratio, but it has rapidly shifted downstream in the subsequent period (as reflected by a rising VS/EX ratio). Japan, on the other hand, was located in an upstream, and has been increasingly so during the observed period (although it has increased a VS/EX ratio simultaneously). Korea was located in a downstream, but it has rapidly moved upstream: this parallel shift with Japan occurred because a large amount of intermediate inputs were exported from Korea to China, where Korean firms invested intensively after China's accession to the WTO.

[Figure2]

Figures 3-1, 3-2, and 3-3 reveal a share of East Asian economies in the VS and VS1 indices. Figure 3-1 indicates that a share of Japan in China's VS index (i.e. foreign content) exceeded 40 percent in 1990, while that of China's VS1 index exceeded 30 percent. These facts imply that Japan used to have a close inter-industry linkage with China—particularly as a supplier of inputs that are assembled in China for exports—although it declined gradually in the subsequent period. On the other hand, Korea and Taiwan steadily increased their VS and VS1 shares. It should also be pointed out that in 1990 Southeast Asia had a very high VS1 share (51 percent) for China, but it was replaced by Korea and Taiwan after that.

[Figure 3-1]

[Figure 3-2]

[Figure 3-3]

Figure 3-2 indicates that in 1990 Japan was heavily dependent on the USA for the VS index (55 percent). But it was gradually replaced by China. The VS1 index also indicates a declining trend of the USA, while Southeast Asia and China respectively increased their VS1 shares in the 1990s and in the 2000s. It should also be noted that shares of Korea and Taiwan plummeted in the 1990s but have remained considerably high.

Figure, 3-3 indicates that in 1990 Southeast Asia had a very high share of the VS index (55 percent) for Korea, but its VS share declined sharply. On the other hand, VS shares of Japan and China increased remarkably. As for the VS1 index, Japan, Southeast Asia, and the USA decreased their shares, while China has become a very important channel of Korea's intermediate exports that are relevant toVS1.

4.2 Technology structure of exports

Table 1 shows the composition of exports by technological level. The technological classification of exports is based on Lall (2000), and all the original input-output industry classification in the AIO tables was converted into Lall's classification.[6] As

[6] Lall (2000) developed his original method of categorizing products by technology. The major categories of products are (i) high-technology manufactures (electronics and electrical products, and other high technology); (ii) medium-technology manufactures (automotive products, medium technology process industries, and medium technology engineering industries); (iii) low-technology manufactures (textile/fashion cluster, and

discussed in Section 2, the export structure of China continued to be upgraded and a share of the high-technology sector in China's exports, finally exceeded that of Japan in 2005. However, when measured with value added exports or domestic content of exports, the structure changes drastically: in particular a share of the high-technology industry shrinks very sharply (e.g. 9.8 percent and 9.9 percent as against 29.5 percent in 2005). Obviously, this is due to heavy dependence of the high-technology industry on imported inputs (i.e. foreign content and imports from the ROW), as will be discussed later. These facts suggest the possibility of overestimation of China's technological intensity of exports. Furthermore, it is shown that a high percentage (e.g. 90 percent in 2005) of China's high-technology exports comes from the electronics and electrical sector. This implies that the electronics and electrical sector is a major source of the overestimation.[7] It should, however, be added that despite a serious concern over the overestimation, China's true technological intensity of exports—in terms of domestic content of exports, for example—has improved considerably from 4.9 percent to 9.8 percent during 1990-2005. This may reflect China's own efforts for upgrading export

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other low technology); (iv) primary products; (v) resource-based manufactures (agro/forest-based products, and other resource-based products.

[7] Likewise, the shares of electronics and electrical products in high-technology exports in Japan and Korea were high at 87.5 percent and 95 percent respectively. Note that the electronics and electrical sector has the most advanced and extensive production networks in East Asia. Thus, it is natural that this sector contains a large amount of import content.

structure, as well as the spillover effects arising from its involvement in production networks.

[Table 1]

Japan reached its peak of a high-technology export share in earlier years and has continued to decrease its share, with the largest portion of exports being held by medium-technology industry (note that automotive, which is a major export product for Japan, is included in the medium-technology category). It is also important to note that, when measured with value added exports or domestic content of exports, the service sector becomes far the largest exporting sector of Japan: shares of the service sector are respectively 48.3 percent and 48.2 percent in 2005. This implies that a large amount of services were indirectly or disguisedly exported (embodied in exported goods). Korea, on the other hand, continued to increase its share of high-technology exports, and came to have the greatest share among the three countries, in terms of both export values as well as value added exports and domestic content of exports. Simultaneously, like Japan, Korea continued to increase its share of medium-technology exports.

Focusing on China, Table 2 documents the decomposition of China's exports by technological level. The upper half of the table reveals the decomposition of the exports. What is striking is that high-technology exports contained less domestic content than medium- and low-technology exports (e.g. 75 percent as against 85 percent and 85 percent in 2005): that is, high-technology exports had higher dependency on import content. Furthermore, the dependency on foreign content as well as imports from the ROW continued to increase: foreign content of the high-technology exports, for example, increased from 7 percent to 16 percent during 1990-2005.

[Table2]

The lower half of Table 2 demonstrates, in descending order, the decomposition of foreign content by country-industry combination, which is contained in China's exports. The table clearly indicates that Japanese goods and services comprised important content of China's exports, regardless of technological level of export products. In particular, China's high-technology exports required substantial amount of Japanese services and high-technology industry content. Also, it is important to note that in 1990 US industries were the second most important source of foreign content (after Japan) for China's exports. In the subsequent periods, however, Korea and Taiwan industries came to play a more important role, so that their content was increasingly contained in China's exports.

5. Conclusion

The study shows that production networks involving China and its neighboring economies have strengthened and deepened during the observed period. In particular, high-technology industry, which is largely dominated by the electronics and electrical sector, contains substantial amount of import content provided by neighboring countries.

Countries in production networks are placed in different positions according to their endowments and comparative advantages. In East Asia, China has rapidly moved downstream in its production network. This may reflect the fact that China has become increasingly dependent on its upstream economies for the procurement of intermediate inputs. Japan, on the other hand, was located upstream, and has become increasingly so, as neighboring economies, including China, have shifted downstream. Korea is in a unique position: Korea used to be located downstream, but it has moved upward and become an important supplier of intermediate inputs.

Next, the analysis of value added exports indicates that China's technological intensity of exports has been significantly overestimated due to its high dependency on import content, especially in high–technology exports. Furthermore, a greater portion of import content of China's exports comes from relevant industries in neighboring countries. In the case of high-technology exports, the Japanese service and high-technology industries were leading suppliers of import content, followed by similar industries in Korea, Taiwan, and the USA.

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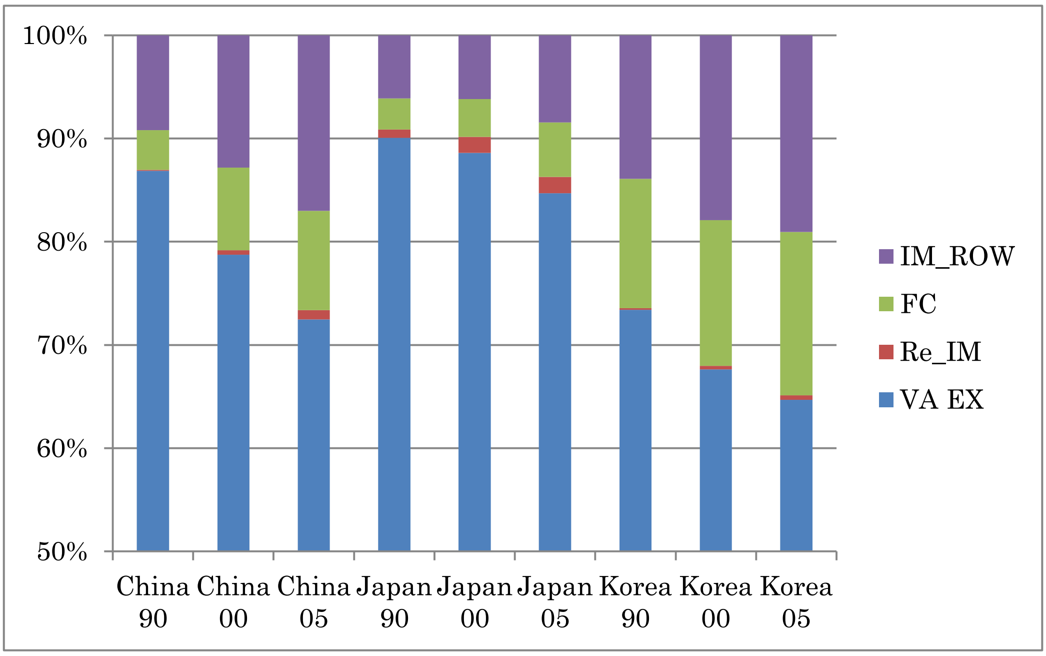
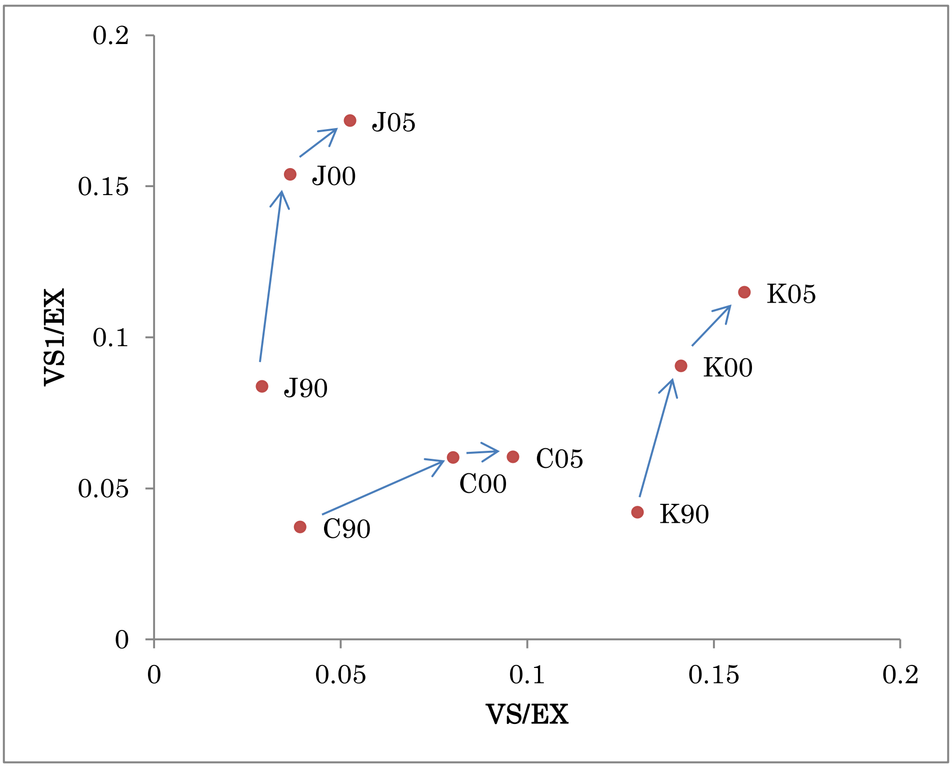
Figure 1. Decomposition of gross exports



1) VA EX: value added exports, Re-IM: re-imports, FC: foreign content,
IM_ROW: imports from the Rest of the World

Source: Asian International Input-Output Tables, 1990, 2000, and 2005 (IDE-JETRO)

Figure 2. VS/EX and VS1/EX



Source: Asian International Input-Output Tables, 1990, 2000, and 2005 (IDE-JETRO)

Figure 3-1. VS and VS1 shares (China)

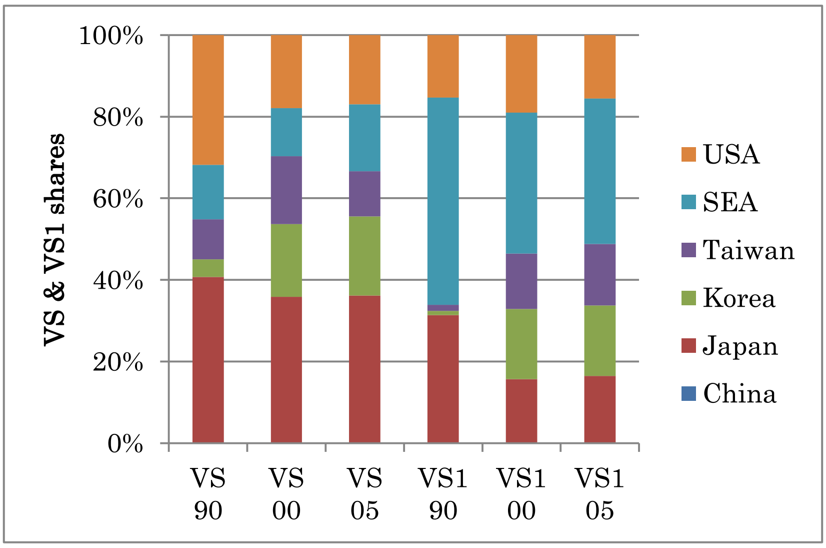


Figure 3-2. VS and VS1 shares (Japan)

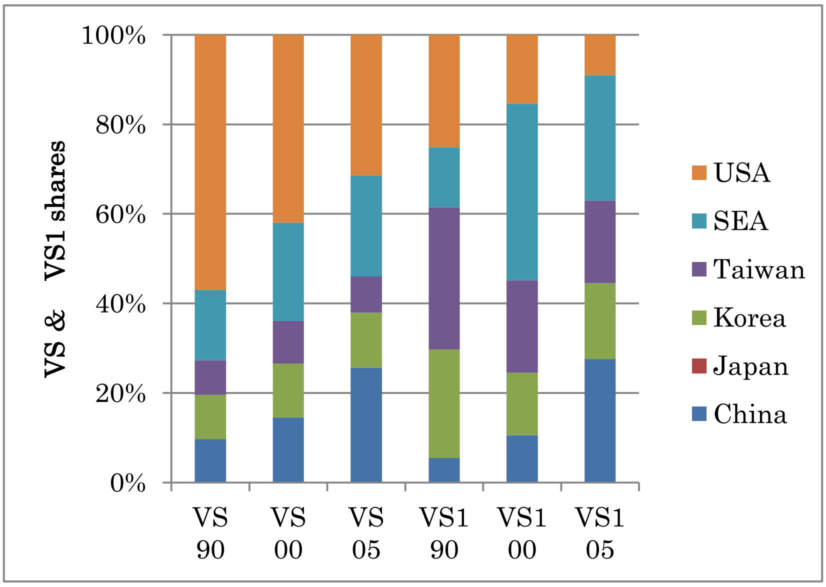
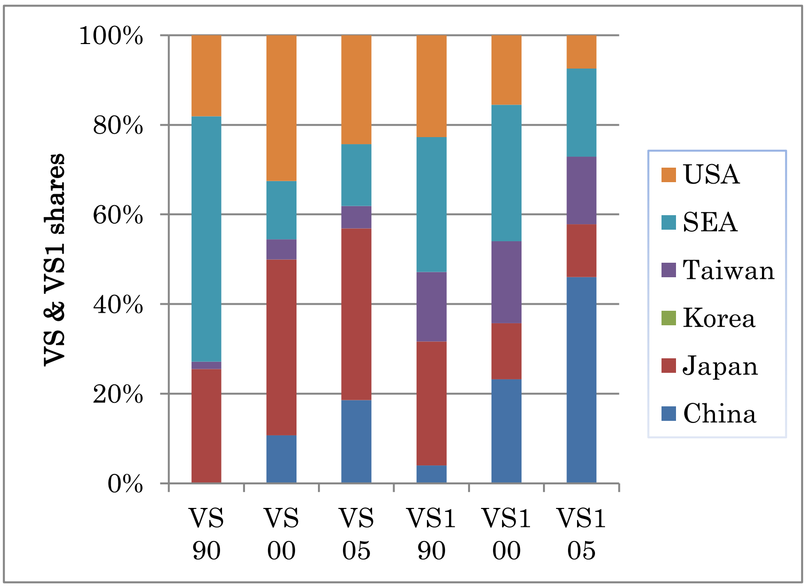


Figure 3-3. VS and VS1 shares (Korea)



1) Southeast Asian (SEA) comprises of Singapore, Malaysia, Thailand, the Philippines, and Indonesia.

Source: Asian International Input-Output Tables, 1990, 2000, and 2005 (IDE-JETRO)

Table1. Composition of exports by technological level (1990, 2000, 2005)

1990	China			Japan			Korea		
	EX	VA EX	DC	EX	VA EX	DC	EX	VA EX	DC
High Tech*	11.9	4.9	4.9	25.1	14.5	14.5	19.6	10.2	10.2
Medium Tech	11.0	12.8	12.8	37.3	25.8	25.7	13.9	14.1	14.1
Low Tech	26.2	15.7	15.7	8.3	9.2	9.3	24.0	15.5	15.5
Primary products	11.6	29.0	29.0	0.2	1.6	1.6	1.5	6.8	6.8
Resource based	37.5	24.8	24.8	11.8	12.7	12.7	22.6	18.4	18.4
Service	1.8	12.7	12.7	17.4	36.3	36.2	18.4	35.0	35.0

2000	China			Japan			Korea		
	EX	VA EX	DC	EX	VA EX	DC	EX	VA EX	DC
High Tech*	18.3	8.6	8.6	25.3	14.2	14.4	29.4	14.6	14.7
Medium Tech	20.1	15.7	15.7	44.3	26.8	26.7	26.4	18.4	18.4
Low Tech	34.4	21.6	21.6	7.7	9.5	9.6	16.9	14.3	14.3
Primary products	3.2	15.8	15.8	0.2	1.0	1.0	0.4	3.5	3.5
Resource based	9.9	10.8	10.8	3.2	5.0	5.0	8.4	8.9	8.9
Service	14	27.4	27.4	19.4	43.3	43.2	18.6	40.4	40.3

2005	China			Japan			Korea		
	EX	VA EX	DC	EX	VA EX	DC	EX	VA EX	DC
High Tech*	29.5	9.8	9.9	19.5	10.5	10.6	31.0	15.3	15.3
Medium Tech	19.3	15.1	15.1	45.3	25.3	25.2	34.6	22.1	22.0
Low Tech	25.8	18.6	18.6	8.2	10.0	10.1	12.5	13.4	13.4
Primary products	2.0	14.3	14.3	0.1	0.9	0.9	0.2	2.6	2.6
Resource based	9.3	10.3	10.3	3.6	5.0	5.0	8.0	8.8	8.8
Service	14.1	31.8	31.8	23.2	48.3	48.2	13.7	37.9	37.9

1: Technological classification is based on Lall (2000).

Source: Asian International Input-Output Tables, 1990, 2000, and 2005 (IDE-JETRO)

Table 2.Decomposition of China's exports by technological level

1990	High-tech		Medium-tech		Low-tech
Exports	7,289(100)	Exports	8,434(100)	Exports	22,343(100)
DC	5,456 (75)	DC	7,206 (85)	DC	19,085 (85)
FC	527 (7)	FC	440 (5)	FC	866 (4)
IM_ROW	1,306 (18)	IM_ROW	788 (9)	IM_ROW	2,392 (11)
J-S	97	J-M	70	J-L	124
J-H	88	U-M	61	U-S	99
J-M	56	J-S	55	J-S	97
J-L	44	U-S	48	J-M	69
U-S	34	J-L	45	U-M	63
J-R	32	T-M	18	U-P	62
U-H	25	J-R	17	T-M	39
U-M	24	U-R	13	J-R	35
K-H	12	U-P	12	U-L	30
T-M	11	U-L	11	U-R	29

2000	High-tech		Medium-tech		Low-tech
Exports	54,951(100)	Exports	60,325 (100)	Exports	103,486(100)
DC	36,237 (66)	DC	47,389 (79)	DC	83,180 (80)
FC	7,814 (14)	FC	5,040 (8)	FC	7,666 (7)
IM_ROW	10,901 (20)	IM_ROW	7,896 (13)	IM_ROW	12,640 (12)
J-S	986	J-S	755	J-S	1,095
J-H	767	J-M	628	J-L	833
U-S	650	T-S	367	T-S	651
U-H	641	U-S	355	K-L	591
T-S	525	J-L	354	J-M	535
K-H	480	K-M	262	K-S	461
J-M	451	K-S	257	U-S	442
T-H	413	U-M	255	T-L	439
K-S	351	T-M	210	K-M	277
J-L	247	K-L	190	T-M	226

2005	High-tech		Medium-tech		Low-tech
Exports	261,327(100)	Exports	171,059(100)	Exports	227,958(100)
DC	159,404 (61)	DC	125,126 (73)	DC	173,471 (76)
FC	41,667 (16)	FC	16,338 (10)	FC	17,015 (7)
IM_ROW	60,256 (23)	IM_ROW	29,595 (17)	IM_ROW	37,472 (16)
J-S	6,637	J-S	2,749	J-S	3,002
J-H	4,130	J-M	1,679	J-L	1,923
K-H	3,444	U-S	1,339	K-L	1,268
U-S	3,208	K-S	1,177	U-S	1,252
K-S	2,648	K-M	953	T-S	1,232
U-H	2,307	U-M	933	K-S	1,137
J-M	1,966	J-L	866	J-M	1,007
T-H	1,640	T-S	848	T-L	642
T-S	1,608	K-L	553	U-L	523
M-S	1,406	T-M	489	K-M	446

1: Technological classification is based on Lall (2000).

2. The letters in the lower half of the table indicates a country-industry combination. J-S, for example, indicates service (S) industry of Japan (J). H, M, L, P, R, and S respectively indicate high-, medium-, and low-technology industry, primary industry, resource based industry, and services industry.

Source: Asian International Input-Output Tables, 1990, 2000, and 2005 (IDE-JETRO)