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Korea's Participation in Global Value Chains: Measures and Implications

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This paper measures the extent to which South Korea participated in global value chains (GVCs) from 1995 through 2011 and scrutinizes the consequences of such participation on the Korean economy. To this end, the World Input Output Database is utilized to calculate GVC income, GVC employment, and value-added exports created by Korean and foreign industries. Our findings show that Korea radically internationalized its production activities during the sample period, widening the gap between gross exports and value-added exports. We also document that Korea's participation in GVCs has changed the value-added and employment structures in domestic industries in accordance with their comparative advantages while exacerbating the degree of wage inequality.

Key Word: Global Value Chain, GVC, Trade in Value Added, GVC Income, GVC Employment, International Fragmentation of Production
JEL Code: F10, F21, F23

I. Introduction

The global value chain (hereafter, GVC) refers to the chain-like structure of a product's value-added characteristics across countries resulting from the division of the production sequence on a global scale. Although such international fragmentation has long been practiced, it has recently drawn significant attention from both researchers and policymakers, as technological advancements along with ever-lower trade barriers has made it much more active and complex.

In a seminal paper, Hummels *et al*. (2001) first developed a measure of imported intermediate goods' share of exports, also known as vertical specialization (VS), finding that the VS share of 14 major countries' exports was approximately 21% in 1990. They also document that the share increased by almost 30% over the ensuing two decades. As a more recent and intuitive example, Linden *et al*. (2009) dissect

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the iPod, valued at US $300, finding that China, the final iPod exporting country, contributes only about $5 to the total value through assembly and inspection steps. Meanwhile, Japan earns $27 for each iPod, though not by exporting it directly but by providing core parts and components.

Thus, it is recognized that using gross output or exports may not be appropriate to gauge the value of the production activities conducted in each country. Indeed, a burgeoning amount of literature introduces alternative measures and analyses based on the GVC perspective to better explain what a country does and how much value it adds (See Daudin *et al*. (2011), Johnson and Noguera (2012), Timmer *et al*. (2013, 2014), Koopman *et al*. (2014), Baldwin and Lopez-Gonzalez (2015) among others). These papers usually apply their measures to cross-country comparison analyses, but not to a particular country.

The main purpose of the present paper is to provide a broad picture of the level as well as the change in Korea's position in this integrated world through GVCs. Not only for policy implications, studying the Korean experience is interesting, as Korea is representative of small open economies that rely largely on trade. In particular, it has been involved in global supply chains since the 1960s as a core strategy for its economic growth. Despite this long history, we are deficient in the relevant statistics on how much Korea has engaged in the vertical linkages across countries and what the consequences of such engagement are.

Applying the method suggested by Johnson and Noguera (2012) and Timmer *et al*. (2013) and using the World Input Output Database (WIOD), this paper specifically calculates three GVC-related measures: value-added exports, GVC income and GVC employment. We then use these measures to gauge the degree of participation by Korean industries in GVCs during the sample period from 1995 to 2011. Furthermore, we analyze the compositional changes in value-added aspects and employment in the Korean manufacturing industry due to GVC participation.

Our finding indicates that Korea is one of the most active countries in terms of GVC participation among 40 countries. While gross exports had grown, allowing Korea to become the seventh largest exporter by 2011, its growth of value-added exports, i.e., the domestic value-added created by foreign countries, lagged, widening the gap between the two figures. In fact, the ratio of value-added exports to gross exports, or the VAX ratio, fell continuously from 75% in 1995 to 59% in 2011. Moreover, the VAX ratios are the lowest among the top exporting industries, such as the petro-chemical, transport equipment, and electronic equipment industries. These findings suggest that value-added exports can be an alternative measure of the competitiveness of Korean industries in the global market, especially when one is more interested in production activities as opposed to transacted products.

We also find that Korea's active participation in GVCs induced substantial changes in its industrial structure in terms of both value-added and employment aspects over the sample period. Specifically, 25% of the value added in Korean manufactured final goods ultimately went to foreign countries in 1995, but the foreign share increased to 38% in 2011. In terms of employment, approximately 51% of all employees were found to be non-nationals who worked in relation to the production of the same Korean manufactured final goods, but this foreign share increased further to 60% in 2008. During this period, a critical number of middle-

and high-skilled foreign workers were substituted for low- and middle-skilled domestic workers, potentially exacerbating wage inequality in Korea. Korean manufacturers, as suppliers of intermediate products, also enlarged their role in foreign GVCs throughout the same period; the share of manufacturing GDP created by participating in foreign GVCs increased from 26% in 1995 to 42% in 2011, and the share of employment increased from 26% in 1995 to 37% in 2008.

This paper contributes to the literature in three ways. First, we provide a useful analytical framework with which to measure Korean industries' global competitiveness, overall structure, and its changing patterns in the GVC world. The complicated real world is well summarized in our two-country, three-sector framework, providing a clear picture and thus informative statistics on the value chain structure between domestic and foreign industries.[1]

Second, our study complements prior studies of the internationalization of production activities using micro-level data by providing aggregate changes and related implications. Although micro-based studies have advantages when used to identify the causal effect of internationalization on domestic economies, they typically lack aggregate consequences. For example, Ahn (2006) and Park (2009) estimate the causal, marginal effect of offshoring on domestic employment, but these studies are limited in terms of how they identify the numbers of domestic workers lost or gained as a result of offshoring.

Third, by exploiting world input-output tables (WIOTs), our study provides useful information that cannot be obtained by analyzing domestic input-output (IO) tables. For example, WIOTs allow us to calculate the contribution of each foreign country to the total GDP in Korea, whereas domestic IO tables cannot provide such information. All analyses of structural changes in Korean industries are only possible with WIOTs.

The remaining sections are organized as follows. Section II provides an illustrative example to define the three measures related to GVC and introduces the data used in the paper. Section III contrasts statistics based on value-added exports and those pertaining to gross exports to measure the degree to which Korea has participated in GVCs. It also highlights the recent trend of international competitiveness in Korean industries. Section IV narrows our focus to the Korean manufacturing industry to show its pattern of structural changes in the composition of value-added and employment using GVC income and GVC employment. Section V concludes with policy implications.

[1]In a spirit similar to ours, Kim *et al.* (2014) and Yoon (2015) measure the competitiveness and value-added structure of Korean exports, respectively, using the decomposition method of Wang *et al.* (2013). Our analyses deal with not only exports but also with the production structures of Korean industries.

II. Concepts and Measurement of GVCs

A. *An Illustrative Example*

In this section, we introduce three measures to evaluate Korea's participation and activity in GVCs: GVC income, GVC employment, and value-added exports. The first two measures come from Timmer *et al.* (2013, 2014), and the last one was originally developed by Johnson and Noguera (2012). For formal definitions and detailed derivations of each measure, readers can refer to the Appendix or to the original papers. Here, we start with a simple example to illustrate the concepts intuitively.

Suppose there is a firm that produces diamond rings in country B (country B refers to the home country). This firm does not mine rough diamonds (intermediate good 1) itself but it imports them from country A for $10 per unit. In addition, shanks (the band part of a ring) (intermediate good 2) are procured from a domestic shank-producing firm at $3 per unit. The firm producing diamond rings in country B processes the imported rough diamonds and combines them with the shanks to sell in the global market. Figure 1 illustrates this diamond ring GVC structure.

The processing of rough diamonds and the assembly of ring parts require labor and capital inputs, and their value added in unit terms is $4 and $2, respectively. Finally, the diamond ring production firm pays $1 for insurance (intermediate good 3) provided by an insurance company in country C in order to provide buyers with a one-year warranty service for any defective or damaged products. Therefore, the final price of one diamond ring (final good) is $20, i.e., the sum of the prices of the intermediate goods ($10+$3+$1) and the value-added of labor and capital inputs ($4+$2).[2]

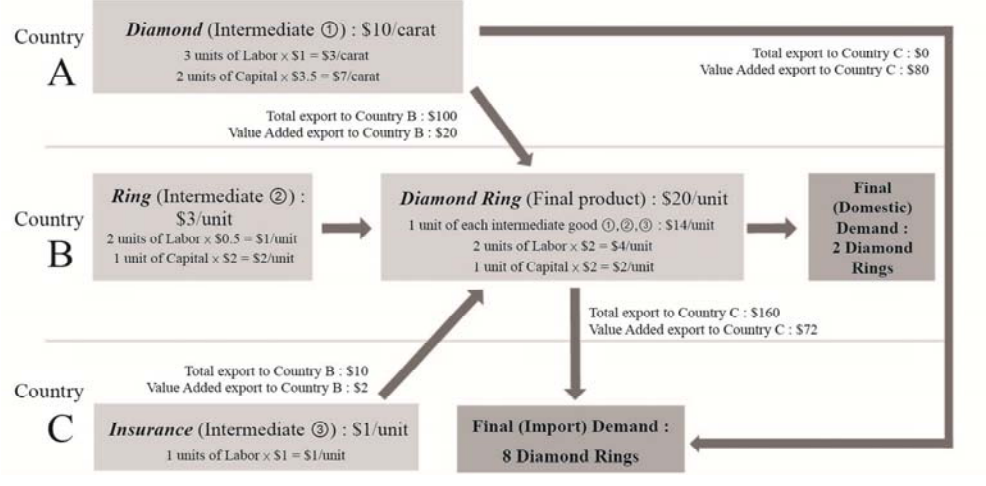

FIGURE 1. GVC OF DIAMOND RINGS

[2]We assume an absence of a retail margin and transport expenses in this example. In reality, these factors are included in the value-added of the final producers (the diamond-ring-producing firm in country B in this example).

TABLE 1—ALLOCATION OF INCOME, EMPLOYMENT IN THE DIAMOND RING GVC

Cnty	Industry (Product)	GVC Income	GVC Employment	GVC Capital	Labor Income	Capital Income	Value-added Export	Gross Export
A	Diamond	100	3	2	3×1×10=30	2×3.5×10=70	B:10×2=20 C:10×8=80	B:10×10=100 C: 0
B	Ring	30	2	1	2×0.5×10=10	1×2×10=20	C:3×8=24	C: 0
	Diamond	60	2	1	2×2×10=40	1×2×10=20	C:6×8=48	C:20×8=160
	Ring							
C	Insurance	10	1	0	1×1×10=10	0	B:1×2=2	B:1×10=10
Total		200	8	4	90	110	174	270

If two diamond rings are bought in country B (domestic market) and eight diamond rings are purchased in country C, the final demand for the diamond rings is 10. Thus, the total output must be \$20×10=\$200. The realized value-added of each industry in each country is shown in Table 1. As a result of this production sequence organized by the diamond ring firm of country B, country A gains \$100 of added value by mining rough diamonds, and by producing shanks and manufacturing diamond rings, country B gains added value of \$30 and \$60, respectively. Country C gains \$10 of added value by providing the insurance service.

As shown in the example of the production of diamond rings, we define global value chains as a fragmented sequence of production along with its corresponding value-added structure across countries and industries. The created value-added component in each industry of each country is termed the global value chain income (GVC income). The sum of GVC income is, hence, equal to the total output (=total expenditure).

Among the participants in this GVC, the diamond-ring-producing firm of country B, or the final producer, makes decisions about whether to produce or outsource the intermediate goods and from where to outsource once decided. Thus, it serves as an organizer of the GVC.[3] All other firms participate in the GVC as intermediate goods suppliers.

Meanwhile, the gross domestic products (GDPs) of countries A, B, and C are \$100, \$90, and \$10, respectively, as they are expressed as the sum of GVC income within each country. Note that the GVC income of country B (=GDP of country B) accounts only for 45 percent of the total output, while the GDP of country A accounts for 50 percent of the total output. In other words, despite the fact that country B is the final producer and exporter of diamond rings, country A receives the most income from the diamond ring GVC structure.

If we know the types and amounts of input used in the production process for each country and industry participating in the GVC along with the created value-added component, we can also calculate how much each factor of production indeed creates with regard to added value. As shown in Figure 1, the final producer in country B generates \$4 and \$2 of added value from two units of labor and one unit of capital, respectively, for each diamond ring. It is also possible to determine the amounts of labor and capital which are injected to produce each of the

[3]Final producer is not necessarily an organizer in all GVCs.

intermediate goods in the production of a diamond ring (the final good), as shown in columns (4) and (5) in Table 1. In particular, each country and industry-specific labor input required for the production of the final good is defined as the global value chain employment (GVC employment). The total final demand of ten diamond rings creates GVC employment of 30 units in country A, 40 units in country B, and 10 units in country C.

Summarizing the illustration thus far, the formation of a GVC means the participation of various industries (or firms) of different countries in the intricate and segmented stages of production, and the generated value-added and labor input within such a network are defined as GVC income and GVC employment, respectively. GVC income and GVC employment are not directly observed in unprocessed data. Instead, it is possible to calculate these factors with certain assumptions as to the appropriate data. The calculation method is introduced in the next section. Through the GVC analysis, we obtain a clear sense of how the total output of $200 is allocated across countries and industries.

Meanwhile, value-added exports shown in column (6) refer to the amount of added value demanded by the foreign final consumers. According to Figure 1, the final consumers of the ten diamond rings are country B (two rings) and country C (eight rings). Thus, out of the total value-added exports of $100 by country A, $20 goes to country B and $80 to country C. Country B, by producing shanks and manufacturing diamond rings, exports value-added of $24 and $48, respectively, to country C. Likewise, country C exports a value-added of $2 to country B, which demands two rings. The total value-added exports of $174 and the sales in the domestic markets of country B (=$18) and country C (=$8) add up to $200, which is the total GVC income (=total output).

It is important to note the difference between value-added exports and conventional gross exports tallied for each country, even with identical transactions. The gross exports of country B to country C is $160, which is the price of eight diamond rings. However, the value-added exports in country B is only $72. The remaining $88 is the sum of the intermediate goods prices imported by countries A and C, and it is already accounted for in their exports to country B. Moreover, $8 of insurance exported from country C is then re-imported and domestically consumed, causing a double-counting problem. In other words, 88+8=$96 has also been recorded to make the world's gross exports $270. Due to this double-counting problem, country B's gross export level leaves room for overestimating the income of country B.

Another noticeable difference between value-added exports and gross exports is shown in the case of country A. Although country A transacts only with country B, 80 percent of the created value-added by the mining of rough diamonds is ultimately consumed in country C, causing a large discrepancy between the two export measures for country A. At first glance, country A's major trade partner appears to be country B, but its trade performance is actually more affected by the economic situation of country C, where the majority of diamond ring buyers are located. The key aspect of value-added exports is that it splits each country's gross output according to the destination in which it is ultimately absorbed in the form of final demand.

B. *World Input-Output Table*

In order to calculate GVC income, GVC employment, and value-added exports for the actual economy, we use world input-output tables (WIOTs). The World Input Output Database (WIOD) project has developed WIOTs for forty-one countries, including 27 EU members and what is referred to as the rest-of-the-world (ROW), covering the period from 1995 to 2011. The tables connect the trade flows of intermediate and final goods across countries and industries. NACE Rev. 1 provided by the EU is used to classify 35 industries, among which 14 belong in the manufacturing sector.[4] A thorough description of the methods and original sources of information used for the construction of the WIOTs is available in Timmer (2012).

In fact, several leading international organizations and research institutes also provide data similar to WIOT, each of them having its own advantages and disadvantages. The reasons for using the data constructed by WIOD are as follows: (i) WIOT provides more industries and countries relative to other published data sources, and (ii) WIOTs are available for every year from 1995 to 2011, while other institutions provide tables for only a few years (e.g., every five years). Of course, a national input-output table is required every year in order to develop WIOT on a yearly basis. If this is not available, additional assumptions such as an invariable input-output structure are needed to create it.

One fact that should be mentioned at this point is that there always exists statistical discrepancies in IO tables, and there is no means by which clearly to identify the more accurate instances among them. This also applies to the WIOT used in this study. Therefore, rather than having absolute confidence in the statistical figures calculated from the WIOTs, we place more emphasis on understanding trends and relative statuses by means of time series analyses and cross-section comparisons.

The WIOD also provides information such as national input-output tables (NIOTs) and what are termed socio-economic accounts (SEAs) at the industry level. In particular, SEAs contain data on output, value-added, capital stock, and employment factors according to three skill type (i.e., the low, middle, high skill types) that are needed to measure the contribution of each production factor to economic growth, also known as growth accounting, for the 40 sample countries.[5] We use this data in section 4 to determine whether GVC participation leads to changes in the input structure of production factors.

[4]The term NACE is derived from the French *Nomenclature statistique des Activités économiques dans la Communauté Européenne*. See also Table A1 and Table A2 in the Appendix for industry classification and sample countries in the WIOT, respectively.

[5]The data here are constructed in the same manner used by the EU KLEMS database, a database frequently used in growth accounting exercises.

III. Value-Added Exports in Korea

A. *Indicator of Korea's participation in GVCs*

In this section, we present evidence of how active Korea's GVC participation was from 1995 to 2011 by comparing value-added exports and gross exports. This analysis calls for a reevaluation of the international competitiveness of Korean industries based on value-added exports, which we undertake at the end of the section.

As the first comparison, Figure 2 shows the time trends of Korea's export share of the world's exports based on gross exports and value-added exports. For gross exports, the share starts at 2.7% in 1995 and increases to 3.3% in 2011, when Korea became the seventh largest exporting country in the world. However, the value-added export share more or less stagnated over the sample period, widening the gap between the two trends.

Table 2 presents the VAX ratio across the major countries defined in the previous section. When gross exports are assumed to be $100, the VAX ratio of Korea is $75 (3/4) for 1995 but then drops to $59 in 2011. The downward trend in the VAX ratio (by 21.7%) is much greater than that of other major countries, including manufacturing-based economies such as Germany and Japan. The sharp and sudden drop in the VAX ratio indicates that Korea was incorporated into the GVC more rapidly compared to other countries.[6]

Meanwhile, because value-added content of exports (VAX) is the GDP created

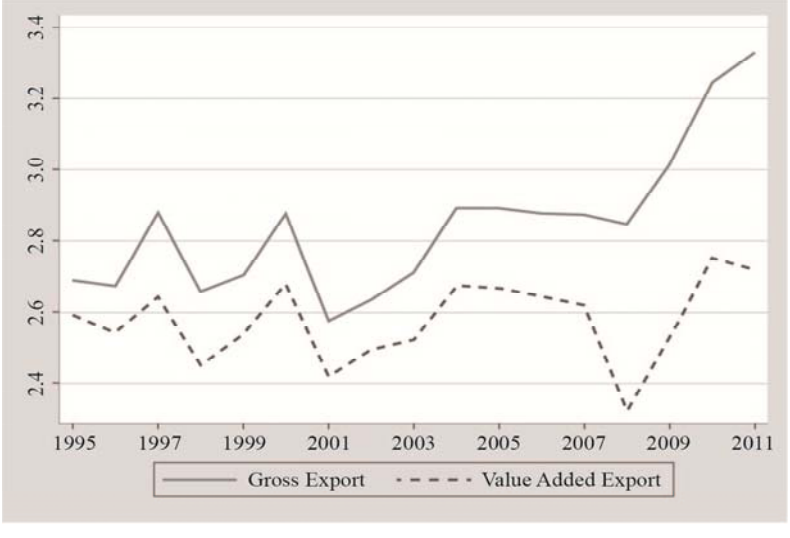

FIGURE 2. RATIO OF KOREA'S EXPORTS TO WORLD EXPORTS

Source: World Input-Output Database (WIOD) and the author's calculations.

[6]We discuss the implications of the rapid GVC participation of Korean industries in Section 4A.

TABLE 2—TIME TRENDS OF THE VAX RATIO BY COUNTRY

Year	1995	2000	2005	2011	Growth Rate (%)
Korea	0.75	0.70	0.67	0.59	-21.7
Japan	0.92	0.9	0.86	0.81	-11.3
China	0.84	0.82	0.72	0.75	-9.7
Taiwan	0.67	0.63	0.56	0.52	-21.6
Germany	0.79	0.74	0.72	0.69	-12.6
USA	0.83	0.78	0.78	0.79	-4.3

Source: World Input-Output Database (WIOD) and the author's calculations.

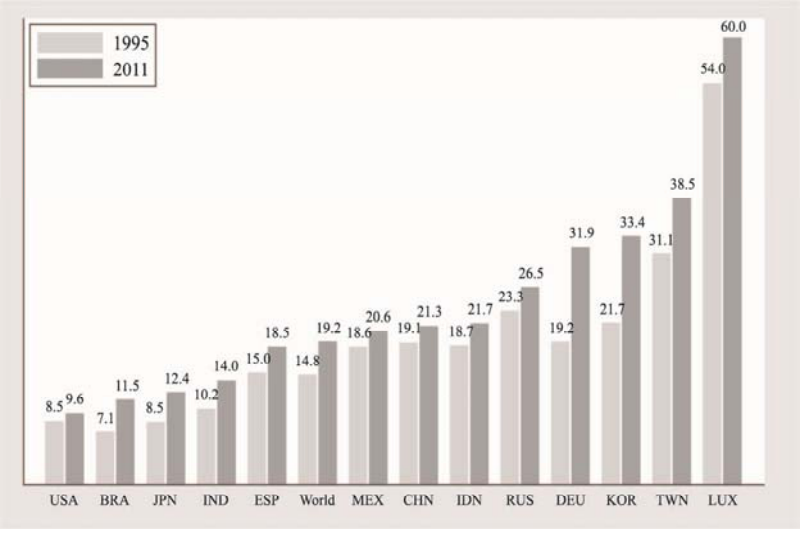

FIGURE 3. RATIO OF VALUE-ADDED EXPORT TO THE COUNTRY'S GDP

Source: World Input-Output Database (WIOD) and the author's calculations.

by foreign demand for the domestically produced goods and services, the rising level of VAX within a country can be interpreted as its GDP having a growing dependence on foreign markets. When value-added exports are calculated at the country level, the contribution of each foreign country to Korea's GDP becomes known. This could not be estimated prior to the creation of WIOTs.

In that sense, Figure 3 shows the share of value-added exports to the country's GDP. The Korean share of 33.4% in 2011 indicates that approximately one-third of Korea's GDP is generated by the final demand from other countries. When considering the world average of 19.2%, Korea's reliance on overseas markets is quite high, and its growth rate from 1995 (53.6%) is also among the highest compared to those of other countries in the WIOD data. Of course, this is another indication of Korea's rapid involvement in the global market.

It can be meaningful to identify the largest foreign consumer of Korean value-added goods, and this is what Table 3 shows. Specifically, Table 3 compares value-added exports with gross exports in 1995 and 2011 for four major partner countries.

TABLE 3—EXPORTS TO MAJOR CONSUMERS OF KOREAN PRODUCTS

	1995			2011		
	Value-added export	Gross Export	Difference (%p)	Value-added export	Gross Export	Difference (%p)
Subtotal	62.9	60.5	2.4	58.6	59.4	-0.9
China	7.2	9.3	-2.1	20.4	25.7	-5.3
EU	17.7	14.9	2.8	17.2	14.7	2.5
USA	22.1	20.1	2.1	13.4	9.5	3.8
Japan	15.9	16.3	-0.4	7.6	9.4	-1.8
Other	37.1	39.5	-2.3	41.4	40.6	0.8
Total	100	100		100	100	

Source: World Input-Output Database (WIOD) and the author's calculations.

When examining total exports to these four countries, the value-added exports and gross exports both decreased by about 4% (62.9%→58.6%) and 1% (60.5% →59.4%), respectively, showing no significant difference between the two years.

However, we observe a large change between 1995 and 2011 when investigating the composition for each country/region; the largest export markets in order were the US, the EU, Japan and China in 1995, but the ranking changed to China, the EU, the US, and Japan by 2011. China's position on the list is particularly notable as its share of Korea's value-added exports surged from 7.2% in 1995 to 20.4% in 2011. Korea's dependence on the Chinese market can be accurately calculated by multiplying the dependence rate by the value-added export ratio, which was found to be 0.334×0.204×100 = 6.8%. In other words, nearly 7% of Korea's GDP is generated by China's final demand. Unlike China, the ratios were reduced in Japan and the US such that the sum of the two countries' ratios became similar to that of China alone. The dependence rates for the EU, US and Japan are 5.7%, 4.5% and 2.5%, respectively, and together with China, they amount to 20%, meaning that one-fifth of Korean GDP is generated by these three major trade partners.

Finally, we observe that in both 1995 and 2011, the gross export ratio is larger than the value-added export ratio in China and Japan. This may leave room for overstating China and Japan as consumers of domestic goods and services. The situation is reversed in the cases of US and EU, which both play a more significant role as consumers than would be expected in the gross export figures, as the gross export ratio is smaller than the value-added export ratio.

The dependence of domestic value-added on foreign demand may differ by industry. To check whether this is the case, Figure 4 shows the industry-specific shares of gross exports and value-added exports in the GDP for 2011. Indeed, the dependence on foreign markets differs significantly between the manufacturing and non-manufacturing industries. In particular, approximately two-thirds of the manufacturing value-added figure is attributed to foreign demand. Within the manufacturing industry, light industries such as food-processing, textiles and wood and paper show a relatively low dependence rate of around 30%, while electronics (78.3%) and transport equipment (76.6%) generate more than three-fourths of the total value-added figure from foreign demand. Hence, Korea's manufacturing industries, especially those on a large scale, can be significantly affected by worldwide business cycles due to their high dependence on foreign markets.

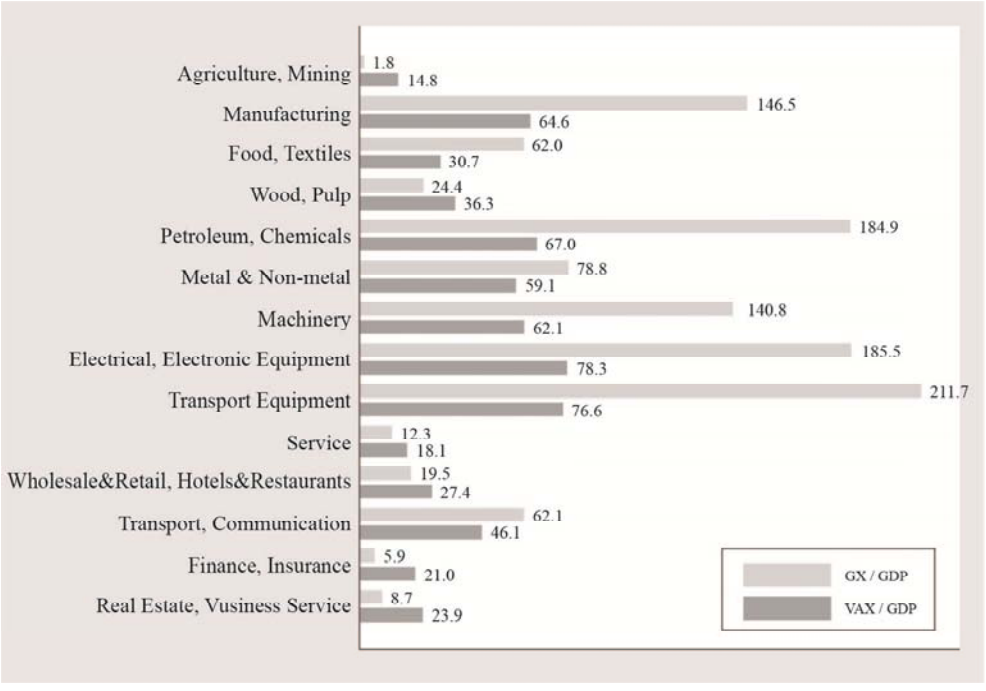

FIGURE 4. EXPORT SHARE IN GDP BY INDUSTRY

Source: World Input-Output Database (WIOD) and the author's calculations.

The ratio of gross exports to GDP for the entire manufacturing industry is 146.5%, and the ratio is highest in the transportation equipment industry given its export amount of more than twice the GDP (211.7%). The higher gross exports as compared to GDP stems from the fact that gross exports includes the value-added figures generated by (i) other domestic industries and by (ii) foreign industries within the GVC of transportation equipment. Thus, gross exports cannot tell us how much foreign purchases contribute to the industry's GDP, whereas value-added exports can serve as a suitable measure for this.

We can also calculate the industry-level VAX ratios using the information in Figure 4. For example, the VAX ratio of the transportation equipment industry is 76.6/211.7 = 0.36, the lowest among all industries. Although the ratio of gross exports to GDP is the largest among all industries, approximately two-thirds of its exports can be attributed to other domestic industries and foreign countries, reducing its contribution to GDP. For the same reason, we can easily witness a low VAX ratio in some of the leading export industries, such as the petro-chemistry, machinery, and electrical and electronic products industries. The VAX ratio for the entire manufacturing sector is 0.44. In the agriculture and service industries, the VAX ratios were found to be 8.06 and 1.47, respectively, meaning that value-added exports in those industries are greater than gross exports. The high VAX ratio in non-manufacturing sectors is easily understood because primary products and services are often inherent in exported manufacturing goods as intermediate inputs.

B. *International Competitiveness of Korean Industries*

Finally, we assess the international competitiveness of Korean industries based on their value-added exports. Thus far, gross exports have been widely used as a measure of international competitiveness. For example, the revealed comparative advantage (RCA) index suggested by Balassa (1965) is popularly used. The RCA is calculated as follows:

$$RCA_{ci} = \frac{GX_{ci} / \sum_i GX_{ci}}{\sum_c GX_{ci} / \sum_c \sum_i GX_{ci}} \quad (1)$$

The RCA index for industry *i* in country *c* is equal to the proportion of the gross exports of industry *i* in country *c* (GX_{ci}) within the country's gross exports (numerator) divided by the proportion of the world gross exports of industry *i* in the world's gross exports (denominator). If the numerator is larger than the denominator, country *c* can be said to have a comparative advantage in sector *i*.

However, because the figure for gross exports includes value-added factors generated by industries and countries other than industry *i* and country *c*, the RCA can misrepresent the true competitiveness of an industry. To give an example, many electronic products, such as the iPhone, are assembled and exported from China to countries all over the world. Though China is involved in a low value-added activity (assembly in this example), the amount of gross exports is high due to the high price of the iPhone, and so is the RCA index. Therefore, the RCA index measured in terms of gross exports is likely to overestimate the true competitiveness of the Chinese electrical and electronic products industry. Another important problem when using gross exports is that it is impossible to measure services that are inherently linked to the exported goods. Therefore, assessing the international competitiveness of the service industry using the RCA index is inappropriate.

Using value-added exports in the RCA calculation can circumvent these problems. Because only the value of the assembly process is factored into value-added exports, we can accurately measure the share of China in its export of electronic products. Moreover, because the exact value of the service provision is applied to the RCA calculation, it is possible to make a meaningful comparison of the service competitiveness between countries. This new equation for value-added RCA (VRCA) can be generated simply by replacing gross exports with value-added exports.

$$VRCA_{ci} = \frac{VAX_{ci} / \sum_i VAX_{ci}}{\sum_c VAX_{ci} / \sum_c \sum_i VAX_{ci}} \quad (2)$$

The VRCA index for each domestic industry is compared with the standard RCA index for the same industries in Figure 5. As presented in the figure, a considerable gap between VRCA and RCA is found in many industries, presenting different implications with regard to international competitiveness. For example, the metal and non-metal industry has been at a comparative disadvantage until recently

FIGURE 5. REVEALED COMPARATIVE ADVANTAGE BY INDUSTRY

Source: World Input-Output Database (WIOD) and the author's calculations.

according to the RCA index (RCA<1). However, the VRCA index shows that the metal and non-metal industries have a comparative advantage and that the level of the advantage has been rising. Korea's leading manufacturers, represented by

electric and electronic products and transportation equipment, have a comparative advantage according to both the RCA and VRCA indices, but VRCA is higher and increasing, thus diverging from RCA. The competitiveness of the two industries in generating added value in the foreign market (VRCA) can be said to be higher than what was implied by the standard index (RCA).

The overall change in the international competitiveness of the Korean manufacturing sector during the past 20 years can be observed in the first seven graphs in Figure 5. The competitiveness of the food-processing and textile industries has been dropping, while the competiveness of the wood and paper and the petro-chemistry industries was stagnant from 1995 to 2011. On the other hand, durable goods such as metals and non-metals, machinery, electrical and electronics goods, and transportation equipment have showed constantly enhanced competitiveness. What about the service industry? All of the service industries presented in the last five graphs in Figure 5 are found to have a comparative disadvantage or show weakening international competitiveness. Because the standard RCA indices for services may not correctly reflect the competitiveness of Korean services, we do not try to interpret them.

In sum, value-added exports provide useful information that gross exports cannot provide, as value-added exports focus on production activity rather than on products per se. Consequently, statistical indicators based on value-added exports can be used as alternative measures for evaluating the competitiveness of domestic activities in the international market.

IV. Structural Changes in the Korean Manufacturing Industry through its Participation in GVCs

As shown in the previous section, Korea's active participation in GVCs allows us to predict many changes in its compositional structure of industry-specific income and labor input. In this sense, this section analyzes the structural changes of GVC income and employment in the Korean manufacturing industry over the sample period. The reasons for focusing on the manufacturing industry are as follows: (1) GVC participation is the most vigorous in the manufacturing industry. (2) The flow of intermediate goods from the manufacturing to the non-manufacturing sector is much more frequent and intensive than the other way around.

We start by introducing the framework used for our analyses. Based on the mathematical exposition in Timmer *et al.* (2013) for calculating GVC income, we originally arrive at a 1435×1435 square matrix (41 countries multiplied by 35 industries).[7] Dealing with such a large matrix not only complicates the analysis but also makes it difficult to obtain the desired information. We thus aggregate countries into Korea (KOR) and the rest of the world (ROW) and industries into agriculture (AGR), manufacturing (MFC), and service (SVC) to formulate a two-

[7]See also Timmer *et al.* (2014) pp. 102~103 for an explanation of the GVC income matrix.

TABLE 4—TWO-COUNTRY, THREE-SECTOR GVC STRUCTURE

			The Final Producer (or product) of GVC						GDP/Emp. by industry
			KOR			ROW			
			AGR	MFG	SVC	AGR	MFG	SVC	
GVC Income / GVC Emp.	KOR	AGR							
		MFG							
		SVC							
	ROW	AGR							
		MFG							
		SVC							
Total Output / Total Emp.									World GDP/Emp.

country, three-sector matrix for GVC income.[8] The same matrix is also used for GVC employment by simply replacing the numbers in each cell.

The simplified GVC income structure is shown in Table 4. Recall the breakdown into an organizer and suppliers in a GVC based on their roles. Column titles in Table 4 indicate the organizers of GVCs, and row titles refer to the suppliers; there are six organizers and six suppliers in this two-country, three-sector world. We first examine the second column (6×1 cells), referring to GVC income (and GVC employment) created by the six suppliers participating in the domestic (i.e., Korean) manufacturing GVC. We then move to the second row (1×6 cells), referring to the GVC incomes of domestic manufacturers through participation in six GVCs.

A. *Structural Changes in the Domestic Manufacturing GVC*

We now investigate GVC income created each year by industries that participate in the GVC organized by the Korean manufacturing sector. Figure 6 presents the proportion of each industry's value-added (i.e., GVC income) in Korea's total manufacturing output. Along with the VAX ratio in section 3, the GVC income ratio within the domestic manufacturing GVC can be used to measure the extent to which the domestic manufacturing sector has been internationalized over the sample period.

Specifically, the proportions of GVC income generated by foreign industries in the GVC gradually increased from 24.5% in 1995 to 37.5% in 2011. Among the three foreign industries, the share for the agricultural sector increases the most, from 5% to 12.7%, followed by the service sector (8.6%→12.1%) and the manufacturing sector (11%→12.7%) in that order. In contrast, the shares of GVC income created by the domestic industries have all been reduced; the proportion fell the most in the agricultural sector (8.7% → 3.2%) and then service (17.3%→14%) and manufacturing sectors (49.6%→45.3%) in that order.

[8]The GVC income matrix is calculated first and is then aggregated to make the two-country, three-sector matrix. Utilities and construction are included in the service industry category.

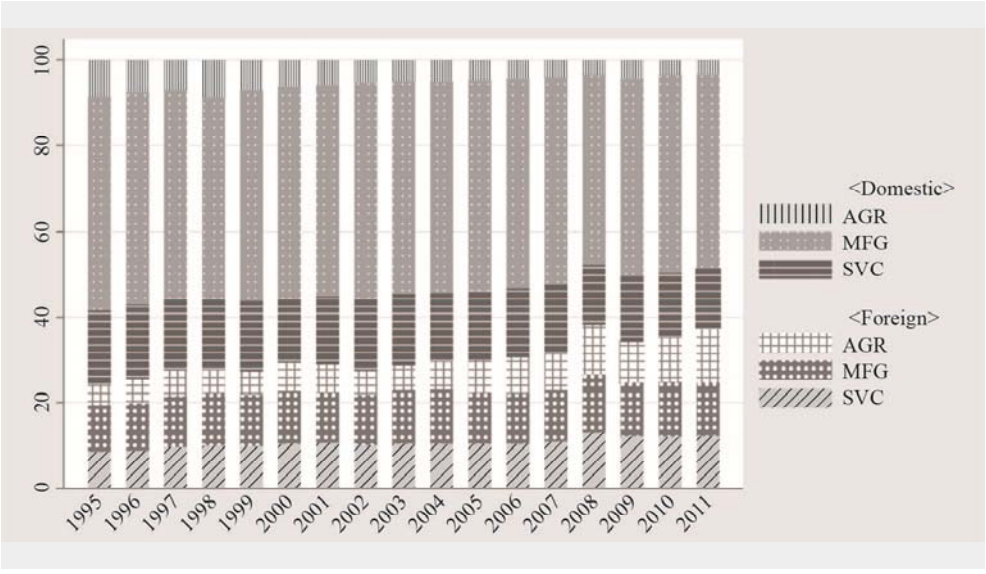

FIGURE 6. SECTORAL INCOME SHARES WITHIN THE DOMESTIC MANUFACTURING GVC

Note: Utilities and construction are included in the service industry category.

Source: World Input-Output Database (WIOD) and the author's calculations.

The trend shown in Figure 6 implies that the Korean manufacturing sector has replaced the domestic contents with foreign contents and that this is particularly true for raw materials and services. In other words, the domestic manufacturing sector has steadily intensified the internationalization of production activities by increasing raw materials and services offshoring. This rapid internationalization has indeed raised concerns regarding the hollowing out of the domestic manufacturing sector.

However, such concerns may be trivial when we take into account the total output of domestic manufacturing goods; if the total output in the manufacturing industry itself increases enough, GDP can still increase even when a significant portion is transmitted abroad through offshoring. Putting this differently, the effects that cause changes in GVC income can be divided into two parts. One is the substitution effect which arises when the domestic value-added is transmitted abroad and reduce the GDP of home country. The other is the output effect, where the variation in total output affects the level of GVC income created by the home country. If the output effect, caused by an increase in total output, is greater than the substitution effect, the GDP can still increase in the domestic manufacturing GVC.[9]

[9]For the same reason, the declining trend in the VAX ratio of Korea itself should not be a concern as long as the total export values compensate sufficiently for the decrease in the domestic value-added per unit of export value.

TABLE 5—GVC INCOME IN 1995 AND 2011

(A) 1995 ($ HUNDRED-MILLIONS, 1995 PRICE)

		KOR			ROW			GDP
		AGR	MFC	SVC	AGR	MFC	SVC	
K	AGR	139	138	31.1	0.7	10.6	9.1	329
O	MFC	11.4	793	310	9.6	217	160	1501
R	SVC	13.5	276	2726	9.6	130	161	3316
R	AGR	5.5	79	70				
O	MFC	5.6	175	139				
W	SVC	6.1	138	151				
Total		181	1600	3426				

(B) 2011 ($ HUNDRED-MILLIONS, 1995 PRICE)

		KOR			ROW			GDP
		AGR	MFC	SVC	AGR	MFC	SVC	
K	AGR	74.0	70.5	50.5	0.4	7.0	7.5	210
O	MFC	10.7	1010	384	20.6	504	507	2436
R	SVC	14.1	312	3770	13.5	243	350	4703
R	AGR	10.4	284	308				
O	MFC	6.5	282	242				
W	SVC	8.3	270	361				
Total		124	2228	5115				

(C) DIFFERENCE BETWEEN 2011 AND 1995

		KOR			ROW			GDP
		AGR	MFC	SVC	AGR	MFC	SVC	
K	AGR	-65	-68	19.4	-0.3	-3.6	-1.6	-119
O	MFC	-0.7	217	74	11	287	347	935
R	SVC	0.7	35	1044	3.9	113	190	1387
R	AGR	4.9	205	238				
O	MFC	0.9	107	103				
W	SVC	2.2	132	210				
Total		-57	628	1689				

(D) % CHANGE

		KOR			ROW			GDP
		AGR	MFC	SVC	AGR	MFC	SVC	
K	AGR	-47	-49	62	-38	-34	-18	-36
O	MFC	-6	27	24	114	132	217	62
R	SVC	5	13	38	40	87	118	42
R	AGR	89	260	342				
O	MFC	16	61	74				
W	SVC	36	96	139				
Total		-32	39	49				

Note: Data on ROW is omitted in order to concentrate on Korean industry.

Source: World Input-Output Database (WIOD) and the author's calculations.

Analyzing the changes in GVC income by isolating one effect from the other requires a more sophisticated model along with more specific data. Given the delicacy and availability of our model and data, we can at least identify which of the two effects is greater within the given period of time. Tables (a) and (b) in Table 5 display GVC income by industry for the years 1995 and 2011, and tables (c) and (d) show the difference and the growth rate in GVC income between the two years, respectively.

All participating industries in the Korean manufacturing GVC create added value of $160 billion in 1995, which increases by $62.8 billion (39%) to $222.8 billion in 2011. Among the $62.8 billion, $18.4 billion was created by the domestic industries, while the remaining $44.4 billion was generated by foreign industries. When calculated in terms of the growth rate, the real GVC income increases by 15% in domestic industries and 113% in foreign industries. This implies that the substitution effect increases from 1995 to 2011, but the output effect is even greater, making the net effect increase the real domestic GDP by 15%.[10] This result is consistent with recent studies that find a positive effect of foreign investment on domestic activities (e.g., Desai *et al*. 2009, Jang and Hyun 2012).

[10]Offshoring affects both the substitution and output effect directly, but the output effect cannot be fully explained by offshoring alone, as it is also caused by productivity growth through technical progress.

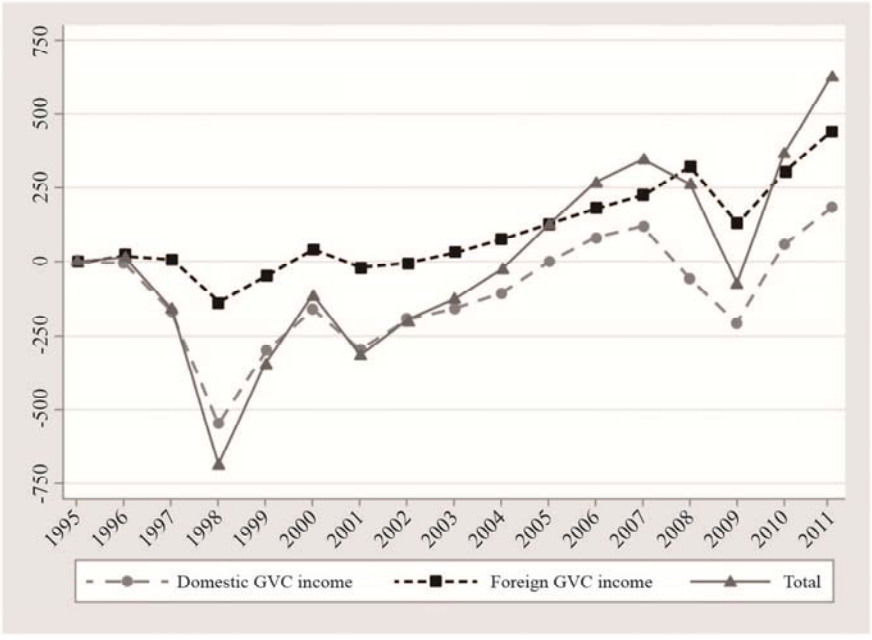

FIGURE 7. GROSS OUTPUT DIFFERENCES OF DOMESTIC MANUFACTURING COMPARED TO 1995

Note: GVC income adjusted to 1995 constant hundred-million US$.

Source: World Input-Output Database (WIOD) and the author's calculations.

However, in the domestic agricultural sector, GVC income decreases regardless of the increase in total output because the substitution effect is greater than the output effect. The GVC income of the domestic service sector does not increase as much. These phenomena imply that the size of the output effect may not always outweigh the substitution effect, as the substitution effect gradually intensifies through offshoring, while the output effect is easily influenced by aggregate shocks, such as recessions or financial crises, leading to a significant drop in GVC income. Thus, it is necessary to observe the change in GVC income by separating the two effects for all years in comparison with the base year of 1995.

Figure 7 plots the trend in the differences in the GVC income levels for each year from the level in 1995. The total output differences for each year are then divided into those of the domestic and foreign value-added. The GVC income of foreign industries rises gradually with small dips and marks steadily above the level for 1995, except for the period of the financial crisis in the 1990s. On the other hand, the GVC income of domestic industries is rather turbulent with significant drops in response to the sharp economic shocks in the late 1990s and late 2000s. The output effect over the course of the year is not large enough to offset the substitution effect, and Korea's real GDP by participating in the domestic manufacturing GVC remained lower than that of 1995 until recently.

As the location of production activities has shifted from Korea to foreign countries, the employment structure is expected to exhibit a pattern identical to that of the income structure. To confirm the validity of this statement, we put GVC

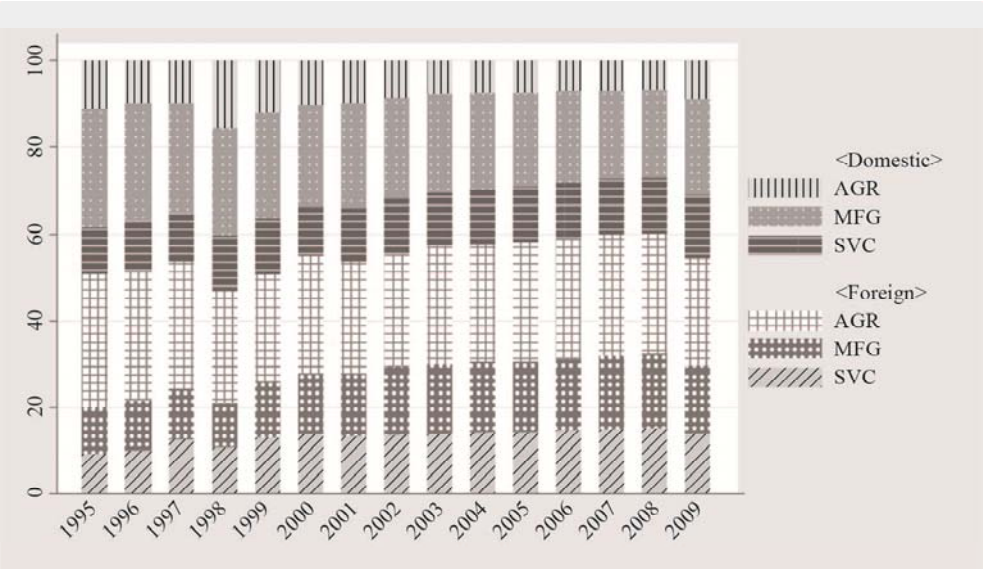

FIGURE 8. SECTORAL EMPLOYMENT SHARES IN THE DOMESTIC MANUFACTURING GVC

Note: Utilities and construction are included in the service industry category.

Source: World Input-Output Database (WIOD) and the author's calculations

employment in place of GVC income in Table 4. Subsequently, Figure 8 shows the GVC employment shares in the Korean manufacturing GVC. WIOD's SEAs provides data on national and industrial characteristics during the period from 1995 to 2009.

In Figure 8, we find the increase in the proportion of foreign GVC employment, just as in the case of GVC income. Specifically, in 1995 domestic and foreign workers numbered 4.7 million and 4.9 million, respectively, corresponding to 49% and 51% of the total working population in the domestic manufacturing GVC. However, 3.6 million domestic workers and 5.5 million foreign workers account for 40% and 60%, respectively, of the total labor force in 2008.[11] The substitution effect from the domestic to foreign industries occurs in GVC employment as well.

The structure of GVC income and employment are not identical in all respects however. One difference that stands out is that the proportion of foreign labor input is generally higher than that of foreign income. Foreign workers participating in the domestic manufacturing GVC already accounted more than 50% of the total labor force in 1995. The employment share in the foreign agricultural sector is especially high, presenting a stark contrast to the share in income in the agricultural sector. This suggests that the difference in the labor wage between the domestic and foreign industries is one of the main reasons for offshoring.

Dividing GVC income by GVC employment in each cell gives the labor

[11]We excluded 2009 data because in 2009, production and employment plummeted as the global financial crisis hit the world economy. Although 2008 was also affected by the exchange rate shock during the initial phase of the crisis, we still use 2008 data, as the GVC income shares for that year appear to be closest to those of 2011 and because its GVC employment shows a pattern similar to that for 2007.

TABLE 6—GVC EMPLOYMENT AND REAL LABOR PRODUCTIVITY IN 1995 AND 2008

(A) 1995 GVC EMPLOYMENT (TEN-THOUSANDS)

		KOR			ROW			TOT
		AGR	MFC	SVC	AGR	MFC	SVC	EMP
K	AGR	110	106	14	0.5	7.1	5.7	243
O	MFC	3.2	263	90	2.7	75	48	482
R	SVC	4.6	103	1089	4.1	51	63	1315
R	AGR	34	298	150				
O	MFC	3.2	105	76				
W	SVC	4.1	89	162				
Total		160	965	1580				

(B) 2008 GVC EMPLOYMENT (TEN-THOUSANDS)

		KOR			ROW			TOT
		AGR	MFC	SVC	AGR	MFC	SVC	EMP
K	AGR	62	61	43	0.3	4.6	4.7	175
O	MFC	1.9	184	73	2.8	80	72	414
R	SVC	4.7	116	1412	6.8	91	135	1766
R	AGR	18	258	260				
O	MFC	3.4	155	146				
W	SVC	4.0	139	193				
Total		93	913	2127				

(C) 1995 LABOR PRODUCTIVITY ($ THOUSANDS, 1995 PRICE)

		KOR			ROW			AVG
		AGR	MFC	SVC	AGR	MFC	SVC	
K	AGR	12.6	13.1	22.8	14.5	14.9	16.0	13.6
O	MFC	35.8	30.1	34.6	36.1	29.1	33.1	31.2
R	SVC	29.3	26.7	25.0	23.7	25.4	25.4	25.2
R	AGR	1.6	2.6	4.6				
O	MFC	17.4	16.7	18.2				
W	SVC	15.1	15.5	9.3				
Average		11.4	16.6	21.7				

(D) 2008 LABOR PRODUCTIVITY ($ THOUSANDS, 1995 PRICE)

		KOR			ROW			AVG
		AGR	MFC	SVC	AGR	MFC	SVC	
K	AGR	10.1	10.2	11.4	12.8	13.2	14.1	10.7
O	MFC	46.2	44.7	47.5	58.7	50.3	53.5	47.9
R	SVC	24.1	22.7	25.0	21.7	22.5	22.9	24.6
R	AGR	4.7	8.4	10.8				
O	MFC	14.5	16.3	16.1				
W	SVC	17.6	17.7	18.8				
Average		11.0	20.4	22.6				

Note: Data on ROW is omitted in order to concentrate on Korean industries.

Source: World Input-Output Database (WIOD) and the author's calculations

productivity (i.e., value-added per worker) and its trends. (a) and (b) in Table 6 show GVC employment in 1995 and 2008, respectively, and (c) and (d) in the table calculate the real labor productivity for those years. Both the share and absolute level of labor input decrease in the domestic agricultural and manufacturing sector but increase in the domestic service sector. Accordingly, the service sector labor productivity within the domestic manufacturing GVC is decreased from $26,700 in 1995 to $22,700 in 2008, showing a reduction of approximately 15%.

The main reason for the lower productivity of the service sector within the domestic manufacturing GVC is that the labor productivity in the business service industry, which is the most committed service in terms of value-added, dropped significantly from $39,300 in 1995 to $23,100 in 2008.[12] In contrast to the decline in domestic service productivity, foreign service productivity improved by 14% during the same period.

[12]See Table A3 for the service productivities engaged in the Korean manufacturing GVC at a disaggregate level.

B. *Redistribution of Production Factors within the Domestic Manufacturing GVC*

Given the finding that domestic income and employment in the Korean manufacturing GVC were replaced by foreign income and employment, respectively, through its active offshoring, we scrutinize in more detail the re-distribution of the domestic and foreign factors of production within the GVC.

Production factors that create added value can be divided in various ways depending on the classification method, but we classify them into labor and capital in this study. Capital is defined in its broadest sense and includes all production factors other than labor. On the other hand, labor is further divided into the low-skilled, middle-skilled and high-skilled types. In accordance with the standard classification method provided by the socio-economic accounts of WIOD, lower secondary or less, post-secondary to non-tertiary education, and tertiary education or above are classified as low-, middle-, and high-skilled workers, respectively.

In Table 7, the income for each of the production factors in 1995 and 2008 is calculated as a share of the total GVC income. The labor and capital income ratios in both the domestic and foreign industries add up to 100, as shown in the shaded area in the top two panels of the table. The labor income share in each industry is then divided into the shares for low-, middle-, and high-skilled labor. When examining the difference between the figures for 2008 and 1995, the income shares for low- and middle-skilled labor show a noticeable decline, by 9.7%p and 7.6%p respectively, whereas the share of high-skilled labor has increased slightly by

TABLE 7—DOMESTIC & FOREIGN SHARES OF FACTOR INCOMES WITHIN THE DOMESTIC MANUFACTURING GVC

Year	1995 (%)				
Prod. Factor	Low-skill	Mid-skill	High-skill	Labor	Capital
Domestic	13.2	26.3	18.5	**57.9**	**17.6**
Foreign	3.8	6.3	3.1	**13.2**	**11.2**
Developed	1.9	5.3	2.7	9.9	6.4
Developing	1.9	1	0.4	3.3	4.8

Year	2008 (%)				
Prod. Factor	Low-skill	Mid-skill	High-skill	Labor	Capital
Domestic	3.5	18.7	19.8	**42.0**	**19.7**
Foreign	4.2	7.8	4.8	**16.8**	**21.5**
Developed	1.3	4.9	3.6	9.8	7.1
Developing	2.9	2.8	1.3	7.0	14.4

Year	2008 - 1995 (%p)				
Prod. Factor	Low-skill	Mid-skill	High-skill	Labor	Capital
Domestic	-9.7	-7.6	1.3	-15.9	2.1
Foreign	0.4	1.5	1.7	3.6	10.2
Developed	-0.6	-0.4	0.9	-0.1	0.7
Developing	1.0	1.8	0.9	3.7	9.6

Note: Developed country consists of 20 out of 40 WIOD countries, excluding Korea. They are Australia, Austria, Belgium, Canada, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, Portugal, Sweden, Taiwan, and the United States. The rest of the WIOD countries plus ROW are classified as developing countries.

Source: World Input-Output Database (WIOD) and the author's calculations.

1.3%p. Due to the significant drop in the shares of low and middle-skilled income, the total labor income share has also been reduced by 15.9%, while the total capital income share has increased by 2.1%p. In consequence, the labor share of total factor income has decreased by 9%p, from 77% in 1995 to 68% in 2008.

The 13.8%p reduction in total in the domestic income shares has been replaced by increases in all of the foreign factor income shares. Note that, however, the increment of each share in the foreign industries is not proportional to that in the domestic industries. For example, despite the significant drops in the low- and middle-skilled labor income shares of domestic industries, the corresponding shares of foreign industries increased only slightly, by 0.4%p and 1.5%p, respectively. Meanwhile, it is interesting to note that high-skilled foreign labor income has increased even more, by 1.7%p.

The higher increase in the high-skilled labor income share is most likely due to the various destinations for production offshoring. For example, the manufacturers of leading-edge products and professional business services are likely to be offshored in advanced countries, increasing the high-skilled income share within the foreign industry. On the other hand, the low- and middle-skilled income shares may increase in developing countries, which are involved in simple assembly production processes.

Therefore, we divide the factor income shares into those of developed and developing countries. As expected, low- and middle-skilled income shares decreased in developed countries but increased in developing countries. However, the corresponding increments are only 1% and 1.8% in developing countries, and these levels do not appear to be high enough to compensate for the reduction in the domestic income shares. Rather, it is the increment in the capital income share in developing countries (9.6%p) that compensates for most of the reduction of the domestic income shares. But again, this result is not surprising, as developing countries tend to maintain a higher rate of return on their scarce capital, as explained in Timmer *et al.* (2014).

In the same manner presented in Table 7, we finally show in Table 8 the GVC employment shares by skill level between domestic and foreign industries within the domestic manufacturing GVC. The shaded areas in the top two panels of the table add up to 100, and the foreign employment shares are divided into those of developed and developing countries, as was done before. Moreover, we report the real average wages for each skill level by dividing labor income by the corresponding number of workers employed for a clearer understanding of the redistribution of the different types of labor across countries and industries within the GVC.

In the table, we note that the changes in the employment shares present a pattern similar to those of income shares. The high-skilled labor share has increased while the middle- and low-skilled labor shares have decreased within the domestic industries. The patterns of the increased high-skilled labor share and decreased low-skilled labor share are also evident in the foreign industries. Moreover, the middle- and high-skilled labor shares have increased greatly while the low-skilled labor share remained the same in developing countries.

The phenomenon by which the income and employment shares of middle- and high-skilled labor increase more than those of low-skilled labor is consistent with

TABLE 8—DOMESTIC & FOREIGN SHARES OF EMPLOYMENT AND CORRESPONDING AVERAGE REAL WAGES WITHIN THE DOMESTIC MANUFACTURING GVC

Year	1995					
	Employment (%)			Wage ($ thousands)		
Prod. Factor	Low	Mid	High	Low	Mid	High
Domestic	**13.8**	**23.5**	**11.6**	15.8	18.5	26.4
Foreign	**38.7**	**10.6**	**1.8**	-	-	-
Developed	1.2	2.4	0.8	27.8	36.7	56.9
Developing	37.5	8.2	1	0.8	2.1	6.1

Year	2008					
	Employment (%)			Wage ($ thousands)		
Prod. Factor	Low	Mid	High	Low	Mid	High
Domestic	**4.4**	**19.5**	**15.8**	23.2	27.8	36.1
Foreign	**38.5**	**17.6**	**4.2**	-	-	-
Developed	1	2.8	1.3	38.5	50.2	79.6
Developing	37.5	14.8	2.9	2.2	5.5	12.4

Year	2008 – 1995					
	Employment (%p)			Wage ($ thousands)		
Prod. Factor	Low	Mid	High	Low	Mid	High
Domestic	-9.4	-4	4.2	7.4	9.3	9.7
Foreign	-0.2	7	2.4	-	-	-
Developed	-0.2	0.4	0.5	10.7	13.5	22.7
Developing	0	6.6	1.9	1.4	3.4	6.3

Note: Developed country consists of 20 out of 40 WIOD countries, excluding Korea. They are Australia, Austria, Belgium, Canada, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, Portugal, Sweden, Taiwan, and the United States. The rest of the WIOD countries plus ROW are classified as developing countries.

Source: World Input-Output Database (WIOD) and the author's calculations.

the claim by Feenstra and Hanson (1997, 1999). These authors argue that the tasks that were once done by unskilled labor in advanced countries are now completed by middle- or high-skilled workers of developing countries, thus decreasing the demand for unskilled labor in developed countries while increasing the demand for and income of skilled labor in developing countries.

Finally, the table indicates an exacerbated degree of wage inequality between skilled and unskilled labor in all country groups, which again confirms the claim made by Feenstra and Hanson (1997, 1999).[13] Compared to foreign countries, however, the relative wage gap according to skill level is not that large in Korea. Perhaps this can be explained by the fact that the high college enrollment rate has increased the share of high-skilled labor in Korea.

C. *Change in the Pattern of Domestic Manufacturers' GVC Participation*

We now turn our attention to the trends of GVC incomes domestic manufacturers create by participating in GVCs as suppliers. As shown in Table 4,

[13]Jeon *et al*. (2013) employ Feenstra and Hansen's (1997, 1999) empirical strategy to identify the offshoring and trade effect on the wage premium in Korean industries. Their result is consistent with ours.

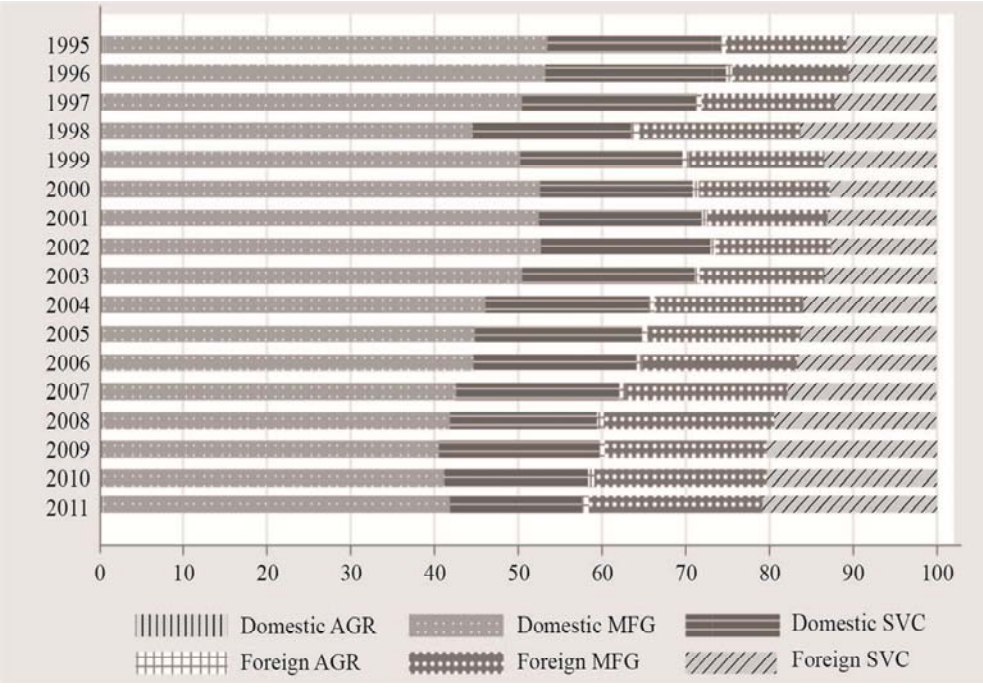

FIGURE 9. INCOME SHARES OF DOMESTIC MANUFACTURING BY PARTICIPATING IN SIX GVCS

Source: World Input-Output Database (WIOD) and the author's calculations

there are six GVCs joined by domestic manufacturers as suppliers including its own. The second row in the table refers to the GVC incomes generated through its participation. GVC income in each cell is then depicted in Figure 9 as a percentage of the total, which forms the GDP of the domestic manufacturing industry.

The GVC income share from participating in the three foreign GVCs is 25.7% for 1995, and it gradually increases to 42.3% for 2011. Specifically, 42.3% of the domestic manufacturing GDP is generated by participating in foreign GVCs. In addition, the income generated by participating in foreign GVCs has been greater than the income through its own GVC since 2009. Therefore, the production of intermediate goods to sell in the global market plays a more significant role for domestic manufacturers as compared to the production of final goods. Thus, the participation of domestic manufacturers as suppliers in foreign GVCs is as conspicuous as the participation as an organizer; the levels have been active in both cases.

We can find how much of the domestic manufacturing GVC income changes in each of the six GVCs by looking at the second rows of (a) through (d) in Table 5. For example, as shown in (d) in the table, the domestic manufacturing GVC incomes change by -6%, 27%, and 24% within domestic GVCs, whereas these levels increase by 114%, 132%, and 217% in the foreign GVCs. Therefore, more than two-thirds (69%) of the increase in the domestic manufacturing GDP between 1995 and 2011 can be attributed to the income generated by participating in foreign GVCs as suppliers.

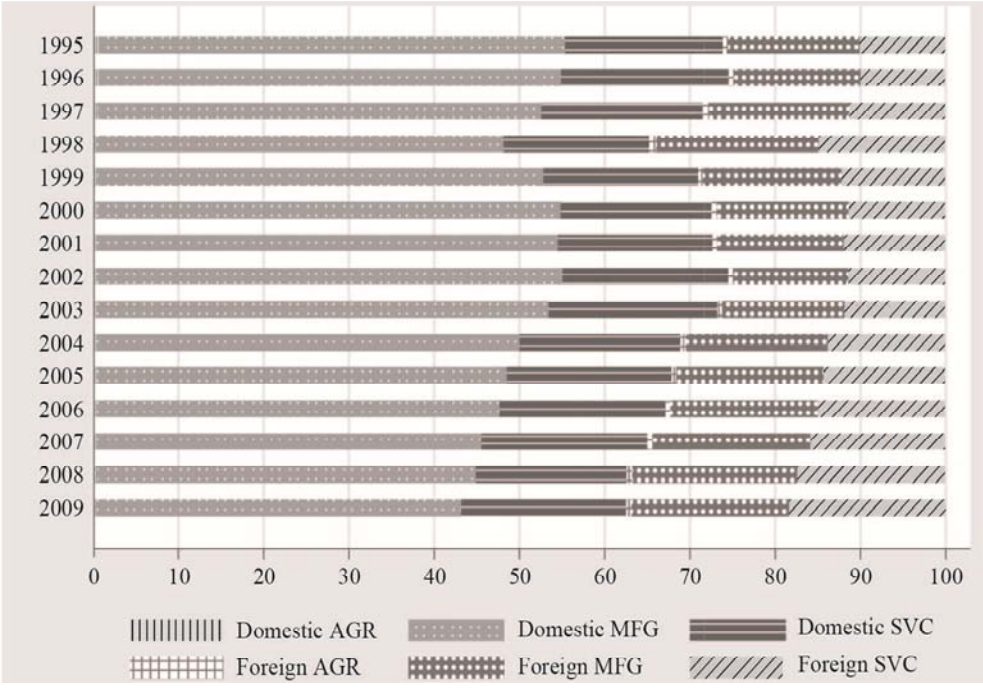

FIGURE 10. EMPLOYMENT SHARES OF DOMESTIC MANUFACTURING BY PARTICIPATING IN SIX GVCS

Source: World Input-Output Database (WIOD) and the author's calculations.

Figure 10 provides information about the domestic manufacturing GVC employment created by both home and foreign GVCs. As in the case of GVC income, the GVC employment share within the foreign GVCs increases from 26.1% in 1995 to 37.4% in 2008. The GVC income and employment shares are similar in 1995 (26%), but over time we find that the income share surpasses the employment share. In other words, the same domestic manufacturers happen to have higher productivity when participating in foreign GVCs than in the domestically organized GVCs. This is illustrated in the second rows of (c) and (d) in Table 6.

If the result above is true, it is plausible that the suppliers of intermediate goods to export abroad have higher productivity than those that satisfy the domestic demand. The reason for the higher productivity cannot be explained directly in this study, but related literature gives interesting explanations, such as the tendency of highly productive firms to enter export markets (Melitz 2003) and the learning effect of exporting firms to become highly productive (De Loecker 2013).

V. Concluding Remarks

Global value chains have been widespread in recent decades due to technological developments and greater trade openness across countries. Firms now have more options than before regarding how to produce a good; by strategically organizing their production sequences on a global scale, they can

improve their efficiency and thus the competitiveness of their products.

How have Korean industries utilized this changing environment and what are the consequences? To answer this question, we formally measure the extent to which Korea has participated in GVCs over the last two decades and evaluate how this level affects the value-added and employment structure in the Korean manufacturing industry. It was found here that Korea is one of the countries that participated in GVCs most actively between 1995 and 2011, both as the organizer of its own GVC and as a supplier of foreign GVCs. As a result, the final products of the Korean manufacturing industry contain a greater value-added from foreign labor and capital than before, which in turn reduces the ratio of value-added exports to gross exports. At the same time, however, Korean manufacturers also increased their contribution to foreign GVCs by supplying intermediate goods, thereby accounting for more than 50% of the total manufacturing GDP. Another result of Korea's active GVC participation is the reallocation of labor within the domestic manufacturing industry toward skilled workers and thereby an increase in the wage premium.

Although the findings above are mainly to inform the reader of the overall trend in the international activities of Korean industries, they still have several policy implications. The first is related to the need to strengthen the input competitiveness of domestic industries. The GVC perspective emphasizes that we should focus more on contributing to the product than on the selling price. Thus far, Korea has been good at exports, but in many exporting products, the core inputs with high value-added tend to be outsourced from foreign countries, particularly Japan. This tendency is more evident in major exporting industries and thus reduces the contribution of exports to GDP, as shown in Table 2 and Figure 4.[14] Therefore, domestic industries need to develop the ability to provide highly valued inputs in this GVC world. Note also that the need to strengthen the input competitiveness is not specifically limited to manufactured goods. Figure 6 shows that significant service inputs are embedded in manufactured goods, but the competitiveness of Korean services has been weak, as indicated in Figure 5.

The second policy implication, related to the first, is to provide more incentives to firms to locate their production facilities in Korea. In the end, the GDP is created only when production activities occur within domestic territories. The high reliance on offshoring can seriously hamper domestic economic growth when global demand shrinks, as shown in Figure 7. On the other hand, Tables 5 and 6 (as well as Figures 9 and 10) indicate that domestic industries create ever-growing amounts of value-added and employment by participating foreign GVCs as intermediate goods exporters. Hence, it is important to incentivize firms to locate and produce within Korea, regardless of whether they are domestic- or foreign-owned. Korea has been in fact unattractive to foreign firms, as the ratio of inbound FDI stock to GDP was only 13.7% in 2013, the third lowest among all OECD countries.[15]

Thirdly, industrial policies should reflect the trend of foreign final demand. As shown in Figure 3, close to one-third of Korean GDP was created by foreign final

[14]Recall that the VAX ratios of three major exporting industries are just about 0.4.

[15]The average ratio of inward FDI stock to GDP in all OECD countries is 61.1%, while the ratios of Japan and Greece are 3.5% and 11.5%, respectively.

demand in 2011, and this reliance on foreign final demand has been much larger than in 1995. As Korea has become one of the most globalized countries, its economy can easily be affected by foreign economic shocks. Thus, suitably managing such foreign shocks should be essential to the economic success of Korea. In particular, Table 3 indicates that China is now the largest single consumer of Korean value-added, which implies that structural changes in Chinese final demand can systematically affect Korea's production and exports (see Chung 2015 for more details).

APPENDIX

In this appendix, we derive the equations for GVC income, GVC employment, and value-added exports. Suppose there are N countries and S sectors in each country. Each country produces only one good (or service) within each sector. Hence, there are $N \times S$ goods in the world that can be used as either an intermediate good (m) or a final good (f). We denote $y_i(s)$ as the output of sector s in country i for a given year. Let the final demand in country j for good s produced in country i be $f_{ij}(s)$, and the intermediate demand in sector s' in country j for the good s in country i be $m_{ij}(s,s')$.

The market clearing condition for the good s in country i is then given by

$$y_i(s) = \sum_j f_{ij}(s) + \sum_j \sum_{s'} m_{ij}(s,s') = \sum_j \left[f_{ij}(s) + \sum_{s'} m_{ij}(s,s') \right]. \tag{A1}$$

The gross exports in sector s from country i to country j is, by definition, the sum of its intermediate and final good exports:

$$x_{ij}(s) = f_{ij}(s) + \sum_{s'} m_{ij}(s,s'). \tag{A2}$$

It is convenient to express above equations in vector and matrix notations. First, we define the following notations.

y_i : output of country i $(S \times 1)$

y : output of all countries $(SN \times 1)$

f_{ij} : final demand of country j for all goods from country i $(S \times 1)$

f_j : final demand of country j for all goods from all countries $(SN \times 1)$

$f = \sum_j f_j$: final demand of the world for all goods from all countries $(SN \times 1)$

$a_{ij}(s,s') \equiv m_{ij}(s,s') / y_j(s')$: unit value of good s in country i to produce one unit (value) of good s' in country j, i.e., the input coefficient

A: input coefficient matrix where $a_{ij}(s,s')$ is a typical element $(SN \times SN)$

$r_i(s) = 1 - \sum_j \sum_{s'} a_{ji}(s',s)$: value-added to output ratio in good s in country i

R: diagonal matrix where $r_i(s)$ is a typical element $(SN \times SN)$

F: diagonalized matrix of f $(SN \times SN)$

(A1) can then be rewritten in the form of the equation on the left in (A3), which can further be solved for y as in the equation on the right-hand side in (A3),

$$\text{(A3)} \qquad y = Ay + \sum_j f_j \Leftrightarrow y = (I - A)^{-1}\left[\sum_j f_j\right] = (I - A)^{-1} f$$

where $(I - A)^{-1}$ is the Leontief inverse. This matrix measures how much each sector in each country should produce to satisfy one unit of final demand in the world. Therefore, pre-multiplying the Leontief inverse by R gives the value-added in each sector created by one unit of world final demand.

GVC income is obtained when post-multiplying $R(I - A)^{-1}$ by the actual (diagonalized) final demand in the world (F), i.e.,

$$\text{(A4)} \qquad GVC\ income = R(I - A)^{-1} F.$$

GVC income can be decomposed further into the incomes by production factors, as we know the income share of each production factor. For example, if the labor income share of the total value-added in sector s in country i is $w_i(s)$, the GVC labor income is obtained as follows,

$$\text{(A5)} \qquad GVC\ labor\ income = WR(I - A)^{-1} F,$$

where W is the diagonal matrix with the $w_i(s)$ elements.

GVC employment is obtained when replacing the labor input-to-output ratio, $l_i(s)$, with R in (A4), i.e.,

$$\text{(A6)} \qquad GVC\ employment = L(I - A)^{-1} F$$

where L is the diagonal matrix with the $l_i(s)$ elements. As in GVC income, GVC employment can also be decomposed into the employment by skill level (e.g., low-,

medium-, and high-skilled workers) if we know the distribution of employment at different skill levels.

Meanwhile, value-added exports (VAX) of sector s from country i to country j is calculated as

$$VAX_{ij}(s) = r_i(s)\, y_{ij}(s), \tag{A7}$$

where $y_{ij}(s)$ is the output produced in sector s of country i due to the final demand in country j. Finally, the VAX ratio of country i is defined as the ratio of its aggregate value-added exports to the aggregate gross exports, i.e.,

$$VAX\ ratio_i = \frac{\sum_j \sum_s VAX_{ij}(s)}{\sum_j \sum_s x_{ij}(s)}. \tag{A8}$$

WIOT provides all of the necessary information, including industry-level outputs (y), final demand (f), intermediate demand (A), value-added ratio (R), and labor input (L). Table A1 and Table A2 show the industry classification and sample countries in the WIOT, respectively.

TABLE A1—INDUSTRY CLASSIFICATION IN THE WIOT AND CORRESPONDING KSIC9

Industry number	Industry name	KSIC9	Three-sector classification
1	Agriculture, Hunting, Forestry and Fishing	A	Agriculture
2	Mining and Quarrying	B	
3	Food, Beverages and Tobacco	10t12	Manufacturing
4	Textiles and Textile Products	13t14	
5	Leather, Leather and Footwear	15	
6	Wood and Products of Wood and Cork	16	
7	Pulp, Paper, Printing and Publishing	17t18, 58	
8	Coke, Refined Petroleum and Nuclear Fuel	19	
9	Chemicals and Chemical Products	20t21	
10	Rubber and Plastics	22	
11	Other Non-Metallic Mineral	23	
12	Basic Metals and Fabricated Metal	24t25	
13	Machinery, Nec	285, 29	
14	Electrical and Optical Equipment	26t27, 281t284, 289	
15	Transport Equipment	30t31	
16	Manufacturing, Nec, Recycling	32t33, 37t39	
17	Electricity, Gas and Water Supply	D	Service
18	Construction	F	
19	Sale, Maintenance and Repair of Motor Vehicles	45, 952	
20	Wholesale Trade and Commission Trade	46	
21	Retail Trade; Repair of Household Goods	47, 951, 953	
22	Hotels and Restaurants	I	
23	Inland Transport	49	
24	Water Transport	50	
25	Air Transport	51	
26	Other Supporting and Auxiliary Transport Activities	52	

TABLE A1—INDUSTRY CLASSIFICATION IN THE WIOT AND CORRESPONDING KSIC9 (*CONTINUED*)

Industry number	Industry name	KSIC9	Three-sector classification
27	Post and Telecommunications	61	Service
28	Financial Intermediation	K	
29	Real Estate Activities	68	
30	Renting of M&Eq and Other Business Activities	62t63, 69t75	
31	Public Admin and Defense; Compulsory Social Security	O	
32	Education	P	
33	Health and Social Work	Q	
34	Other Community, Social and Personal Services	50t60, R, 94, 96	
35	Private Households with Employed Persons	T	

TABLE A2—SAMPLE COUNTRIES IN THE WIOT

Country code	Country name	Country code	Country name
AUS	Australia	ITA*	Italy
AUT*	Austria	JPN	Japan
BEL*	Belgium	KOR	Korea
BGR*	Bulgaria	LTU*	Lithuania
BRA	Brazil	LUX*	Luxembourg
CAN	Canada	LVA*	Latvia
CHN	China	MEX	Mexico
CYP*	Cyprus	MLT*	Malta
CZE*	Czech Republic	NLD*	Netherlands
DEU*	Germany	POL*	Poland
DNK*	Denmark	PRT*	Portugal
ESP*	Spain	ROM*	Romania
EST*	Estonia	RUS	Russia
FIN*	Finland	SVK*	Slovakia
FRA*	France	SVN*	Slovenia
GBR*	United Kingdom	SWE*	Sweden
GRC*	Greece	TUR	Turkey
HUN*	Hungary	TWN	Taiwan
IDN	Indonesia	USA	United States
IND	India	ROW	Rest of the world
IRL*	Ireland		

Note: * indicates EU27 countries.

TABLE A3—VALUE-ADDED AND LABOR PRODUCTIVITY IN KOREAN SERVICE INDUSTRIES

Industry	2008 Value-added ($ hundred million)	1995 Labor productivity ($ thousands)	2008 Labor productivity ($ thousands)
Wholesale	32.3	13.3	15.1
Retail	23.2	13.6	14.7
Inland Transport	23.7	25.1	27.3
Finance & Insurance	39.1	41.3	54.0
Real Estate	15.1	144.4	94.6
Business Services	68.5	39.3	23.1

Note: 1995 constant prices.

Source: World Input-Output Database (WIOD) and the author's calculations.

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