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# Research on Participation and Position Evaluation of Korean Manufacturing Global Value Chain: Based on the Comparative Analysis with China and the United States

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## Abstract

***Purpose*** – This article will take the Korean manufacturing industry as an example to estimate Korea's global value chain status from the perspective of overall and sub-industry, hoping to provide a theoretical reference for Korean manufacturing to climb the global value chain.

***Design/methodology*** – Based on the WIOD data. The data is calculated by using MATLAB (2014a) coding. The data for 6 sectors are classified according to the International Standard Industrial Classification revision 3 (ISIC Rev. 3), the WIOD data are used to calculate and compare the position, participation and dynamics of the Korea, China and USA` manufacturing industry in the 1995-2016.

***Findings*** – The empirical results supported conclusions of the theoretical model. In the Korean GVC of electrical and optical sector, while stronger forward linkages than backward linkages to GVC are advantageous for an average advanced country, the benefits of downstream tasks are pronounced for non-advanced countries. And proved the correlation for an index to capture a country's upstream position or downstream position, it makes sense to compare that Korea's exports of intermediates in the same sector that are used by China and USA.

***Originality/value*** – The first is to re-examine the characteristics of South Korea's participation in global value chains under a more systematic and accurate theoretical framework, which provides a new empirical reference for related research; the second is to content covers of the manufacturing 6 sectors, so as to more completely describe the characteristics of Korean manufacturing's participation in global value chains; The value of this paper is providing empirical evidence of the effect of Korea's the GVC of manufacturing sectors. In the GVC of 6 sectors, first three have a higher position in the value chain and are in the upper middle and upper reaches of the GVC. The latter two have a low GVC position index, which has become the main sector that pulls down the overall position of Korea's manufacturing industry.

**Keywords**: Global Value Chain, Korea, Participation, Position
**JEL Classifications**: D9, F710, O14

## 1. Introduction

From the early 1960s to the early 1970s, Korea took advantage of the opportunity of industrial restructuring in Japan and Europe and the United States to undertake labor-intensive industries such as textiles, clothing, and daily necessities. This was the first time Korea had undertaken international industrial transfer. Beginning in the early 1970s, the

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outbreak of the two oil crises caused Western developed countries to accelerate the development of technology-intensive industries such as new energy and microelectronics, and gradually abandon capital-intensive industries such as steel, shipbuilding, and chemicals. In response to this change, the Korean government issued the "Declaration of Heavy Chemical Industrialization" in January 1973, focusing on ten industries such as steel, machinery, shipbuilding, automobiles, and petrochemicals. This is the second time that Korea has undertaken industries transfer (Li and Hou,2019). Beginning in the late 1970s, Korea also transferred some labor-intensive industries that gradually lacked comparative advantages to ASEAN and China. In the 1980s, technology-intensive industries represented by information technology and life sciences developed rapidly in developed countries in Europe and the United States. Korea undertook capital and technology-intensive industries such as electrical and electronics, chemicals, and transportation machinery. In these three industrial transfers, parts of Korea's industries, such as shipbuilding and steel, have embarked on a development path of "imitation and innovation". Other industries, such as textiles and garments, automobiles, electronics, daily chemicals, animation, etc., firstly intervene at the low end of the industry chain, even starting from OEM, and gradually extending to ODM and OBM, realizing the leap to the high end of the value chain. However, since the 2008 international financial crisis, with the implementation of the "re-industrialization" strategy of developed countries and the increasing international competition in the manufacturing industry, Korea's manufacturing industry is facing new challenges and urgently needs to implement a new round of transformation and upgrading Korean manufacturing competitiveness.

With the in-depth development of the information technology revolution and economic globalization, the international division of labor has undergone tremendous changes, allowing resources to be integrated and effectively used on a global scale. Under the realistic background of the division of labor in the global value chain, countries obtain certain benefits in the production and creation of product value, but the distribution of benefits in the value chain is uneven. Countries located in the upper reaches of the value chain mainly provide cores to other countries. Raw materials or intermediate products control and control the two ends of the value chain with high added value; developing countries located in the downstream link of the value chain import a large amount of foreign intermediate inputs to produce final products, which are squeezed into low value-added processing Manufacturing process. While the global value chain brings opportunities and benefits to Korean industries, it is also accompanied by many risks and challenges. These uncertain factors will bring some new problems to Korean companies, such as high input and low output, and value chain position bottlenecks, foreign capital's absolute control over the industry, etc. Countries located in the upstream link of the value chain mainly provide core raw materials or intermediate products to other countries, and control and control both ends of the value chain with high added value; developing countries located in the downstream link of the value chain import a large amount of foreign intermediate inputs to The production of final products is squeezed in the low value-added processing and manufacturing links. How to seize the development opportunities of globalization, better integrate into the international division of labor system, and achieve the climb to the high-end links of the global value chain and the acquisition of a controlling position is an effective way for Korea to become a trade power. Since countries are in different positions in the division of labor in the value chain, and their different positions determine the benefits of division of labor a country obtains in trade, how to fully integrate into the global value chain division of labor system, taking into account the global value of Korean manufacturing The position in the chain not only affects the formulation of Korea's opening policy and industrial policy, but also relates to whether

Korea can seek advantages and avoid disadvantages in this process. It is also an important issue that needs to be solved urgently to realize the transformation and upgrading of Korea's manufacturing industry (Yang, 2015). Therefore, measuring and judging Korea's position in the global value chain and the degree of participation in the international division of labor has always been the focus of domestic and foreign scholars. This article will take Korea's manufacturing industry as an example to estimate Korea's global value chain position from the perspective of overall and sub-industry, hoping to provide a theoretical reference for Korean manufacturing to climb the global value chain.

The main contributions of this article are as follows: First, re-examine the characteristics of Korea's participation in global value chains under a more systematic and accurate theoretical framework, and provide new empirical references for related research; second, from the dual perspectives of forward and backward linkages Analyzing the characteristics of global value chains has made up for the lack of existing literature that is limited to a single perspective; third, the research content covers most of the manufacturing sectors, so as to more completely characterize the characteristics of Korean manufacturing participating in global value chains; fourth, revealing that Korea has been involved in global value chains in recent years Some new features of participating in global value chains have revised some conclusions in the existing literature.

The structure of the rest of this article is the second part to explain the methods and data used in this article; the third part is the test results of the position and upgrades position of some of Korea's manufacturing industries in the global value chain, and is similar to the United States, China and other manufacturing powerhouses. Compare the situation; the fourth part is the conclusion.

## 2. Literature Review

### 2.1. The Meaning of Global Value Chain

The United Nations Industrial Development Organization (United Nations Industrial Development Organization, UNIDO) once authoritatively pointed out: "The global value chain refers to a global enterprise that conducts research and development, manufacturing, marketing, and recycling of goods or services on a global scale, and is connected to realize the value of these products. A networked organization chain, which involves the entire process of the procurement and transportation of raw materials, the production and distribution of intermediate inputs and final products, and the final consumption and recycling of goods or services." The global value chain includes the organizational models and value distribution methods of all participating entities and production and operation activities, and uses a professional process system to connect with suppliers, partners and customers in the chain division of labor to support the operating capabilities of the participating entities And efficiency, and multinational companies spreading all over the world and embedded in the global value chain are carrying out a series of continuous value-added activities from product development and design, manufacturing, marketing, after-sales service to final recycling, etc.; worldwide The value chain is mainly based on the vertical dimension of value to study the relationship between the global economic organization and the division of production, while the global production network maps the relationship between the global economic organization and the division of production from the horizontal and vertical dimensions, so the description of the global economic form is more three-dimensional and complex ; The traditional theory of global value chain division of labor particularly emphasizes the analysis

of the value level. Many existing studies decompose the product structure and functional structure of the value chain when analyzing the governance path of the global value chain, in order to find the realization ideas for climbing the high-end nodes of the value chain(Wang,2016). The multi-dimensional construction of global value chains is also conducive to the integrated analysis of multiple industrial chains. Porter (1985) was the first to notice the phenomenon of the division of labor in the value chain between enterprises within the industry, and put forward the value chain theory. His research perspective at that time only paid attention to the country's internal, and only considered the interaction between different enterprises in the production of the same product division of labor and cooperation(Porter,1985).

## 2.2. Measurement of the Position of the Division of Labor in the Global Value Chain

Scholars from various countries have used different indicators to quantitatively analyze the position of the division of labor in the global value chain to judge its governance model. Tu (2011) used RCA and other indexes to analyze the international competitiveness of China's manufacturing industry and its position in the global value chain when studying manufacturing upgrades; Wang and wei (2008) used exports in the research. The commodity structure similarity index is used to consider the different positions of a country's industry in the global value chain. By comparing the similarity of the export product structure of developing countries and developed countries, we can study and judge the relationship between a country's industry and the high-end nodes of the global value chain. Relative distance, and gives a reference; many scholars usually use indirect and alternative indicators to measure the position of a country's industry in the global value chain, although it can help analyze some countries to a certain extent. Or the development position of certain industries in the global economy in the global economy, but there are still certain limitations in the detailed discussion of a specific industry, which is largely due to the difficulty of obtaining and collating relevant data. In addition, the GVC position index is an important indicator and method for judging the position of a country's manufacturing industry embedded in the global value chain. Some studies also use the upgrade index of Kaplinsky and others to measure the dynamic position of manufacturing upgrades(Lin and He,2015). Koopman et al. (2010) created a mathematical decomposition model of total exports based on value-added trade theory and forward linkages, and used Hummels et al. (2001) to construct a global value chain participation index and a position index to quantitatively evaluate a country's global. Hummels et al. (2001) created the "Vertical Specialization Index" and used the HIY model to measure the degree of vertical division of OECD countries and emerging developing countries; Wen and Xian (2010) combined the HIY model with China's national conditions and obtained The latest data on the vertical sub-project degree of China's manufacturing industries; Yu and Deng (2014) reformed the HIY method on the basis of separating processing trade from general trade. Tang (2015) uses a net trade index that pays equal attention to imports and exports to investigate 22 sub-industries in China's manufacturing industry, and evaluates the different performance of these industries in each link of GVC.

## 2.3. Division of Labor in Global Value Chains and Manufacturing Upgrades

In the research on the division of labor in the global value chain and the upgrade path of the manufacturing industry, Wang et al. (2015) used industrial industry panel data to estimate that the overall effect of industrial transformation is on the rise. The deepening of GVC

embeddedness is conducive to promoting China's industrial transformation and upgrading, but It has the most significant impact on labor-intensive and technology-intensive industries; Kam (2013) conducted a study on the international production segmentation of Malaysia's manufacturing industry, and the results showed that international production segmentation is conducive to the technological progress of the manufacturing industry, and also conducive to improvement The country's position in the global value chain. Wang and Li (2020) Research on the position and participation index of manufacturing global value chain in 42 countries from 2003 to 2014, found that OFDI can improve the position and high score of the home country's manufacturing global value chain in the higher quantile Participation in the global value chain of the home country's manufacturing industry hinders the improvement of the position and participation of the home country's manufacturing global value chain in the low quantile. At the same time, OFDI can increase the participation of the developed country's manufacturing global value chain in the high quantile. At the same time, it will hinder the promotion of the global value chain position of the developed countries' manufacturing in the 0.10 quantile and the middle quantile. Ren (2017) uses the world input-output table data to calculate the manufacturing trade value-added and structure of China, Japan and Korea, and comparative analysis of the position of the three countries' manufacturing in the global value chain and the degree of division of engineering. Research shows that the position of China's manufacturing industry in the global value chain is constantly improving, Korea is stabilizing, and Japan is declining. China's low- and medium- and high-tech manufacturing industries are in the upper reaches of the value chain, and high-tech manufacturing has a higher degree of participation in the value chain, but the position is lower than that of Korea and Japan. The manufacturing industries of all technological levels in Japan are in the middle and upper reaches of the value chain, but all have a downward trend. Korea has the highest degree of participation in value chain sub-projects in manufacturing industries of all technological levels. The increase in the proportion of foreign value of exported intermediate products is an important reason for the deepening of the degree of global participation in the value chain of China, Japan and Korea. From the perspective of value chain integration, Shao and Li (2007) explained that the transformation and upgrading process of manufacturing industry is a process of industrial innovation and industrial value appreciation, which promotes the leap of value modules along the value chain and the evolution of the value chain. The transition of value modules and value chains requires the promotion of "innovative energy". The level of "innovative energy" not only reflects the size of industrial innovation and how much industrial value is added, but also can be used as an important measure for judging the integrated performance of the value chain. Chen and Liu (2011) used I-O analysis and found that the lower intermediate input levels and obvious leakage effects in various sectors of the equipment manufacturing industry hindered the extension of the domestic value chain, and intensified GVC's impact on China's equipment manufacturing industry. Lock-in effect.

## 2.4. Global Value Chain Division of Labor System

As the concept of global value chain has received more and more heated discussions in the international academic community, more and more researches on the division of labor system of global value chain have also attracted the attention of many scholars, and this research is also the theory of global value chain One of the core issues. In order to distinguish it from the original form of international division of labor and highlight the differences in the specialization of different stakeholders in the global production network, the concept of the global value chain division of labor system has entered the field of relevant research (Alvstam

et al., 2020; Pratono, 2020; Beach and Virgo, 2019; Sun et al., 2019). Hummels et al. (2001) believe that a country can participate in the vertical specialization international division of labor in two ways, namely, importing intermediate inputs for the production of exports (backward linkage) and exporting intermediate inputs for the production of exports by other countries (Forward linkage), and use the indicators VS (the value of imported inputs contained in a country's exports), VS1 (the part of a country's exports that are used as intermediate inputs for exports by other countries) and the ratio of the two to total exports To measure the scale of vertical specialization and the degree of participation. Fally (2011), Antràs et al. (2012) and other documents try to construct indicators such as the length of the production chain, upstream degree, and downstream degree to measure which part of the global value chain a country conducts specialized production, and then judge a country as a whole and its industry Position and division of labor in the global value chain. The main difference between the global value chain division of labor system and the traditional form of international division of labor is: the division of labor in the global value chain places more emphasis on enterprises represented by multinational companies. Huang et al. (2019) Technological progress has a promoting effect on the improvement of manufacturing competitiveness, blindly Deepening the global division of labor system is not conducive to the upgrading of the manufacturing industry. It is necessary to rely on technological progress to promote the improvement of international competitiveness by improving the position of division of labor, and thus realize the overall upgrade of the manufacturing industry. In the process of shifting the manufacturing industry to the high-end nodes of the global value chain, it is necessary to transform the vertical The idea of division of labor to the level of division of labor, build a "whole industry chain" development model led by technological progress, create a manufacturing value ecosystem, and conduct horizontal cooperation with global partners in multiple value links, increase China's domestic indirect value-added rate, and enhance manufacturing International competitiveness of the industry (Huang, 2019).

It can be seen that due to different research fields, directions and national conditions, the focus of the same general research direction will be different. In addition, due to differences in research angles, database selection, research methods, and index structures, the research results may vary greatly. There are many studies on the position of the manufacturing industry, but the research based on the GVC perspective is relatively lacking. Exploration from this perspective is innovative and can reflect the position of a country's manufacturing industry in the global value chain. Therefore, this article refers to the research results of other scholars, combines the current position of the industry, selects the latest available data, measures the position of Korea's manufacturing industry from the GVC perspective, and proposes more targeted and operable countermeasures based on the calculation results.

## 3. Empirical Method and Data

### 3.1. Model Construction of the Value Chain Position Measurement Index System

This paper draws on the decomposition method of Koopman et al. (2011) on a country's total exports to measure the foreign added value contained in Korea's exports, as well as Korea's participation in GVC and its international division of labor position.

Suppose there are two countries (country r and country s), and each country has n departments. All products can be used as intermediate products or final products, which can be used in the country or exported to foreign countries for use. Therefore, the following

equation can be used to express a domestic product:

$$E_r = A_{rr}X_r + A_{rs}X_s + Y_{rr} + Y_{rs} \quad r,s = 1,2 \tag{1}$$

Among them, X r and Y rs are both N × 1 order vector, which respectively represent the total output of country r and the final demand of country s for domestic production of r; Ars is an N × N order square matrix, which represents the production used in country s The direct consumption coefficient of intermediate goods in country r is: (1) Equation can be written in matrix form:

$$\begin{bmatrix} X_r \\ X_s \end{bmatrix} = \begin{bmatrix} A_{rr} & A_{rs} \\ A_{sr} & A_{ss} \end{bmatrix} \begin{bmatrix} X_r \\ E_s \end{bmatrix} + \begin{bmatrix} Y_{rr} & Y_{rs} \\ Y_{sr} & Y_{ss} \end{bmatrix} \tag{2}$$

The above formula can be sorted out:

$$\begin{bmatrix} X_r \\ X_s \end{bmatrix} = \begin{bmatrix} 1 - A_{rr} & A_{rs} \\ A_{sr} & 1 - A_{ss} \end{bmatrix}^{-1} \begin{bmatrix} Y_{rr} & Y_{rs} \\ Y_{sr} & Y_{ss} \end{bmatrix} = \begin{bmatrix} B_{rr} & B_{rs} \\ B_{sr} & B_{ss} \end{bmatrix} \begin{bmatrix} Y_r \\ Y_s \end{bmatrix} \tag{3}$$

Bsr is an N × N Leontief inverse (complete consumption coefficient) matrix, which represents the increased intermediate input of country s needed to produce a unit of product in country r. Ysr is an N × 1 final demand matrix, which represents the final demand of country r for country s. It can also be abbreviated as:

$$X = (1 - A)^{-1}Y = BY \tag{4}$$

X and Y are both 2N × 1 matrices, and both A and B are 2N × 2N matrices.

Thus, the direct value-added coefficient can be defined:

$$V_1 = u[I - A_{rr} - A_{sr}] \ , \ V_2 = u[I - A_{rs} - A_{ss}] \tag{5}$$

Vr is a 1 × N direct value-added coefficient matrix, which is the direct value-added coefficient vector of country r. The elements of this vector represent

The direct value-added coefficient of a certain industry in the country, that is, the element of the direct value-added output after excluding the intermediate product input Vri=1-"all intermediate input coefficients"; u is a 1 × N matrix, and the element is 1.

Then define the direct value-added coefficient matrix:

$$V = \begin{bmatrix} V_r & 0 \\ 0 & V_s \end{bmatrix} \tag{6}$$

V is a 2 × 2N matrix.

Multiply the value-added coefficient matrix Vri and the Leontief inverse matrix B_sr to obtain the final value-added matrix:

$$VB = \begin{bmatrix} V_1B_{rr} & V_1rs \\ V_2B_{sr} & V_2B_{ss} \end{bmatrix} \tag{7}$$

VB is a 2 × 2N matrix.

Let Ers be an N × 1 matrix, representing the intermediate inputs and final products exported from country r to country s, and then the total export of country r is:

$$X_r = \sum_{r \neq s} E_{rs} = \sum_s (A_{rs}X_s + Y_{rs}) \quad r,s = 1,2 \tag{8}$$

$$\mathrm{E} = \begin{bmatrix} E_r & 0 \\ 0 & E_s \end{bmatrix} \tag{9}$$

$$\hat{\mathrm{E}} = \begin{bmatrix} diag(E)_r & 0 \\ 0 & diag(E_s) \end{bmatrix} \tag{10}$$

E is a 2N × 2 matrix. $\hat{\mathbf{E}}$ is a 2N × N2 diagonal matrix.

The export value-added matrix at the industry (sector) level is:

$$\mathrm{VB}\hat{\mathrm{E}} = \begin{bmatrix} V_1 B_{rr} \hat{\mathrm{E}}_r & V_1 B_{rs} \hat{\mathrm{E}}_s \\ V_2 B_{sr} \hat{\mathrm{E}}_r & V_2 B_{ss} \hat{\mathrm{E}}_s \end{bmatrix} \tag{11}$$

The export value-added matrix at the country (overall) level is:

$$\mathrm{VBE} = \begin{bmatrix} V_1 B_{rr} \mathrm{E}_1 & V_1 B_{rg} \mathrm{E}_s \\ V_2 B_{sr} \mathrm{E}_r & V_2 B_{ss} \mathrm{E}_s \end{bmatrix} \tag{12}$$

Among them, $\mathrm{VB}\hat{\mathrm{E}}$ is a 2 × 2N matrix, and VBE is a 2 × 2 matrix.

Generalizing to the case of country g, the VBE is a 3 × 3 matrix:

$$\mathrm{VBE} = \begin{bmatrix} V_1 rr \mathrm{E}_r & V_1 B_{rs} \mathrm{E}_s & V_1 B_{rg} \mathrm{E}_g \\ V_2 B_{sr} \mathrm{E}_r & V_2 B_{ss} \mathrm{E}_s & V_1 B_{sg} \mathrm{E}_g \\ V_3 B_{gr} \mathrm{E}_r & V_3 B_{gs} \mathrm{E}_g & V_1 B_{gg} \mathrm{E}_g \end{bmatrix} \tag{13}$$

At this time, VBE is a 3 × 3 matrix.

The diagonal elements in the VBE matrix add value to the domestic value of each country's total exports:

$$DV_r = V_r B_{rr} E_r \tag{14}$$

The non-diagonal elements in each column of the VBE matrix add up to the foreign value added in the total exports of a country:

$$FV_r = \sum_{r \neq s} V_s B_{sr} E_r \tag{15}$$

The addition of the non-diagonal elements in each row of the VBE matrix is the domestic indirect value added included in the exports of other countries:

$$IV_r = \sum_{s \neq r} V_r B_{rs} E_{st} \tag{16}$$

Total exports are equal to the sum of domestic value added and foreign value added:

$$E_r = DV_r + FV_r \tag{17}$$

Daudin et al. (2009) finally decomposed a country's export into the following five parts:

$$E_r = DV_r + FV_r = V_r B_{rr} \sum_{s \neq r} Y_{rs} + V_r B_{rr} \sum_{s \neq r} A_{rs} X_{ss} + V_r B_{rr} \sum_{s \neq r} \sum_{t \neq r,s} A_{rs} X_{st} + V_r B_{rr} \sum_{s \neq r} A_{rs} X_{st} + FV_r \tag{18}$$

## 3.2. Index Selection for the Measurement Index System of Manufacturing Value Chain Position

Based on the above decomposition of total exports, four indicators for a country's participation in the global value chain can be constructed:

(1) Index of vertical division of labor in the value chain (foreign value-added index)

Hummels et al. (2001) proposed to use the vertical specialization ratio to measure the degree of participation in the division of labor in the value chain. The vertical specialization ratio uses the input-output table to calculate the value of imported intermediate goods contained in exports, which is divided into absolute quantity (VS) and relative quantity (VSS). With reference to the calculation formula of Hummels et al. (2001), the $VSS_i$measures the degree of division of a country's value chain in a certain industry is:

$$VSS_i = \frac{VS_i}{X_i} \tag{19}$$

$$VS_i = \left(\frac{M_i}{Y_i}\right)X_i \tag{20}$$

Where: i represents the industry, $X_i$ represents the total export value of a country's industry i industry, $VS_i$ represents the value of imported intermediate products contained in the export products of industry i, $M_i$ represents the value of intermediate products imported by industry i, and $Y_i$ represents industry i Gross domestic output. In the previous analysis, $FV_i$ represents foreign value-added, which means the foreign value added in the export of a country's industry i, so it is easy to know $FV_i = VS_i, X_i = E_i$, you can get:

$$VSS_i = \frac{VS_i}{X_i} = \frac{FV_i}{E_i} \tag{21}$$

Therefore, the vertical division of labor in a certain industry is equal to its foreign value-added rate.

Assuming that a country has n industries, the total export of a country is $EX = \sum_{i=1}^{n} X_i = \sum_{i=1}^{n} E_i$, then its total vertical division of labor (foreign value-added rate )for:

$$VSS = \sum_{i=1}^{n} VS_i / \sum_{i=1}^{n} X_i = \frac{1}{EX}\sum_{i=1}^{n} VS_i = \frac{1}{EX}\sum_{i=1}^{n} FV_i = \frac{1}{EX}\sum_{i=1}^{n}\left(\frac{M_i}{Y_i}X_i\right) \tag{22}$$

(2) Export value-added index

Export value-added refers to the proportion of indirect value-added exports of a certain industry in a country's total exports. Among them, indirect value-added exports measure how much value-added is included in the country's intermediate exports of that industry and is After being processed in one country, it is exported to a third country. The export value-added index formula can be expressed as:

$$VSS_i^{VA} = \frac{IV_i}{X_i} \tag{23}$$

$IV_r$ represents the indirect added value brought by the intermediate goods contained in the export of a certain industry in a certain country.

Extending to the overall situation of a country, the country has n industries, the total export value-added index is:

$$VSS^{VA} = \sum_{i=1}^{n} IV_i \Big/ \sum_{i=1}^{n} X_i = \frac{1}{EX}\sum_{i=1}^{n} IV_i \tag{24}$$

(3) GVC participation rate index

According to the GVC participation rate index proposed by Koopman (2011), the GVC participation rate index of a country's i industry can be expressed as:

$$GVC_{Participation_i} = \frac{FV_i}{E_i} + \frac{IV_i}{E_i} \tag{25}$$

In the formula, $\frac{IV_i}{E_i}$ is the export value-added index, which is also called the GVC forward participation rate index, and some scholars call it outward participation. The higher the index, the more global value the country is in the industry. Upstream of the chain; where $\frac{FV_i}{E_i}$ is the foreign value-added index and the vertical division of labor index. It is also called the GVC backward participation rate index, and some scholars call it inward participation. The higher the index, the higher it indicates The country is further down the global value chain in this industry.

Therefore, the total GVC participation rate index of a country can be expressed as:

$$GVC_{Participation} = VSS + VSS^{VA} = \frac{1}{EX\left(\sum_{i=1}^{n} FV_i + \sum_{i=1}^{n} IV_i\right)} \tag{26}$$

Considering that even if the two countries have the same level of GVC participation, their position in the global value chain will be different. Koopman et al. (2011) further constructed an indicator reflecting the position of a country's international division of labor GVC_ Position$_i$.

(4) GVC position index

The GVC position index examines a country's international division of labor position in the GVC by comparing the export value added of a certain industry in a country with the foreign value added. The GVC position index of the i industry is expressed as follows:

$$GVC\_Position_i = \ln\left(1 + VSS_i^{VA}\right) - \ln\left(1 + VSS_i\right) = \ln\left(1 + \frac{IV_i}{X_i}\right) - \ln\left(1 + \frac{VS_i}{X_i}\right) \tag{27}$$

It can be obtained from this that the total GVC position index of a country is:

$$GVC_{Position} = \ln\left(1 + \frac{1}{EX}\sum_{i=1}^{n} IV_i\right) + \ln\left(1 + \frac{1}{EX}\sum_{i=1}^{n} VS_i\right) \tag{28}$$

## 3.3. Data Sources and Selection

The input-output table used in this paper is the World Input-Output Table (WIOT) in the World Input-Output Database (WIOD) jointly developed by OECD and other institutions, We use the world input-output tables (WIOTs). The World Input Output Database (WIOD) project has developed WIOTs for calculating the GVC. and World Input-Output Tables and

underlying data, covering 43 countries, and a model for the rest of the world for the period 1995-2016. The trade data and output data used in the calculation can also be obtained from the world input-output table of the corresponding year. The WIOD tables connect the trade flows of intermediate and final goods across countries and industries.

Meanwhile, some international organizations and research centres provide the database similar to the WIOT during this period, also they are having its own advantages and disadvantages of the database.

For example, the NACE (the French Nomenclature statistique des Activités économiques dans la Communauté Européenne) database is provided by the European Community and it is used to classify 35 industries, belong in the 14 manufacturing sectors. the SITC Rev3 for products, manufactured goods by degree of manufacturing groupings in the SITC 5 to 8 less 667 and 68 of the classification from sample countries in the WIOT

This paper of reasons for using the WIOD` data are as follows:

(i) many Korean studies on GVCs are providing empirical evidence of the WIOT data sources, and there is means by which clearly to absolute confidence in the

statistical figures calculated from the WIOTs. (ii) the WIOTs database is available for the recent years from 1995 to 2016, deflated WIOTs in Previous Years' Prices (World IO Tables PYP) are available, as well as national aggregations (National IO Tables). Additionally the underlying International Supply and Use Tables (International SUTs).while other databases only provide simple tables.

According to the description of methods and original sources of information used for the construction of the WIOTs. We are restructuring for the WIOD data structure.The data in this paper is calculated by using MATLAB (2014a) coding. The following calculation results are analyzed based on the manufacturing industry.

Data for 6 sectors are classified according to the International Standard Industrial Classification revision 3 (ISIC Rev. 3): Manufacture of basic metals, Manufacture of fabricated metal products, Manufacture of electrical equipment,Manufacture of computer, electronic and optical products, Manufacture of machinery and equipment n.e.c.. Manufacture of transport equipment.

# 4. Results

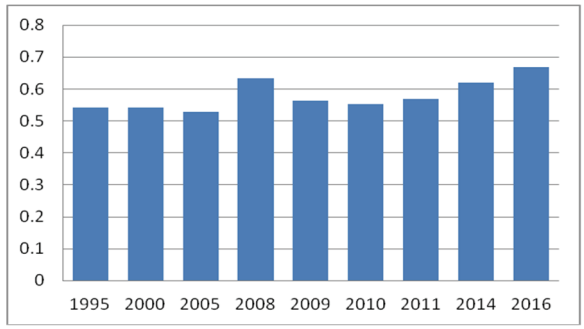
## 4.1. Overall Measurement of Korean Manufacturing Value Chain Position

### *4.1.1. Measurement and Analysis of the Overall GVC Participation Rate Index*

This paper selects representative 9-year data to measure the overall GVC participation rate of the manufacturing industry. The results are shown in Fig. 1. It can be seen that the overall GVC participation rate of the Korean manufacturing industry is relatively stable, floating within the range of 72% to 80%. From the perspective of global value chain participation, Korea's participation in the international division of labor is showing a steady upward trend. The 2008 financial crisis increased the participation index of all industries. This proves from the side that the stimulus of the financial crisis will temporarily prevent Korea from gaining global value. The rise in the upper reaches of the chain has increased the participation of Korean GVCs. Korea's participation in the international division of labor is higher than that of China, and its GVC participation index value is around 0.5, and GVC participation has shown a steady upward trend, indicating that Korea's role in the international division of labor has been deepening.

**Fig. 1.** The change of GVC participation rate in Korea's manufacturing industry from 1995 to 2016

(Unit: GVC participation rate)




**Source**: Authors' calculation using the WIOD data.

Although gratifying progress can be seen in the above analysis, there is still a certain gap between Korea and industrialized countries such as the United States (Table 1). The United States has seized the opportunity of two industrial revolutions and an information technology revolution. Both are industrial powers. The overall backward participation rate of the manufacturing industry of the two countries is very low. The United States stabilized at about 20%, and Korea was only 5.15% in 1995. , Which has risen in recent years, but is always below 20%. Although the overall backward participation rate of China's manufacturing industry has dropped to 43.18% in 2016, it is still about twice that of the United States and three times that of Korea. It can be seen that China's manufacturing industry is highly dependent on imported intermediate products and foreign added value It accounts for a large proportion of China's total manufacturing exports. However, a high backward participation rate does not mean bad. Cheng (2015) found that China's participation was comprehensively evaluated from three perspectives: intermediate product correlation, value-added correlation, and input-output correlation through cross-border input-output analysis, and the degree and evolutionary trend of the division of labor in the global value chain. The study found that China's relationship with the world as measured by the proportion of foreign value added is increasing, and is higher than the degree measured by the proportion of imported intermediate products. China and the United States, Japan, Korea, China Taiwan and Germany are highly correlated; but from a trend point of view, the degree of correlation between China and the United States and Germany is rising, and the degree of correlation with Japan, Korea, and Taiwan is declining. Most industries in China tend to be from higher-income economies. Importing more value-added also tends to export more value-added to the latter. Most industries in China have a value chain correlation index based on output and input exceeding 1.5. There are far more industries with rising correlation indexes than falling industries. It shows that China has deeply integrated into the global value chain through two channels of output supply and input demand. Liu (2015) obtained a similar conclusion that the foreign value-added rate of high-tech manufacturing exports has risen most significantly after calculation and comparison. From this, we can also see the "lock-in effect" of global value chains on medium and high-tech industries. This is consistent with the research conclusions of other scholars (Wang, 2014; Wang,Du and Zhou, 2012).

In terms of forward participation rates, the United States and Korea are both ahead of developing countries and far higher than China. In 1995, the forward participation rate of

China's manufacturing industry was only 11.13%, which was far lower than that of the United States and Korea. However, by 2008, the forward participation rate of China's manufacturing industry was already very close to that of the United States. By 2011, China had already completely surpassed the United States and gradually narrowed the gap with Korea, thanks to the increase in the added value of China's manufacturing exports of intermediate goods.

From the perspective of forward participation rate, Korea is lower than that of the United States and China. China's backward participation rate is too high, resulting in a high overall GVC participation rate, which is about 20% higher than that of the United States and Korea. This reflects the global value of manufacturing level of participation in the chain. However, because the higher the backward participation rate, the more it indicates that you are at the low end of the value chain, and the higher the forward participation rate is, the more you are at the high end of the value chain. Combining the performance of China, Korea, and the United States in the overall GVC and the front and back indicators It is not difficult to find that the manufacturing industries of the United States and Korea as a whole are steadily in the upper reaches of the global value chain; China's manufacturing industry as a whole is still in the lower reaches of the global value chain, but there is a tendency to gradually move closer to the upper and middle reaches.

**Table 1**. Changes in GVC Participation Rates in Manufacturing Industries in Korea China and the United States

| Year | | 1995 | 2000 | 2005 | 2008 | 2009 | 2010 | 2011 | 2014 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Overall backward participation rate $\left(\frac{FV_i}{X_i}\right)$ | China | 0.7234 | 0.7112 | 0.6457 | 0.5983 | 0.5777 | 0.5413 | 0.4916 | 0.4772 | 0.4318 |
| | Korea | 0.0515 | 0.0675 | 0.0967 | 0.1153 | 0.1317 | 0.1503 | 0.1598 | 0.1766 | 0.1889 |
| | USA | 0.1733 | 0.1943 | 0.2092 | 0.2218 | 0.2009 | 0.2128 | 0.2334 | 0.2446 | 0.2517 |
| Overall forward participation rate $\left(IVI_{ji}/X_{j,i}\right)$ | China | 0.1113 | 0.1716 | 0.2456 | 0.3009 | 0.3543 | 0.3677 | 0.3754 | 0.3977 | 0.4123 |
| | Korea | 0.4893 | 0.4741 | 0.4317 | 0.5176 | 0.4311 | 0.4035 | 0.4089 | 0.4426 | 0.4788 |
| | USA | 0.2711 | 0.2785 | 0.3092 | 0.3123 | 0.3589 | 0.3685 | 0.3714 | 0.3810 | 0.3923 |
| Overall GVC participation rate $\left(\frac{FV_i}{X_i}+\frac{IV_i}{X_i}\right)$ | China | 0.8347 | 0.8828 | 0.8913 | 0.8992 | 0.9320 | 0.9090 | 0.8670 | 0.8749 | 0.8441 |
| | Korea | 0.5408 | 0.5416 | 0.5284 | 0.6329 | 0.5628 | 0.5538 | 0.5687 | 0.6192 | 0.6677 |
| | USA | 0.4444 | 0.4728 | 0.5184 | 0.5341 | 0.5598 | 0.5813 | 0.6048 | 0.6256 | 0.6440 |
| Overall GVC Position Index | China | -0.2955 | -0.332 | -0.251 | -0.083 | -0.082 | -0.091 | -0.087 | -0.081 | -0.082 |
| | Korea | 0.1833 | 0. 0833 | 0.0544 | -0.105 | 0.0314 | 0.0438 | 0.0103 | 0.0217 | 0.0344 |
| | USA | 0.1547 | 0.144 | 0.121 | 0.113 | 0.134 | 0.110 | 0.0998 | 0.0878 | 0.0769 |

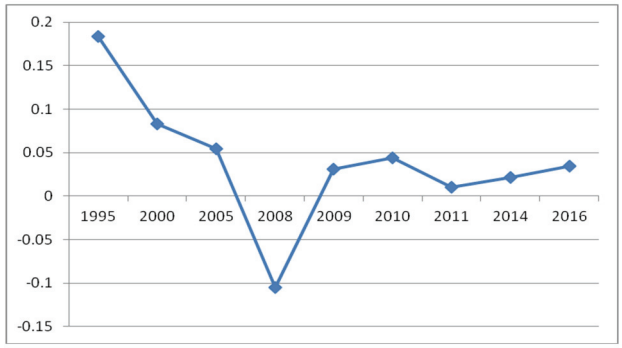
### *4.1.2. Measurement and Analysis of the Overall GVC Position Index*

Fig. 2 illustrates the result of the impact shows the change in the GVC position index of Korea's manufacturing industry. It can be seen that Korea's position in the GVC in 1995 was relatively high, and it was in the upper reaches of the value chain. After 1995, its position in the value chain continued to decrease, and the decline was large. Dropped from nearly 0.2 in 1995 to about 0 in 2011. This is because Korea is more deeply involved in the international division of labor. The growth rate of foreign value added (FV) in its export trade is greater than that of indirect domestic value added exports (IV). Therefore, the value of the GVC position index continues to decrease. The position of division of labor continues to decline.

As Korea's economy has experienced decades of rapid growth, it has entered a period of transition and adjustment since 1991. During this period, the Korean government not only worked hard to improve the country's technical level and international competitiveness to rejuvenate export trade, but also carried out large-scale operations. Foreign investment seeks new economic growth points, which has led to a high degree of external dependence on the Korean economy. It can also be seen from Figure 2 that the value of Korea's GVC position index has dropped significantly. The impact of the financial crisis in 2008 showed a negative value, which also shows that Korea has a strong dependence on the global value chain. The impact is greater.

**Fig. 2.** Changes in GVC position index of Korean manufacturing

(Unit: GVC position rate)




**Source**: Authors' calculation using the WIOD data.

From the perspective of changing trends, the GVC position index of the Korean manufacturing industry showed a downward trend from 1995 to 2008, but rose rapidly after 2008, and was relatively stable after 2008 and gradually approached the axis. In Table1, the overall GVC position index of Korea's manufacturing industry has a very large gap compared with that of the United States. Which sectors have lowered the overall GVC participation rate of Korea's manufacturing industry? Only by calculating the sub-industries below can we make further progress discuss.

## 4.2. Sectoral Measurement of Korea's Manufacturing Value Chain Position

### *4.2.1. Measurement and Analysis of Sector GVC Participation Rate Index*

Table 2 shows the result of the impact that the forward participation rate of each sector has shown an increasing trend as the year progresses, which is consistent with the growth trend of the overall forward participation rate of the manufacturing industry. The number in brackets represents the forward participation of the sector in that year. The ranking of the rate in each sector, across the rankings, the same sector's ranking in different years is very stable, indicating that the export value added of each sector accounted for the proportion of its exports are relatively stable. The backward participation rate of each department has different trends over time. The basic metal industry is relatively stable, with small changes, and its backward participation rate has always maintained the smallest value among the six sectors in different years. In the same year, the smaller the number of backward participation rate rankings, the better. Therefore, the three sectors of metal products, machinery and

equipment manufacturing, electrical machinery and instrument manufacturing are in a higher value chain position than the other three sectors.

Combining the participation rate of the preceding and following items, the three sectors of the metal products industry, machinery and equipment manufacturing, electrical machinery and instrument manufacturing industries have a higher value chain position in the Korean manufacturing industry; the metal products industry is in the middle; computer, electronics, optical equipment manufacturing and electrical The machinery and instrument manufacturing sectors have a low position in the value chain.

**Table 2.** GVC participation rate index of various sectors in Korea's manufacturing industry

| | | 1995 | 2000 | 2005 | 2008 | 2009 | 2010 | 2011 | 2014 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Manufacture of basic metals | GVC forward participation rate | 0.3012 | 0.3122 | 0.3233 | 0.3089 | 0.3214 | 0.3109 | 0.3345 | 0.3215 | 0.3017 |
| | GVC backward participation rate | 0.2433 | 0.2344 | 0.2634 | 0.2712 | 0.2456 | 0.2546 | 0.2598 | 0.2457 | 0.2678 |
| | GVC participation rate | 0.5445 | 0.5466 | 0.5867 | 0.5801 | 0.567 | 0.5655 | 0.5943 | 0.5672 | 0.5695 |
| Manufacture of fabricated metal products | GVC forward participation rate | 0.3467 | 0.3566 | 0.3423 | 0.3876 | 0.3122 | 0.3023 | 0.3134 | 0.3234 | 0.3357 |
| | GVC backward participation rate | 0.1123 | 0.1234 | 0.1346 | 0.1016 | 0.1578 | 0.1349 | 0.1566 | 0.1766 | 0.1548 |
| | GVC participation rate | 0.459 | 0.48 | 0.4769 | 0.4892 | 0.47 | 0.4372 | 0.47 | 0.5 | 0.4905 |
| Manufacture of electrical equipment | GVC forward participation rate | 0.3033 | 0.3123 | 0.3233 | 0.3378 | 0.3417 | 0.3564 | 0.3561 | 0.3603 | 0.3566 |
| | GVC backward participation rate | 0.1997 | 0.2039 | 0.2138 | 0.2213 | 0.2167 | 0.2209 | 0.2146 | 0.2217 | 0.2155 |
| | GVC participation rate | 0.503 | 0.5162 | 0.5371 | 0.5591 | 0.5584 | 0.5773 | 0.5707 | 0.582 | 0.5721 |
| Manufacture of computer, electronic and optical products | GVC forward participation rate | 0.2633 | 0.2655 | 0.2789 | 0.2897 | 0.3011 | 0.2899 | 0.3018 | 0.3323 | 0.3412 |
| | GVC backward participation rate | 0.2442 | 0.2566 | 0.2678 | 0.2744 | 0.2803 | 0.3011 | 0.3013 | 0.2988 | 0.3012 |
| | GVC participation rate | 0.5075 | 0.5221 | 0.5467 | 0.5641 | 0.5814 | 0.591 | 0.6031 | 0.6311 | 0.6424 |
| Manufacture of machinery and equipment n.e.c. | GVC forward participation rate | 0.2997 | 0.3013 | 0.3323 | 0.3513 | 0.3452 | 0.3245 | 0.3313 | 0.3458 | 0.3516 |
| | GVC backward participation rate | 0.1954 | 0.2009 | 0.2122 | 0.2214 | 0.2342 | 0.2412 | 0.2123 | 0.2311 | 0.2452 |
| | GVC participation rate | 0.4951 | 0.5022 | 0.5445 | 0.5727 | 0.5794 | 0.5657 | 0.5436 | 0.5769 | 0.5968 |
| Manufacture of transport equipment | GVC forward participation rate | 0.2211 | 0.2345 | 0.2588 | 0.2755 | 0.2566 | 0.2435 | 0.2514 | 0.2513 | 0.2677 |
| | GVC backward participation rate | 0.2899 | 0.2845 | 0.2909 | 0.3015 | 0.3246 | 0.3442 | 0.3347 | 0.3415 | 0.3542 |
| | GVC participation rate | 0.511 | 0.519 | 0.5497 | 0.577 | 0.5812 | 0.5877 | 0.5861 | 0.5928 | 0.6219 |

*4.2.2. Measurement and Analysis of Departmental GVC Position Index*

In order to further analyze the phenomenon of the gap between the overall Korean manufacturing industry and the United States and China, the GVC position index of each sector of the manufacturing industry is calculated, and Table 3 shows the result of the impact From 1995 to 2016, the industry's GVC position index is equal, it is a positive value, while most of the years in China are negative, and the rest of the sectors are negative. From the perspective of the Korean manufacturing industry, the machinery and equipment manufacturing industry has the highest GVC position, with an average level greater than 0.05, which is much higher than other industries, and the basic metal industry has the lowest GVC position index. The GVC position index of the basic metal industry was ahead of China at the beginning of the research cycle, but it was lower than that of the United States and China in the later period. By 2011, the GVC index of this industry in China was completely ahead of the United States and China. During the study period, Korea's metal products industry, mechanical equipment manufacturing, computer, electronics, optical equipment manufacturing, and electrical machinery and instrument manufacturing industries have lower GVC indexes than the United States, but higher than China. The transportation equipment manufacturing industry was higher than the United States before 2000, but was surpassed by the United States after 2000, and was surpassed by China after 2008, indicating that the overall level of the industry in Korea is declining, and China has intensified reforms in recent years. Intensified, many related policies have been introduced to promote the development of the industry, and the rapid development surpassed the United States in 2011.

**Table 3.** GVC position index of each sector in Korea

| GVC Position Index | 1995 | 2000 | 2005 | 2008 | 2009 | 2010 | 2011 | 2014 | 2016 |
|---|---|---|---|---|---|---|---|---|---|
| Basic Metal Industry | 0.1433 | 0.0374 | 0.0321 | -0.1507 | 0.0123 | 0.0129 | -0.0321 | -0.0117 | 0.0122 |
| Manufacture of fabricated metal products | 0.1809 | 0.0904 | 0.0567 | -0.1017 | 0.0457 | 0.0435 | 0.0127 | 0.0245 | 0.0432 |
| Manufacture of electrical equipment | 0.1898 | 0.1023 | 0.0619 | -0.0903 | 0.0563 | 0.0519 | 0.0234 | 0.0267 | 0.0453 |
| Manufacture of computer, electronic and optical products | 0.1235 | 0.0453 | 0.0123 | -0.1346 | 0.0154 | 0.0213 | -0.0096 | -0.0077 | 0.0213 |
| Manufacture of machinery and equipment n.e.c. | 0.2034 | 0.0813 | 0.0634 | -0.0654 | 0.0432 | 0.0653 | 0.0218 | 0.0239 | 0,0244 |
| Manufacture of transport equipment | 0.1345 | 0.0654 | 0.0128 | -0.1238 | 0.0235 | 0.0217 | 0.0113 | 0.0104 | 0.0237 |

## 5. Conclusion

By examining the overall participation of the Korean manufacturing industry and the global value chain of various sectors and the division of labor position in the value chain, the following conclusions are drawn:

(1) The overall GVC participation rate of the Korean manufacturing industry is relatively stable, fluctuating in the range of 50% to 70%. From the perspective of global value chain participation, Korea's participation in the international division of labor is showing a steady upward trend. The 2008 financial crisis increased the participation index of all industries. This proves from the side that the stimulus of the financial crisis will temporarily prevent Korea from gaining global value. The rise in the upper reaches of the chain has increased the participation of Korean GVCs. Korea's participation in the international division of labor is higher than that of China. The empirical results based on the WIOD date find the same results from previous. Korea was participated in GVCs most actively of Countries from 1995 to 2011. Meanwhile, Korean manufacturers also increased their contribution to foreign GVCs by supplying intermediate goods, and accounted for more than the half of the total manufacturing GDP (Chung, 2016).

According to the empirical results, this paper provides some proposed policies. Korean GVC participation has shown a steady upward trend, indicating that Korea's role in the international division of labor has been deepening. At the same time, Korean entry into the Asia-Pacific region enhances Korea-organized GVC by integrating in the Asia-Pacific region's production division networks (Choi, 2019).

(2) The Korean GVC of forward participation rate of each sector has shown an increasing trend as the year progresses, which is consistent with the growth trend of the overall forward participation rate of the manufacturing industry.

The ranking of the same sector in different years is very stable, indicating that the export of each sector proportion of added value in its exports is relatively stable.

The empirical results supported conclusions of the theoretical model. In the Korean GVC of electrical and optical sector, while stronger forward linkages than backward linkages to GVCs are advantageous for an average advanced country, the benefits of downstream tasks are pronounced for non-advanced countries (Kim and Lee, 2020).

The backward participation rate of each department has different trends over time. The Korean GVC of basic metal industry is relatively stable, with small changes, and its backward participation rate has always maintained the smallest value among the six sectors in different years.

In the same year, the smaller the number of backward participation rate rankings, the better. Therefore, the three sectors of metal products, machinery and equipment manufacturing, electrical machinery and instrument manufacturing are in a higher value chain position than the other three sectors. For example, Generally, Electrical and optical and Metals industries happen to be the top cross cutting industries in all East Asian countries (Robert and Jung, 2014).

(3) A comprehensive comparison of the six sectors shows that the "labor-intensive" and "capital-intensive" manufacturing sectors have a significantly higher division of labor in the GVC than the "technology-intensive" sectors.

The GVC position index of the metal products industry, mechanical equipment manufacturing industry, electrical machinery and instrument manufacturing industry is mostly positive in each year and is higher than that of China, far higher than the basic metal industry and transportation equipment manufacturing sector.

For example, In the GVC of metal industry sector, Korea has the highest participation rate followed closely by China and highest GVC position compared to the rest of East Asian countries (Robert and Jung, 2014).

The value of this paper is providing empirical evidence of the effect of Korea's the GVC of manufacturing sectors. The first three have a higher position in the value chain and are in the upper middle and upper reaches of the GVC. The latter two have a low GVC position index, which has become the main sector that pulls down the overall position of Korea's manufacturing industry.

It not only shows that these two sectors are downstream in the global value chain, but also reflects the research and development of these two sectors insufficient innovation capabilities in important links such as design and production of key components.

The empirical results of this article proved the correlation for an index to capture a country's upstream position or downstream position, it makes sense to compare that Korea's exports of intermediates in the same sector that are used by China and USA (Robert and Jung, 2014).

This paper lacks the identification of specific industries that may have positive effects on GVC. Sophisticating estimation strategies of industry specific estima-tion for domestic manufacturing GVC dependent exporting industries would provide more useful empirical evidence to verify the spillover effect of service industries's GVC reorganization. These short comings are postponed to the future research. Due to the limitations of WIOD's international input-output data, the empirical findings do not fully reflect current industrial structure.

For the future studies, WIOD's updated data of the international input-output table and domestic companies' data should be obtained by 2016 and empirical analysis should be further conducted. Furthermore, panel dynamic estimation analysis is required to control cross-sectional time series variations.

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