Measuring the degree of integration into the global production network by the decomposition of gross output and imports: A cross-country study, 1995-2015

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Abstract

Import content of exports (ICE), suggested in mid-2000s, has been frequently used in empirical studies to measure the degree of integration into the global production network. Kim (2020) suggested an alternative indicator based on the decomposition of aggregate gross output and total imports into the contributions of individual final demand terms, using input-output analysis. His indicator reflects the strategy with which a country manages the domestic production base and utilizes the global production network simultaneously, while ICE only considers the latter. For this reason, Kim (2020) claimed that the indicator is a more comprehensive indicator than ICE.

The purpose of this paper is to apply the method suggested by Kim (2020) to six major exporting countries, China, Germany, Japan, Korea, United Kingdom and United States, for 1995-2015 using OECD's Input-Output tables. The results show that these countries' overall degree of integration into the global production network increased during the period. Korea and China exhibited the strongest degree of integration into the global production network.

Keywords: Integration into global economy, Decomposition of gross output and imports, Import content of exports, Input-output analysis, Cross-country study

JEL Classification: D57, F13, F14

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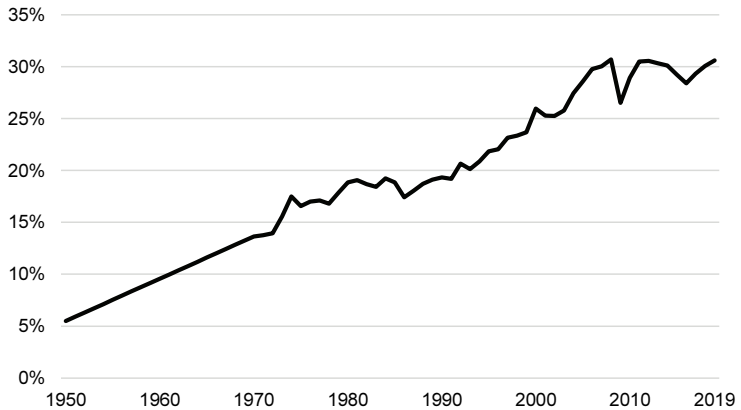
1 Introduction

The past seven decades have witnessed a consistent increasing trend of international trade which could be confirmed from almost every indicator. The world exports of goods and services as percent of GDP, for example, is given in Figure 1, which reveals an almost linear trend. Maddison (2001) reported that it was only 5.5% in 1950, which jumped to 30.6% in 2019. Most authors agree that this trend is due to the dramatic decrease in transportation cost by such factors as weakened protectionism, decrease in physical transportation cost, containerization, etc. (Weil, 2013).

Figure 1. World exports (% of GDP)



Source: Maddison (2001, p.363) and World Bank.
Note: World exports as percent of GDP in 1950 was obtained from Maddison (2001), and those from 1970 from World Bank, and those between 1950 and 1970 were computed by linear interpolation.

Considering the fact that exports are a part of final demand for a national economy, the trend in the world economy could be wrongly interpreted as 'the increase in the share of final demand consumed in foreign countries.' This interpretation is incorrect because a big portion of exported products are consumed as intermediate input, i.e., raw material, in foreign countries. This portion is classified as final demand from the viewpoint of the exporting country, but not from the viewpoint of the world economy.

In fact, the increase in international trade is due to the increase in the trade of intermediate goods as well as of final goods. The dramatic decrease in transportation cost caused a structural change in the global production network in such a way that production processes of products are 'fragmented' and the fragmented processes are allocated among different countries according to comparative advantage system. Nowadays, allocating R&D activity, production of raw material, processed raw material, parts and components and modules, assembly and packaging, and customer service in different countries has become a norm. This implies that firms, and even countries, need to manage domestic production lines and to utilize global production network at the same time. This phenomenon has been named variously depending on the context; such as international fragmentation of production, vertical specialization, integration of global production network, etc.

Import content of exports (ICE) is one of the indicators for measuring the degree of a country's integration into the global production network. ICE is defined as the amount of imported intermediate input embodied in one unit of export. ICE is an intuitive indicator since it is likely that as a country is more integrated into the global production network, it will use more imported raw material than before. ICE has been extensively used in measuring the degree of countries' integration into the global production network since it was suggested in the 2000s. Also, OECD publishes the import content of individual products and of total exports of its member countries and some non-member countries.

While an intuitive measure, ICE can be misleading in some situations. When the final assembly and packaging of a product is done in a foreign country, for example, the export of this product is not counted in exports, and thus not in computing ICE. Also, the ICEs of some major players in the global production network are computed significantly lower than anticipated.

Kim (2020) suggested that more comprehensive measures be used in addition to ICE. Specifically, he suggested that we need to observe the way a country manages its domestic production base and utilizes global production network simultaneously. For this reason, he suggested to use the decompositions of gross output and total imports into the contributions of the components of final demand, based on demand-side input-output (IO) analysis. He computed these measures of Korea for

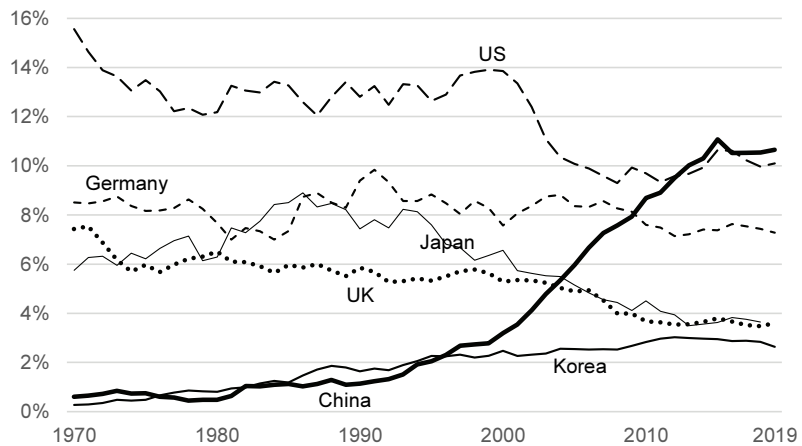
1970-2018. The purpose of this paper is to apply the method of Kim (2020) to six major exporting countries, China, Germany, Japan, Korea, United Kingdom (UK) and United States (US), for 1995-2015 using OECD's Input-Output Database (IO-DB).

The paper is organized as follows. Section 2 provides a brief background and literature review, and section 3 explains the methodology and the data. The result of the paper is given in section 4, and section 5 concludes the paper.

2 Background and Literature Review

We will review the performance of the six countries in terms of various measures related with their integration into the global production network. The major six exporting countries' shares in the world export market since 1970 are depicted in Figure 2. US has ranked the top in the world market until it was surpassed by China in 2013. China's world market share was similar to Korea's until mid-1990s, but began rising steeply in early 1990s. It took only two decades for China to rank the top in the world export market since its rapid economic growth began. China's share peaked at 11.1% in 2015, and has stayed around 10.5% since then.

Figure 2. World market shares of six major exporting countries

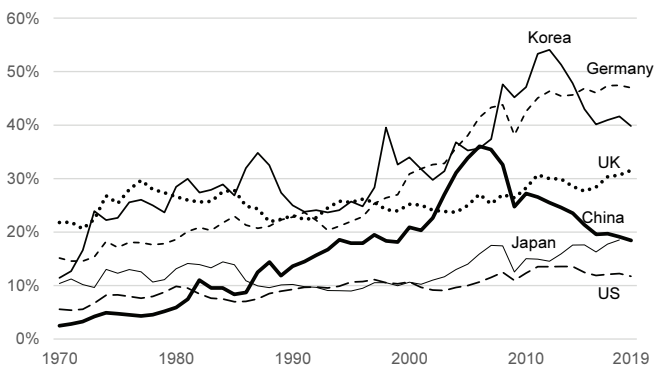


Source: World Bank.

Germany has been one of the steady top exporters, with its world market share around 8%. UK has occupied a steady share, but in a gentle decreasing trend with around 6% in 1970s and 1980s but around 4% in the last decade. Japan once occupied a big share in the world export market, over 8%, in 1980s and 1990s, but has joined UK since early 2000s. Finally, Korea's share has showed a consistent increasing trend. Its world market share was 0.3% in 1970, but increased to 3.0% in 2011 and stayed around 2.8% afterwards. These six countries explain 35~40% of the world export market during the entire period.

Exports of goods and services as percent of GDP can be understood as the extent to which a country utilizes the foreign sector in generating value-added, and thus can be regarded as an elementary measure of integration into the global production network. Exports as percent of GDP of the six countries are given in Figure 3. First, we observe a big variation in the shares of exports as percent of GDP among countries. In 2012, for example, the share of Korea was 54.1% while that of US was only 13.5%. Second, the variation increases over time. The difference between the largest and the smallest shares in 1970 was 19.3%, which increased to 29.4% in 2019. Third, exports as percent of GDP do not seem to have correlation with the world market shares. The correlation coefficient between these two measures was 0.08 in 1970 and -0.43 in 2018.

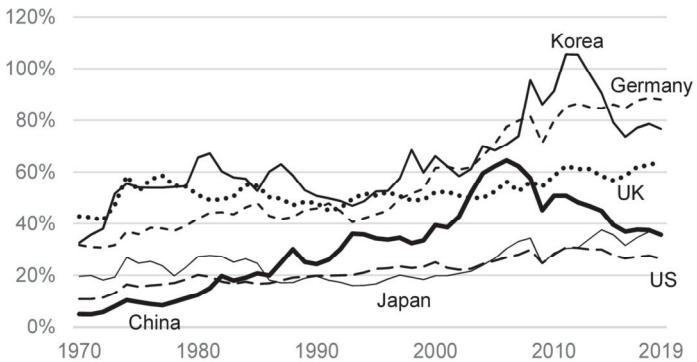
Figure 3. Exports of six major exporting countries (% of GDP)



Source: World Bank.

Figure 4 depicts the exports and imports of goods and services as percent of GDP. This is a frequently used measure of openness of a country. Note that Figure 3 and Figure 4 show a highly similar pattern. This might be because exports and imports have strong positive correlation. Figure 4 shows that Korea and Germany have maintained high levels of imports and exports as percent of GDP while US and Japan have maintained low levels. China and UK are between the two groups. China's share kept increasing until mid-2000s, but entered a decreasing trend afterwards.

Figure 4. Sum of exports and imports of six major exporting countries
(% of GDP)



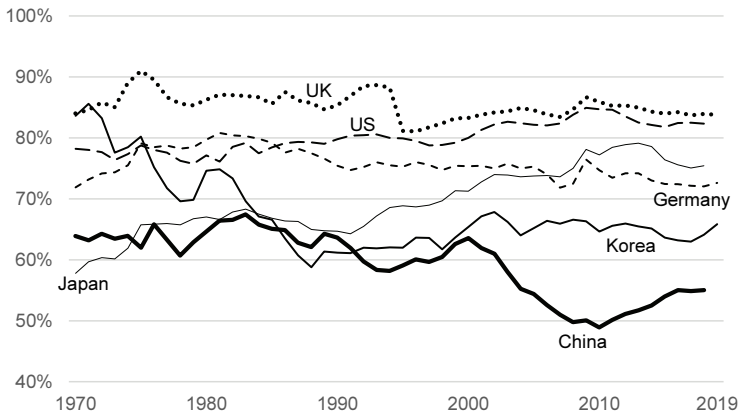
Source: World Bank.

We also need to review the consumption and investment patterns along with exports and imports since they, along with exports, constitute the total final demand, hence they might give clue to understanding the degree of integrating into the global production network. Figure 5 and Figure 6 imply that western countries show relatively high levels of consumption and low levels of investment compared to China and Korea. Japan's share joined those of the western countries in recent years.

China's share of consumption in GDP showed a gentle decreasing trend in the 1980s and 1990s, but the trend turned steep in the 2000s. This trend stopped at around 2010, and then entered an increasing trend. On the other hand, China has shown a surprising investment record. China's investment rate was only 24.1% in 1970, but it increased almost at a linear trend until late 2000s. It peaked at 43.9% in 2010, and has been stagnant

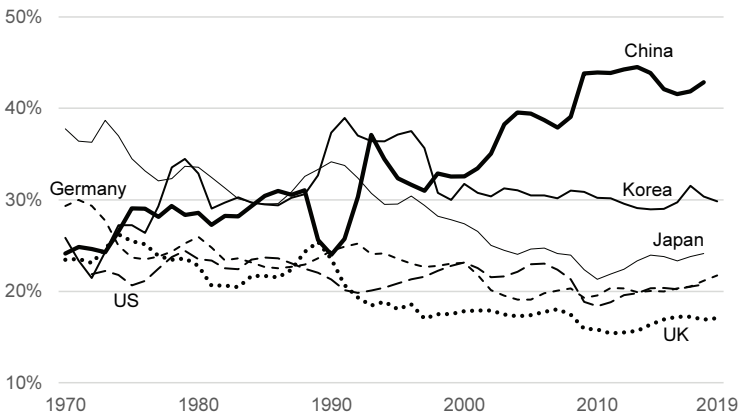
since 2010s. Japan's shares of consumption and investment as percent of GDP have gradually increased and decreased, respectively, during the entire period.

Figure 5. Final consumption expenditure of six major exporting countries (% of GDP)



Source: World Bank.

Figure 6. Gross fixed capital formation of six major exporting countries (% of GDP)



Source: World Bank.

It can be said that the above six countries took best advantage of the

global production network in their economic growth. Nevertheless, it is not easy to measure the degree of integration into the global production network of these countries using a single indicator. For instance, indicators based on a few traditional macroeconomic aggregate variables such as shares of exports, imports, consumption or investment as percent of GDP, provide partial implications about the issue, but not a comprehensive picture of a country's integration into the global production network.

In fact, ideal indicators might incorporate 'imported intermediate input' since it is at the core of the increase in international trade and of the expansion of the global production network in the past two to three decades. At the same time, ideal indicators might utilize IO analysis because inter-industry relationships must be considered properly in order to incorporate imported intermediate input. ICE is an example of such indicators; ICE incorporates imported intermediate input, and is computed by IO analysis. The measures suggested in the next section also incorporate imported intermediate input, and are computed by IO analysis.

The rest of this section provides a brief literature review, which is based on the corresponding section in Kim (2020). Woo et al. (2003) evaluated Korea's trade performance of selected sectors using various trade statistics and indicators for the period 1992-2000. This study, however, was not focused on the integration into the global production network. Kim (2004) applied a more sophisticated method to Korea. His study was motivated by the diminishing impact of exports on GDP. He applied demand-side IO analysis to compute the amount of GDP embodied in one unit of export, and showed that it began decreasing since 1990s. Export is a part of a country's final demand, so its increase equals the sum of increases in GDP and imports. According to IO analysis, this result implies that export consists of domestic and foreign value-added embodied in it, or, alternatively, domestic and foreign intermediate input embodied in it. These two components can be alternatively named 'domestic value-added content of export (DVCE)' and 'import content of export (ICE),' respectively. The finding of Kim (2004) implies, therefore, that ICE of Korea increased since early 1990s.

It was Hummels et al. (2001) who used ICE as a degree of integration into the global production network. They also interpreted it as a measure of vertical specialization. Loschky and Ritter conducted a similar research

published by OECD in 2006. They showed that while Germany's exports of goods and services increased rapidly in mid-2000s (See Figure 3.), the share of imported raw material embodied in exports also increased rapidly. They called this share as ICE, and they computed its values of Germany in mid-2000s. As just mentioned above, the measures by Kim (2004) and Loschky and Ritter (2006) add up to one.

Backer and Yamano (2008) explained various indicators of globalization that can be computed using input-output tables such as import penetration, export share, ratio of imported intermediate inputs to domestic intermediate inputs, offshoring indicators, ICE, etc., and computed most of these indicators using OECD's IO-DB.

Breda et al. (2009) interpreted ICE as an indicator of 'internationalization,' similar to vertical specialization. They computed the import content of individual products and of total exports of European countries in 1995 and 2000, and showed that the degree of internalization increased in many countries. OECD has published the import content at product level and of total exports as a part of their IO-DB. The ICE data by OECD is available since 2005, and included in their 2018 Edition of IO-DB.

Kim (2020) computed the import content of individual products and of total exports of Korea over a long period, 1970-2018 by using Korea's IO tables. For this purpose, he rearranged Korea's IO tables according to a common product/sector classification in such a way that analysis at sectoral level is possible over the entire period, and, furthermore, that analysis at aggregate level maintains time-series continuity. Using IO tables with common product/sector classification is useful because import content of total exports depends on product/sector classification. Finally, Kim (2020) suggested that the degree of integration into the global production network be measured in a more comprehensive manner by simultaneously considering the decompositions of gross output and total imports into the contribution of individual final demand terms. He claimed that these measures represent the way a country manages the domestic production base and utilizes the global production network simultaneously.

3 Methodology and Data

As mentioned earlier, this paper will apply the method by Kim (2020) to the data of six major exporting countries, and this section is an excerpt of the corresponding section in Kim (2020), to which readers are referred for detailed explanation.

Let n be the number of products/sectors in an economy, and let $\mathbf{x}$, $\mathbf{y}$ and $\mathbf{m}$ be $n \times 1$ gross output, value-added and import vectors, respectively, $\mathbf{u}^d$ and $\mathbf{u}^m$ be domestic and imported intermediate demand vectors, respectively, $\mathbf{f}^d$ and $\mathbf{f}^m$ be $n \times 1$ domestic and imported final demand vectors, respectively, $\mathbf{A}^d$ and $\mathbf{A}^m$ be $n \times n$ domestic and imported input coefficient matrices, respectively, and $\mathbf{A}^y$ be the $n \times n$ diagonal value-added ratio matrix. We can show that $\mathbf{u}^d = \mathbf{A}^d\mathbf{x}$ and $\mathbf{u}^m = \mathbf{A}^m\mathbf{x}$. Market equilibrium in the domestic product markets is represented by $\mathbf{x} = \mathbf{u}^d + \mathbf{f}^d = \mathbf{A}^d\mathbf{x} + \mathbf{f}^d$. Upon solving this for the gross output vector, we get equation (1) which shows that the final demand for domestic products, $\mathbf{f}^d$, determines the amounts of productions in individual sectors, $\mathbf{x}$.

$$\mathbf{x} = (\mathbf{I} - \mathbf{A}^d)^{-1}\mathbf{f}^d \tag{1}$$

Similarly, $\mathbf{m} = \mathbf{u}^m + \mathbf{f}^m = \mathbf{A}^m\mathbf{x} + \mathbf{f}^m$ is the market equilibrium condition for imported product markets, which becomes $\mathbf{m} = \mathbf{A}^m(\mathbf{I} - \mathbf{A}^d)^{-1}\mathbf{f}^d + \mathbf{f}^m$ by substituting $\mathbf{x}$ with (1). Finally, we can show that $\mathbf{y} = \mathbf{A}^y\mathbf{x} = \mathbf{A}^y(\mathbf{I} - \mathbf{A}^d)^{-1}\mathbf{f}^d$, in which we used (1) in the last equality. In summary, we get (2) below, which explains how final demand determines the supply-side variables, i.e., gross output, value-added and import at sectoral and aggregate levels.

$$\begin{cases} \mathbf{x} = \mathbf{R}^x\ \mathbf{f}^d \\ \mathbf{m} = \mathbf{R}^m\,\mathbf{f}^d + \mathbf{f}^m \\ \mathbf{y} = \mathbf{R}^y\ \mathbf{f}^d \end{cases} \quad \text{where} \quad \begin{cases} \mathbf{R}^x = \quad (\mathbf{I} - \mathbf{A}^d)^{-1} \\ \mathbf{R}^m = \mathbf{A}^m\,(\mathbf{I} - \mathbf{A}^d)^{-1}. \\ \mathbf{R}^y = \mathbf{A}^y\ (\mathbf{I} - \mathbf{A}^d)^{-1} \end{cases} \tag{2}$$

Let $\mathbf{ex}$ be the $n \times 1$ exports vector. Since export is a part of domestic final demand $\mathbf{f}^d$, we can use the second equation in (2) to compute its impact on imports, which becomes $\mathbf{R}^m\mathbf{f}^d$. ICE is defined as the import content in one unit of export, so it is computed as the ratio of total import induced by export to total import, as equation (3) below where $\mathbf{o}$ is the $n \times 1$ sum vector.

$$\text{ICE} = \frac{\mathbf{o}'\mathbf{R}^m\mathbf{ex}}{\mathbf{o}'\mathbf{ex}} = \frac{\mathbf{o}'\mathbf{A}^m(\mathbf{I}-\mathbf{A}^d)^{-1}\mathbf{ex}}{\mathbf{o}'\mathbf{ex}}. \quad (3)$$

This is the measure of integration into the global production network, degree of internationalization, and the measure of vertical specialization suggested by Hummels et al. (2001), Loschky and Ritter (2006), Breda et al. (2009) and published by OECD in the IO-DB. ICEs at product/sectoral level can be computed by $\mathbf{o}'\mathbf{R}^m$. We can compute the import content of domestic consumption and investment by replacing $\mathbf{ex}$ with domestic consumption and investment vectors, respectively. These three measures, i.e., the import contents of domestic consumption and investment and export, are not identical because they have different compositions of products and because individual products have different import contents.

We can compute the amount of value-added generated by export by replacing $\mathbf{R}^m$ in (3) with $\mathbf{R}^y$. The result is interpreted as the domestic value-added content of export (DVCE), which is the indicator used in Kim (2004).

$$\text{DVCE} = \frac{\mathbf{o}'\mathbf{R}^y\mathbf{ex}}{\mathbf{o}'\mathbf{ex}} = \frac{\mathbf{o}'\mathbf{A}^y(\mathbf{I}-\mathbf{A}^d)^{-1}\mathbf{ex}}{\mathbf{o}'\mathbf{ex}}. \quad (4)$$

As mentioned earlier, DVCE and ICE represent domestic and foreign value-added content of export, respectively. We can show that DVCE + ICE = 1, which is rooted on the national income identity in macroeconomics.

We now explain the procedure suggested by Kim (2020). Let $\mathbf{c}^d$ and $\mathbf{c}^m$ be $n \times 1$ domestic and imported consumption vectors, respectively, and $\mathbf{i}^d$ and $\mathbf{i}^m$ be $n \times 1$ domestic and imported investment vectors, respectively. Then we have

$$\mathbf{f}^d = \mathbf{c}^d + \mathbf{i}^d + \mathbf{ex}\,, \qquad \mathbf{f}^m = \mathbf{c}^m + \mathbf{i}^m\,. \tag{5}$$

Substitute (5) into the first two equations in (2), respectively, we obtain

$$\mathbf{x} = \mathbf{R}^x\mathbf{c}^d + \mathbf{R}^x\mathbf{i}^d + \mathbf{R}^x\mathbf{ex}, \qquad \mathbf{m} = \mathbf{R}^m\mathbf{c}^d + \mathbf{R}^m\mathbf{i}^d + \mathbf{R}^m\mathbf{ex} + \mathbf{c}^m + \mathbf{i}^m. \tag{6}$$

The terms on the right-hand sides are the contributions of individual final demand terms, thus equation (6) decomposes gross output and import into the contributions of individual final demand terms. For example, the second term on the right-hand side of the first equation is the contribution of domestic investment on gross output.

Equation (6) provides the decomposition of gross output and import at product/sector level, and we can derive the decompositions at aggregate level by pre-multiplying the sum vector and divide both sides by the left-hand sides as follows;

$$1 = \frac{\mathbf{o}'\mathbf{R}^x\mathbf{c}^d}{\mathbf{o}'\mathbf{x}} + \frac{\mathbf{o}'\mathbf{R}^x\mathbf{i}^d}{\mathbf{o}'\mathbf{x}} + \frac{\mathbf{o}'\mathbf{R}^x\mathbf{ex}}{\mathbf{o}'\mathbf{x}}, \qquad 1 = \frac{\mathbf{o}'\mathbf{R}^m\mathbf{c}^d}{\mathbf{o}'\mathbf{m}} + \frac{\mathbf{o}'\mathbf{R}^m\mathbf{i}^d}{\mathbf{o}'\mathbf{m}} + \frac{\mathbf{o}'\mathbf{R}^m\mathbf{ex}}{\mathbf{o}'\mathbf{m}} + \frac{\mathbf{o}'\mathbf{c}^m}{\mathbf{o}'\mathbf{m}} + \frac{\mathbf{o}'\mathbf{i}^m}{\mathbf{o}'\mathbf{m}}. \tag{7}$$

The two equations in (7) represent the decompositions of aggregate gross output and import into the contributions of domestic and imported consumption and investment, and export. Keeping track of the changes in these compositions, we can figure out the directions in which a country manages its domestic production base and utilizes global production network in satisfying the final demand of the economy.

Two Editions of OECD IO-DB were used in this study. The 2016 Edition includes the IO tables of 64 countries in 1995~2011, and the 2018 Edition includes the IO tables of 64 countries in 2005~2015. We can compute the above-mentioned measures in 1995~2015 using these two Editions. However, these two Editions were produced according to different product/sector classification systems. The 2016 Edition was produced according to ISIC (International Standard Industry Classification)

Revision 3 with 34 sectors, while the 2018 Edition was produced according to ISIC Revision 4 with 36 sectors. The difference in industry classification makes it difficult to use the measures computed from the two Editions together. Furthermore, it is also possible that the two Editions employed different procedures and data handling methods in various components of the IO tables.

Unlike in Kim (2020), we did not convert the IO tables in the two Editions according to a common sector classification not only because it is not the fundamental solution but also because we are not interested in the analysis at product/sector level but at aggregate level. Instead, an ad-hoc procedure was used in this paper. We computed the above measures using the 2016 Edition for 1995~2005 and the 2018 Edition for 2005~2015 separately, and adjusted the first series in such a way that the two series coincide at 2015. We determined that the discrepancies between the values of the measures at 2015, about 2%p at the most, were acceptable. Even though this procedure is not justifiable, we can still use the time-series trends during 1995~2005.

We also obtained several aggregate macroeconomic variables, such as consumption, investment, export and import, etc. from World Bank's Databank.

4 Results

We already reviewed the two simple measures of 'openness' in Section 2, exports and the sum of exports and imports as percent of GDP. We observed that these two measures show increasing trend of international trade. We also learned that the statistics imply an increasing integration of global production network and vertical specialization in the global economy.

In addition, there has been a significant change in the composition of exports and imports of products. Figure 7 depicts the composition of exports of the six major exporting countries. The most prominent change in the composition of exports during 1995~2015 is the expanding shares of heavy industry products of China and Korea, from 47.7% to 71.5% and 62.0% to 79.6%, respectively, while those of Germany and Japan did not

change much and those in UK and US decreased significantly.

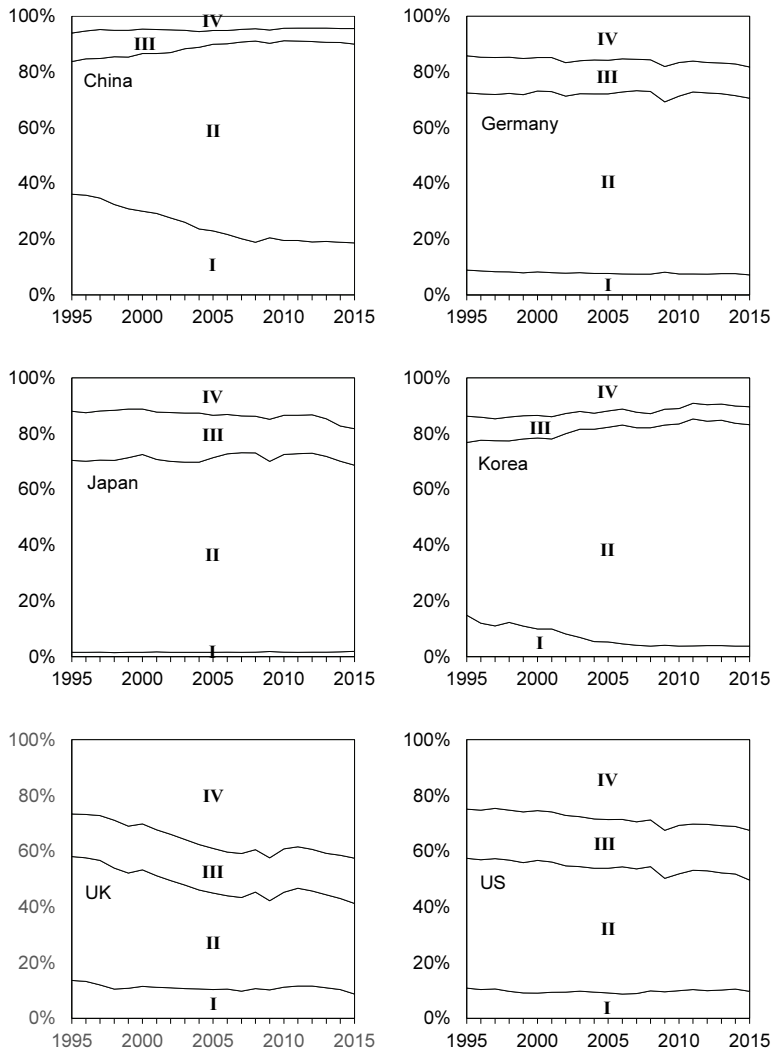
The difference in the magnitude of and the change in the share of business service exports are striking. The shares of business service exports of UK and US are much bigger than those of the other four countries and have increased significantly, while those of China and Korea are much smaller and even are decreasing. Considering that business service, in particular, professional service, enhances the competitiveness of manufactured products and is a high value-added sector, improving the comparative advantage of the business sector might be necessary for China and Korea in their growth strategy. These two groups of countries also show a significant difference in the share of traditional service exports.

Compositions of imports of the six countries during the same period are given in Figure 8. We observe that the changes in the compositions of imports and the variation among countries are significantly smaller than those of exports. In particular, the compositions of imports of these countries have been relatively stable, compared to those of exports. The share of the first product group of most countries increased until early 2000s and then declined afterwards, this was mostly due to the changes in the international crude oil prices. See Figure 9.

As mentioned in Section 2, the share of imported intermediate input in total imports might be an important measure of internationalization. According to Figure 10, there is a big variation in the shares among countries. Korea, China and Japan ranked the first, second and third almost during the entire period, respectively, which implies that these countries heavily depended on imported raw material in meeting the final demands. We observe an inverted U shape in the shares of all countries, in particular in the second half of the period, in which the trends of international raw material prices and the international financial crisis in 2008 might have played an important role.

Import contents of exports during 1995~2015 are given in Figure 11. We observe a long-term upward trend in ICE, which can be interpreted as the growing degree of internationalization. According to Figure 11, Korea's ICE was the highest during the entire period, and those of other countries are concentrated in a band with width of about 0.1. International raw material prices and the international financial crisis seem to also have been influential in ICE.

Figure 7. Composition of exports by product group



Source: OECD.

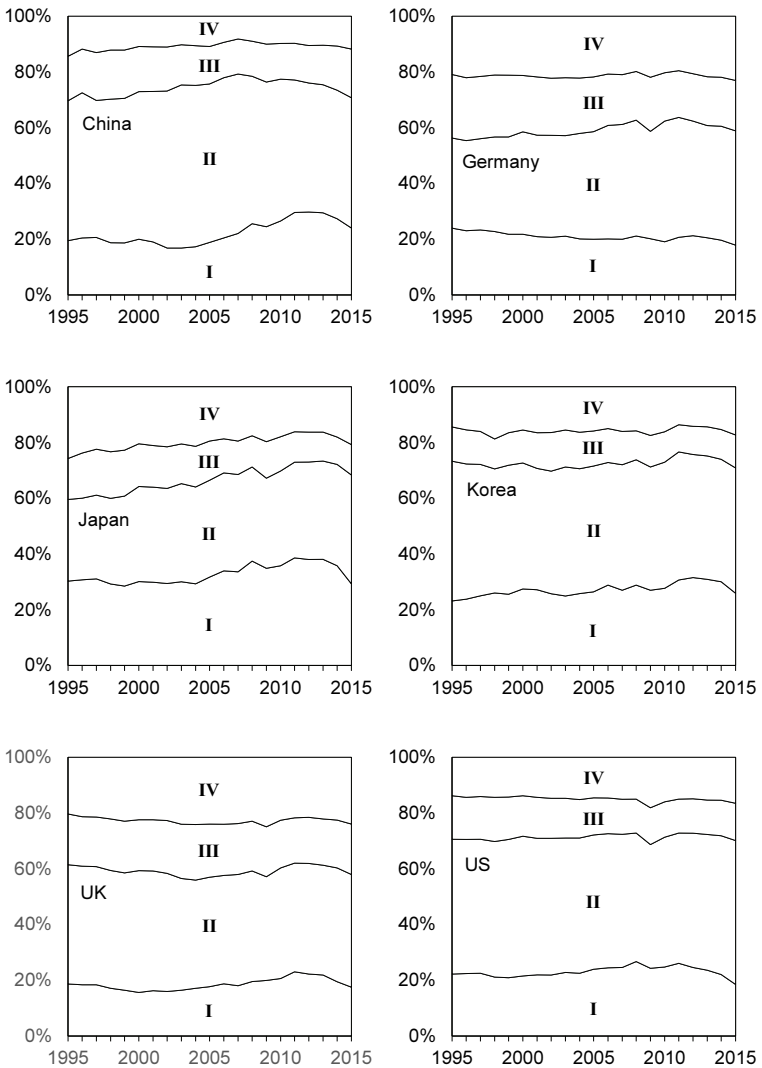
Note: I = agriculture and light industry: agriculture, forestry and fishery, mining, food and beverage, textile and apparel, and wood and paper products

II = heavy industry: coal and petroleum products, chemical products, basic metals, metal products, machinery, electrical and electronic products, transport equipment, and miscellaneous manufactured products

III = traditional service: utility, construction, wholesale and retail, accommodation and food service, public administration, education, and health service

IV = business service: transport and storage, communication, financial service, real estate, professional service and other business service

Figure 8. Composition of imports by product group



Source: OECD.

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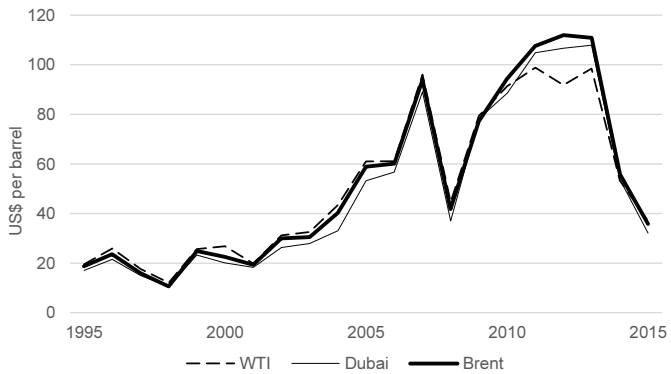
III = traditional service: utility, construction, wholesale and retail, accommodation and food service, public administration, education, and health service

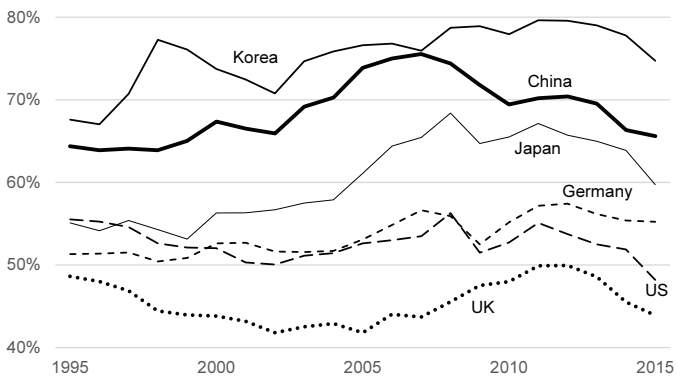
IV = business service: transport and storage, communication, financial service, real estate, professional service and other business service

Figure 9. International crude oil price



Source: Bank of Korea.

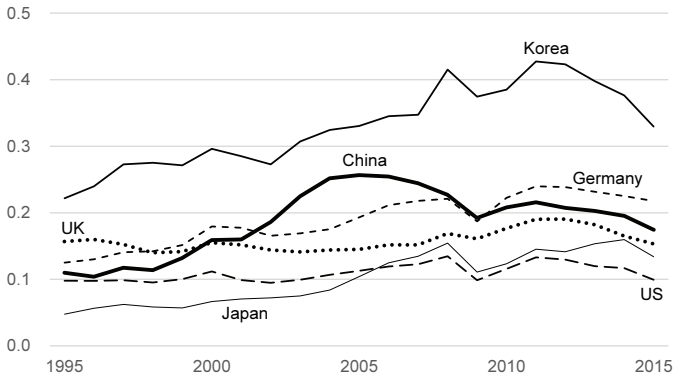
Figure 10. Share of intermediate input in six major exporting countries (% of total imports)



Source: OECD.

As in Kim (2020), we computed the import contents of consumption of domestic products (ICC^d) and of investment of domestic products (ICI^d) in addition to ICE, as given in Figure12. First, note that the inequality ICE > ICI^d > ICC^d holds for all countries during the entire period except a few years for China. As explained in Section 2, these three import contents are not identical because they have different compositions of products and because individual products have different import contents. Specifically, the shares of products with high import contents are high in export and low in the consumption of domestically produced products. Second, the

Figure 11. Import content of exports (ICE) in six major exporting countries



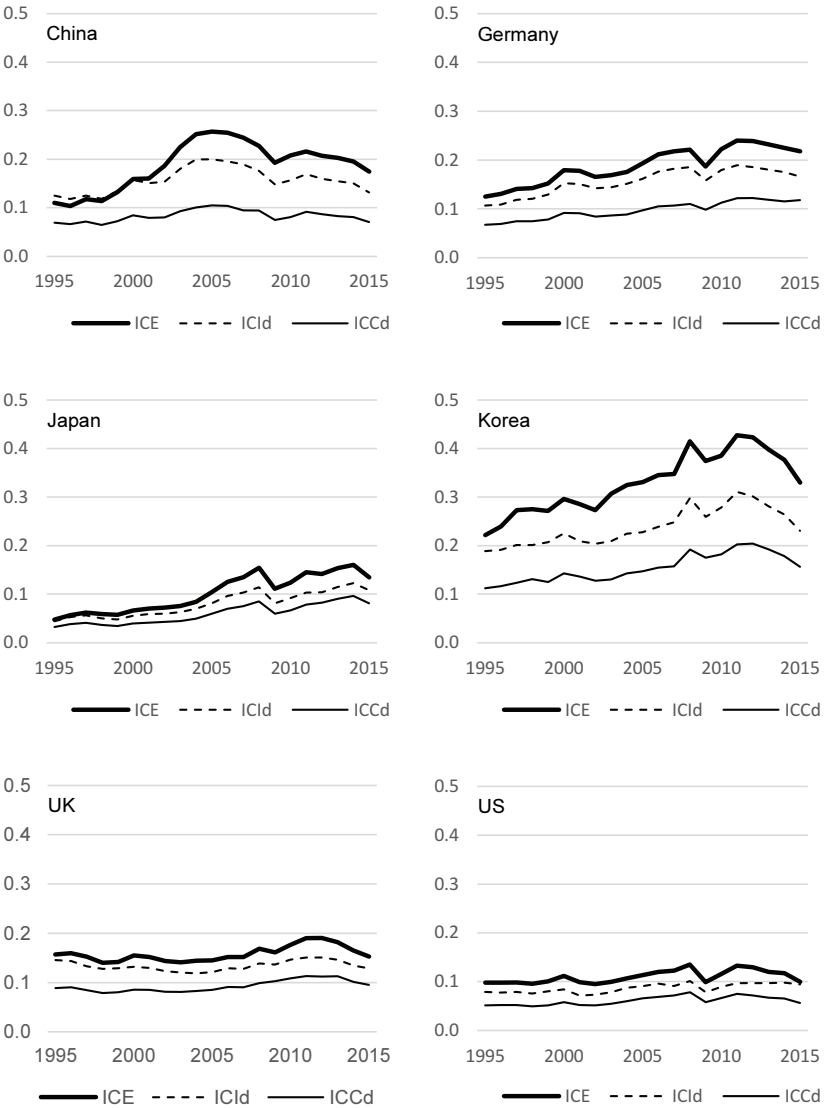
Source: OECD.

difference among ICE, ICI^{d} and ICC^{d} is considerably big in Korea compared to those in other countries. This signifies that the impact of export on GDP is relatively small compared to the other countries. This also signifies that Korea's exports are concentrated in a few items with high import contents. Third, these three indices show a common gentle increasing trend.

Finally, we computed the decompositions of aggregate gross output and imports of the six countries into the contributions of consumption, investment and export, using the equation (7). The results are given in Figures 13 and 14, respectively.

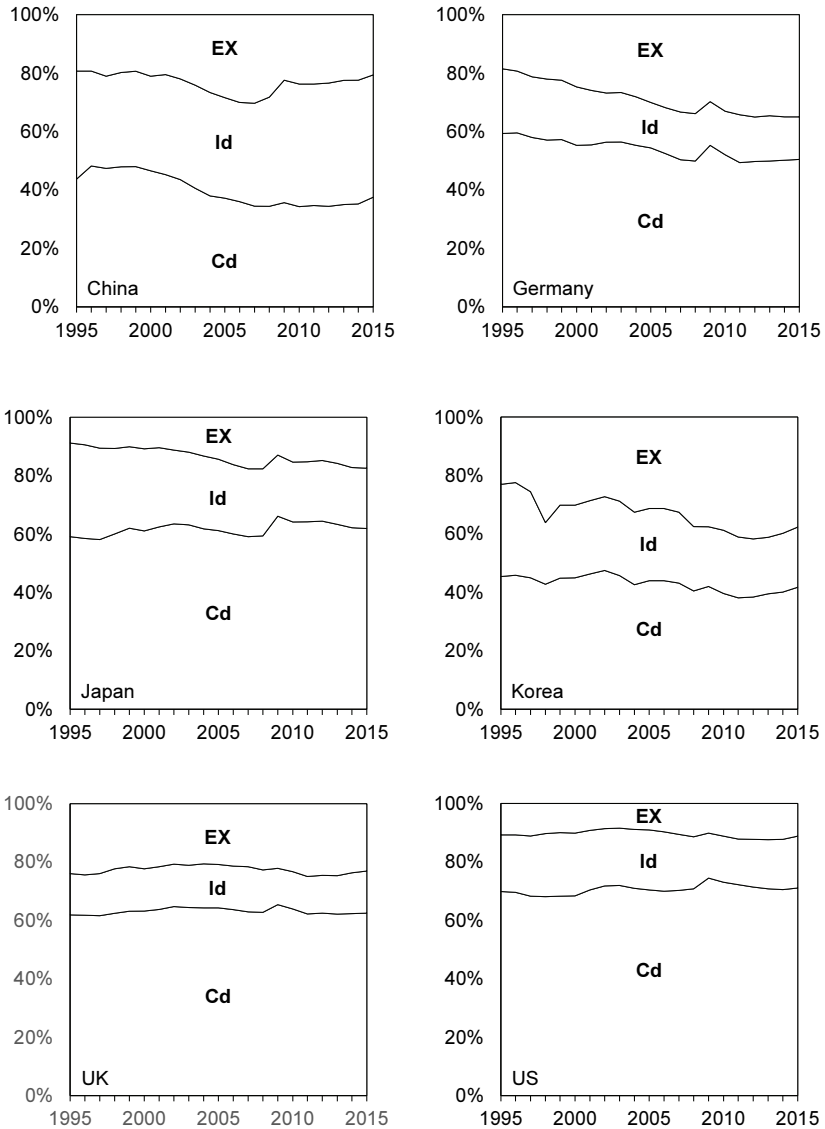
We can draw the following conclusions from the decomposition of aggregate gross output. First, we observe a big variation in the decomposition among countries. For example, the shares of the contributions of domestic consumption of US, UK and Japan are much bigger than those of China and Korea, and the shares of the contributions of exports of Korea, Germany and China are bigger than those of US and Japan.

Figure 12. Import contents of exports (ICE), of investment (ICI[d]) and of consumption (ICC[d])



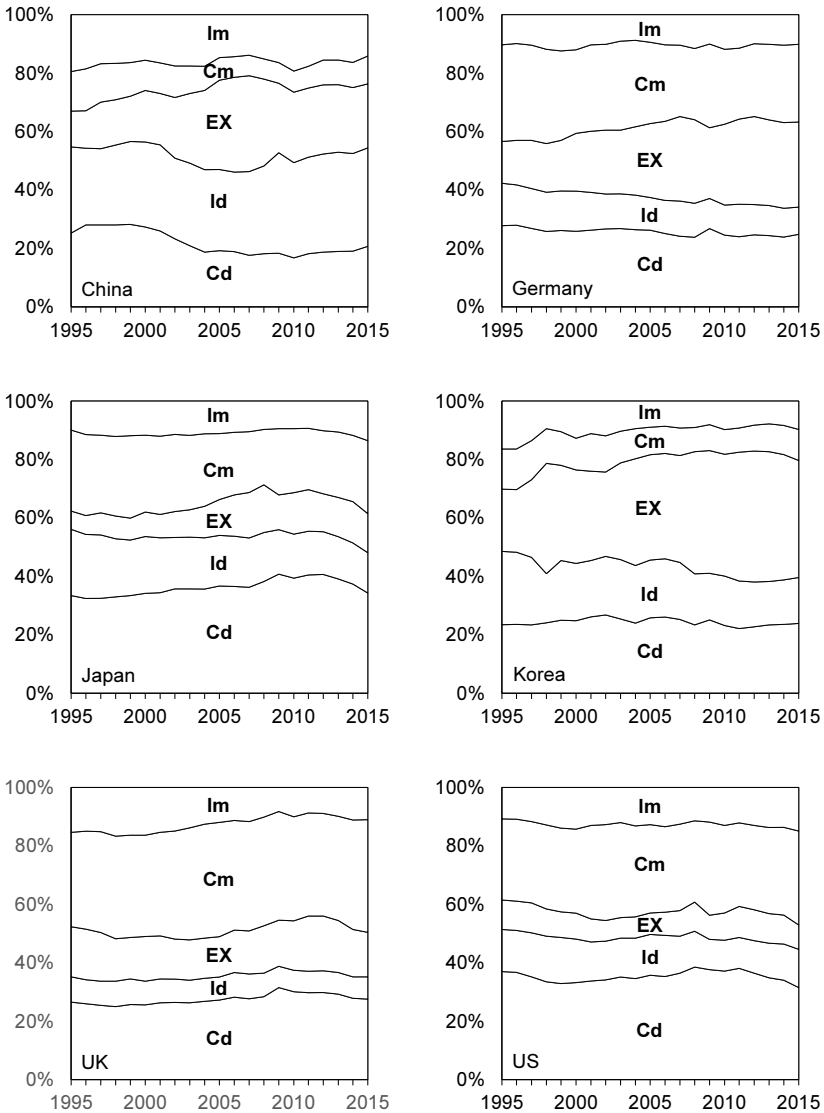
Source: OECD.

Figure 13. Decomposition of aggregate gross output



Source: OECD.
Note: Cd = domestic consumption, Id = domestic investment, EX = export.

Figure 14. Decomposition of total imports



Source: OECD.
Note: Cd = domestic consumption, Id = domestic investment, EX = export, Cm = imported consumption, Im = imported investment.

Second, the shares of the contribution of exports in gross output increased in all countries except in UK. During the period 1995~2015, the increase was the biggest in Germany (16.5%p), followed by Korea (14.6%p), and was small in China (1.3%p) and US (0.5%p) or slightly decreased in UK (-0.9%p). Third, the share of the contribution of domestic consumption decreased in many countries. It increased in Japan (2.8%p), UK (0.7%p) and USA (1.2%p), but the increases were small. Fourth, the share of the contribution of domestic investment also decreased in most countries except in China. It can be said, in conclusion, that in the major exporting countries, the share of the contribution of exports in aggregate gross output increased while those of domestic demand decreased.

On the other hand, the following can be found from the decomposition of total imports. First, we can also observe a big variation in the decomposition among countries. In fact, we observe big variations in the shares of all five components. Second, the share of the contribution of exports in total imports increased in most countries. The increase was the biggest in Korea (18.7%p), followed by Germany (14.8%). It decreased in US (-1.7%p), but the decrease was small. Third, the shares of the contributions of total consumption and total investment decreased in most countries. The increments were small even when they increased. It can be said, in conclusion, that in the major exporting countries, the share of the contribution of exports in total imports also increased while those of domestic demand decreased. Considering Figures 13 and 14 simultaneously, we observe that the shares of the contribution of exports increased in both gross output and imports in most countries, and we can conclude that the overall degree of internationalization increased during the period.

It is interesting to compare the experiences of Germany and Korea. Shares of the contributions of exports in gross output and imports of Germany increased by 16.5%p and 14.8%p, respectively, while those of Korea by 14.6%p and 18.7%p, respectively. In meeting the foreign demand, in other words, Korea's relative utilization of the global production network, compared to the dependence on domestic production capacity, became stronger while that of Germany weakened.

When evaluating the degree of integration into the global production network, in conclusion, considering the shares of the contributions of exports in both aggregate gross output and total imports simultaneously can provide a more comprehensive and rigorous evaluation. This is

because the compositions of gross output and imports given in equation (7) represent how a country manages domestic production base and utilizes global production network, and because the decisions are made jointly. For this reason, it can be said that equation (7) is a more comprehensive way to assess the degree of integration into the global production network than ICE, since it considers both domestic and global production aspects simultaneously while ICE considers only the global production aspect. For example, it is possible that two countries have similar values of ICE and similar shares of contributions of exports in imports, but with different shares of contributions of exports in gross output. This happens when a country depends on domestic and global production bases to the same extent in producing goods and services to be exported, while the other country depends more heavily on imported intermediate input than on domestically produced intermediate input.

The results of this paper provide some information about the structural change in the Chinese economy.

The Chinese economy is the biggest not only in terms of GDP, but also in terms of international trade, so studying its characteristics cannot be emphasized too much.

Symptoms of a structural change in the Chinese economy is detected from many indicators. China's world market share showed a steep rise from early 1990s, but it became stagnant since then. (Figure 2) Also, exports as percent of GDP steadily increased at least for four decades since 1970s, but it peaked in mid-2000s and has decreased afterwards. Total international trade, i.e., the sum of exports and imports, as percent of GDP, shows similar time-series trend (Figures 3 and 4). China's investment rate has also risen rapidly and steadily for at least four decades since 1970s, but it seems that it has entered a stagnant phase since 2010s (Figure 6). On the other hand, average consumption propensity seems to have touched the bottom in around 2010, and has risen since then (Figure 5).

Decompositions of gross output and imports also show strong indications of structural change in the Chinese economy. The share of the contribution of consumption in gross output kept decreasing, but seems to have begun recovering since early 2010s; that of exports also began declining since mid-2000s; and that of investment entered a stagnant trend since late 2010s. Decomposition of total imports shows similar trend (Figures 13 and 14).

In conclusion, it can be said that the Chinese economy has restrained, or, sacrificed, consumption, and invested its increased savings on capital accumulation and on exports until mid- to late 2000s, but has arrived at a stage where restraint can be relieved, so the share of investment and exports began stagnating or even decreasing while the share of consumption began increasing. It can be said, in other words, that the Chinese economy has been a 'production base' in the world economy until mid- to late 2000s, but has been changing into a 'consumption base,' or equivalently,'from a factory into a market.'

5 Conclusion

Import content of exports (ICE) was suggested as a degree of integration into the global production network in mid-2000s, and has been used in empirical studies. Kim (2020) suggested an alternative indicator based on the decomposition of aggregate gross output and total imports using simple demand-side input-output analysis. His indicator takes into consideration how a country manages the domestic production base and utilizes the global production network simultaneously, while ICE only considers the latter. For this reason, Kim (2020) claimed that the suggested indicator is a more comprehensive indicator than ICE.

The purpose of this paper is to apply the method suggested by Kim (2020) to six major exporting countries, China, Germany, Japan, Korea, UK and US, for the period 1995-2015 using OECD's IO-DB. We showed that the overall degree of integration into the global production network increased during the period, but weakened in recent years. According to the estimation results, Korea and China exhibited the strongest degree.

The results of this paper also signify that a structural change is taking place in the Chinese economy since late 2000s such that (i) restraint on consumption has been mitigated and the relative importance of consumption is increasing while that of exports is decreasing, (ii) the increasing trend of investment rate seems to have ended, and (iii) the Chinese economy, which has been the 'production base' in the world economy until mid- to late 2000s, is changing into a 'consumption base,' or equivalently,'from a factory into a market.'

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