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INTERDEPENDENCE OF MANUFACTURING INDUSTRY BETWEEN KOREA AND ASEAN-5 COUNTRIES: ASIAN INTERNATIONAL INPUT-OUTPUT ANALYSIS

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ABSTRACT

The purpose of this study is to analyze the interdependence of the manufacturing industry between South South Korea and ASEAN-5 countries. To conduct an international analysis for the manufacturing industries, an interregional input-output (IRIO) model is applied. The Asian International Input-Output Table (AIIO) provided by IDE-JETRO (2017) is employed and the spillover effects of manufacturing industry are compared in terms of inducement production, value added and backward/forward linkages. The results indicate that the production inducement outcome between Malaysia and South Korea and the effect of forward and backward linkage industry are high, and the dependence on industry is high. On the other hand, in terms of decomposition of value added exports to ASEAN from South South Korea in the manufacturing sector; Vietnam, Singapore, and Indonesia are the states where South South Korea's domestic value-added exports are high. The result shows that South South Korea is necessary to diversify economic cooperation between East Asian and ASEAN member states.

Keywords: Asian International Input-Output Table, Interdependence, Backward and Forward Linkages, Manufacturing Industry, ASEAN

INTRODUCTION

This study aims to analyze the interdependence of the manufacturing industry between South Korea with Indonesia, Malaysia, the Philippines, Singapore, as well as Thailand. The five countries are commoly refered to as ASEAN-5 as part of the Association of Southeast Asian Nations (ASEAN). The interdependence is examined in terms of inducement production, value added and backward/forward linkages between South Korea and ASEAN-5 using interregional input-output (IRIO) model.

The economies of East Asia, including South Korea and ASEAN, have shown rapid growth since the mid-1980s and continue to develop, and as a result, they have now emerged as the world's three largest economies after the North American Free Trade Agreement (NAFTA) and the European Union (EU). In particular, ASEAN's economic growth has played a major role in strengthening trade relations between East Asian countries, and mutual direct investments are also increasing significantly.

ASEAN is in the spotlight for its huge market and attractive production bases while maintaining high economic growth. ASEAN has a population of 650 million and its economy is almost replicating China's economic growth rate. In addition, with the launch of the ASEAN Economic Community, global investment and trade in ASEAN and the region is also increasing. This movement is even more evident as China's production bases are weakening, as they are being transferred to ASEAN not only by domestic but also foreign companies in

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
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China. This suggests that the global value chain or production network centered on China is now more diversified, encroaching into other regions like Southeast Asia.

ASEAN is South Korea's 2nd largest trading partner and 2nd largest investment destination (IMF, 2019; South Koreaexim, 2019). This seems to be related to South Korea gradually changing its China-centered value chain or production network to ASEAN member states. In general, South Korea's total trade to ASEAN recorded US$ 159.7 billion in 2018. The increase in South Korea's trade with ASEAN is an annual average increase of 9.3% from US$ 38.3 billion in 2000 to US$ 159.7 in 2018 (Table 1).

Table 1: ROK Trade to ASEAN (billion dollars)

YEAR	EXPORT	IMPORT	TOTAL TRADE	BALANCE OF TRADE
2000	20.1	18.2	38.3	1.9
2005	27.4	26.1	53.5	1.3
2010	53.2	44.1	97.3	9.1
2015	74.8	45.0	119.8	29.8
2018	100.1	59.6	159.7	40.5

Source: K-STAT, South Korea International Trade Association, (2000, 2005, 2010, 2015, 2018)

LITERATURE REVIEW AND THEORITICAL FRAMEWORK

The industry association analysis was developed by the American economist W. Leontief. He noted that economic activities move in relation to each other through various sectors, such as households and industrial sectors, and those economic activities influence each other. In order to understand this quantitatively, he systematically created a table showing how the general interdependence relationship between sectors maintains the relationship with price, production, investment and income (Leontief, 1953).

Industry-related analysis shows the economy as a multisector effect of industries. In other words, the LeonTF inverse matrix represents the multi-sectoral multiplier relationship, and this inverse matrix itself becomes the core of industry-related analysis. Industry-related analysis can be said to be an analysis method that focuses on industries from microeconomics and macroeconomics (Lee and Okamoto, 2002).

From the 1960s onwards, the interdependence relationship between regions has emerged as an important concern due to the economic development of Asian countries and the expansion of trade, and an attempt was made to analyze the international industry connection (Asia Economic Research Institute, 1967). The core structure of international industry linkage analysis is based on regional industry linkage analysis. This analysis method was applied to analyze the interdependence relationship between regions in Asia itself (Nakamura, 1993).

Nakamura (1993) expanded Leontief's input-output model and developed an empirical model that divides into two entities, countries, and industries. This Leontief inverse matrix multiplier decomposition method is one of the most widely used basic application models in international industry association analysis in Asia. The basic analysis of the industry-related model is established in the following two forms. One is to analyze impact on production inducement, and the other is to analyze the relationship between industries, that is, interdependence (Lee and Okamoto, 2002).

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

The economic effect caused by an industrial input can be seen through the LeonTF inverse matrix. The production inducement effect is composed of the direct production induction effect and the indirect production induction effect in the own industry and other industries due to interdependence of intermediate goods. When the final demand for a good or service occurs, the effect is not limited to the production of that good or service, but extends to the production of other goods or services through interdependence of intermediate goods. The concept of measuring the change in the total output, which is the sum of the outputs of all industries, caused by the increase in final demand for one production sector is the production inducement effect (Yi and Goh, 2013). Analysis of value-added standards and export competitiveness is identified the international division of labor using the international industry linkage table (Jung, 2014). One of the major outcomes of this paper is to analyze the forward and backward linkages between manufacturing sub-sector and other sectors of the region using the input-output model. According to Chui (2012), linkages are input-output relationships between firms or industrial sectors in an economy. A firm purchasing inputs from a local supplier is an example of a backward linkage, while a firm selling intermediate inputs to another firm creates a forward linkage.

METHODOLOGY

Most of the earlier studies were analyzed using data from the World Input-Output Database (WIOD), and the data period is limited to 2014. This study uses the 2017 Asian Development Bank-Multi-Region (ADB-MRIO) Input Output to analyze based on recent data. More importantly, it is different from previous studies in that it contains an analysis of export competitiveness based on value-added in South Korea and Asia.

Industry-related analysis is mainly used as a method to analyze the impact of one industry on the national economy, production, employment, and other industries. Industry-related analysis, also called input-output analysis, is an analysis method that quantitatively grasps the correlations (South Korea Bank, 2012). This industry-related analysis can quantitatively analyze the relationship between various industries. It is used as a useful tool for structural analysis and economic planning and forecasting of the national economy by allowing the quantitative analysis of economic impact of final demand on production or added value (Miller and Blair, 2009). In particular, industry-related analysis is often used to analyze economic impact. The industry-related table is expressed in the form of a matrix so that the production activities of each industry within an area for a certain period of time are understood as the flow of goods and services, and the input and output structure of each industry can be read in a single table. When writing, it is necessary to set the target period (usually one year) and determine which industrial sectors in the domestic economy will be emphasized (Masahiro Ide, 2003).

Table 1 in the earlier section shows the basic structure of the industry association table composed of n industries. First, the vertical direction is divided into intermediate input representing raw material input and added value representing labor or capital input. And the total is the total input. The horizontal direction is divided into two parts: intermediate demand sold as intermediate goods and final demand sold as consumer goods, capital goods, etc., the sum of which becomes the total demand, and when income is subtracted from the total production amount. And the total output of each industrial sector and the corresponding total input are always the same.

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Journal of Social Sciences and Humanities

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

In the industry-related table in Table 2, various multipliers is derived using the industry-related table from the relationship of total output = intermediate demand + final demand-income to calculatedvarious spread effects.

Table 2: The basic structure of the Input-Output Table

		endogenous sector		exdogenous sector		Import (M)	Total supply amount (X+M)
		1 ·· j ·· n	Intermediate output	Consumption Investment Export	Final demand		
endogenous sector	1	X_{11} ·· X_{1j} ·· X_{11}	W_1	C_1 ·· I_1 ·· E_1	Y_1	M_1	X_1+M_1
	:	: : :	:	: : :	:	:	:
	i	X_{i1} ·· X_{ij} ·· X_{in}	W_2	C_i ·· I_i ·· E_i	Y_i	M_i	X_i+M_i
	:	: : :	:	: : :	:	:	:
	n	X_{n1} ·· X_{nj} ·· X_{nn}	W_n	C_n ·· I_n ·· E_n	Y_n	M_n	X_n+M_n
	Intermediate Input	U_1 ·· U_j ·· U_n					
exdogenous sector	employee income	R_1 ·· R_j ·· R_n					
	operating surplus	S_1 ·· S_j ·· S_n					
	consumption of fixed capital	D_1 ·· D_j ·· D_n					
	Net production tax	T_1 ·· T_j ·· T_n					
	Value-added system	V_1 ·· V_j ·· V_n					
Total Input amount		X_1 ·· X_j ·· X_n					

Source: Masahiro (2003)

Using the industry-related table in Table 1, first, the input coefficient of equation (1) can be derived by dividing the intermediate input and intermediate demand by the total input. These input coefficients represent the direct effects of one industry sector purchasing raw materials from another industry sector and are the basis for analyzing the interdependence relationship between industries. Also, the value-added row is dividing by total input. It gives the value-added coefficient of equation (2). Through this, the sum of the input coefficient and the value-added coefficient with the same column is as shown in Equation (3), and the sum becomes 1.

Input coefficients $a_{ij} = x_{ij} / X_j$ ·· Equation (1)
Value-added coefficient $v_j = V_j / X_j$ ··· Equation (2)
$\Sigma a_{ij} + v_j = 1$ ··Equation (3)

If the input coefficient and the industry-related table are linked and expressed in a simultaneous equation, it is as follows.

$$
\begin{array}{c}
a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n + Y_1 - M_1 = X_1 \\
\vdots \quad \vdots \quad \vdots \quad \vdots \\
a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{in}X_n + Y_i - M_i = X_i \\
\vdots \quad \vdots \quad \vdots \quad \vdots \\
a_{n1}X_1 + a_{n2}X_2 + \cdots + a_{nn}X_n + Y_n - M_n = X_n
\end{array}
$$

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

Where aij is the input coefficient, Xi is the output of sector i, Yi is the final demand of sector i, and Mi is the income of sector i.
If the above system of equations is expressed as a matrix, it is as in Equation (4).

AX + Y – M = X ···Equation (4)
X – AX = Y – M
(I - A)X = Y - M
X = (I – A) -1 (Y - M)

Eqation (4) means that in order to achieve the final demand ([Y]-[M]), each sector must be calculated by [I-A]-1([Y]-[M]). In other words, according to Equation (4), the final demand fluctuation (⊿(Y-M)) means that the domestic output (⊿X) fluctuates according to the production induction factor ([I-A]-1). To prepare an industry association table, after preparing the table in Table 1 from various statistics, the input coefficient [A] and the inverse matrix [I-A]-1 are calculated (Yi and Goh, 2013).

The inverse matrix is the production induction coefficient matrix. This represents a unit of output that is directly or indirectly induced in each industrial sector to meet the final demand increase by one unit. Also, since it has the property of a multiplier that represents the spread effect derived from final demand, it is also called a multi-sector multiplier or Leontief multiplier (Nakamura, Y, 1993).

However, the production function induction coefficient must be able to be deduced and calculated in a normal inverse matrix. For this, it satisfies the Hawkins-Simon Condition (HS) that the entire leading principal minors in [I-A] are greater than 0. If any one of the consecutive address matrix equations is less than 0, this means that the amount of the product (or service) directly or indirectly required producing one unit of the product (or service) is greater than one unit. This has no economic meaning, and in this case, if production is continued, the existing goods (or services) are exhausted (Yi and Goh, 2013).

In addition, the added value can be expressed by multiplying the production induction coefficient (X) by the added value coefficient (vj), which is shown in Equation (5).

V = vjX ··· Equation (5)

And if Equation (4) is substituted into Equation (5), it can be expressed as Equation (6). Here, the value-added induction coefficient is vj (I-A)-1, which means the value-added unit that is induced in the entire national economy when one unit of final demand for domestic products is generated.

V = vj (I – A)-1 (Y – M) ···Equation (6)

The statistics used in the industry-related model are industry-related tables. As mentioned in 1.5, the industry-related table consists of a part of the statistical system, and is published by national statistical agencies along with the GDP. However, GDP is released annually and quarterly, but the basic table is released every 5 years for the industry-related table. This is because statistics of various sectors such as production statistics, trade statistics, and national income statistics are collected and prepared through a special survey, and there is a time difference of 4 to 5 years in general.

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

In order to overcome this time difference, extension tables is prepared for each country. It is common to collect statistics exogenously and then measure them using a mathematical method based on them. In addition, even if there is a lag, the structure of the industry does not change rapidly, and it is a general evaluation that even if the statistics from 5 years ago are supplemented and modified with recent statistics, the analysis results of relatively high reliability can be obtained.

Since the industry-related model organically combines the whole and part of the national economy, it is useful for analyzing industrial causal relations across specific industries and economies. All micro-analysis is possible, so useful data can be presented for establishing and forecasting national economic plans or setting the direction of industrial structure policies.

The regional industry-related model is a single-region model according to the target of the industry model and the many region models. The multi-regional model (MRIO) is an interregional input output model (IRIO) according to the method of calculating the input coefficient.The international industry association table was created by applying the method of preparing the regional industry association table to the relationship between the state and the state. In this study, The Asian International Input-Output Table (IDE-JETRO, 2017) prepared by the company was used as a basic table for analysis.

Using A_{ij}^{rs} (i,j=line, row; r, s = I, M, P, S, T, K) in <Table 2>, the intra-country and inter-country transaction matrix A is expressed in the form of a partition matrix as shown in Equation (7) below.

$$A = \begin{bmatrix} A^{KK} & A^{KI} & A^{KM} & A^{KP} & A^{KS} & A^{KT} \\ A^{IK} & A^{II} & A^{IM} & A^{IP} & A^{IS} & A^{IT} \\ A^{MK} & A^{MI} & A^{MM} & A^{MP} & A^{MS} & A^{MT} \\ A^{PK} & A^{PI} & A^{PM} & A^{PP} & A^{PS} & A^{PT} \\ A^{SK} & A^{SI} & A^{SM} & A^{SP} & A^{SS} & A^{ST} \\ A^{TK} & A^{TI} & A^{TM} & A^{TP} & A^{TS} & A^{TT} \end{bmatrix} \cdots\cdots \text{Equation (7)}$$

The diagonal matrix $A^{kk,}$ A^{II}, A^{MM}, A^{PP}, A^{SS}, A^{TT} represents intra-country trading relationships, and the non-diagonal matrix A^{rs} (however, $r \neq s$) represents cross-country trading relationships. The equilibrium equation (8) from the general industry association model is applied to the industry association model between the six countries and expressed as equation (9).

$$X_j = a_{i1} + a_{i2} + \cdots + a_{in} + f_i \cdots\cdots \text{Equation (8)}$$

$$x_1^k = a_{11}^{kk} + a_{12}^{ki} + a_{12}^{km} + a_{13}^{kp} + a_{14}^{ks} + a_{15}^{kt} + f_1^{kk} + f_1^{ki} + f_1^{km} + f_1^{kp} + f_1^{ks} + f_1^{kt} \cdots\cdots \text{Equation (9)}$$

In Equation (9) above, a_1^{kk} on the right side represents sales from sector 1 in South Korea to each sector in South Korea. a_1^{ki}, a_1^{km}, a_1^{kp}, a_1^{ks}, and a_1^{kt} represent the flow of cross-border goods exported from sector 1 in South Korea to sectors in Indonesia, Malaysia, the Philippines, Singapore and Thailand. The items on the right-hand side f_1^{kk}, f_1^{ki}, f_1^{km}, f_1^{kp}, f_1^{ks}, and f_1^{kt} indicate how much South Korea's 1st sector output was sold at the final demand in Indonesia, Malaysia, Philippines, Singapore and Thailand. Malaysia's total output can also be expressed in the form of equation (9).

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

If we express the input factor z_{ij} as Equation (10),

$z_{ij} = a_{ij} / x_j$ ··· Equation (10)

Since a_j^{kk} can be expressed as $z_j^{kk}x_j^k$, a_j^{ki} can be expressed as $z_j^{ki}x_j^i$, and a_j^{km} can be expressed as $z_j^{km}x_j^m$, Equation (9) is as Equation (11)

$x_1^k = z_{11}^{kk}x_1^k + z_{12}^{ki}x_2^i + z_{13}^{km}x_3^m + z_{14}^{kp}x_4^p + z_{15}^{ks}x_5^s + z_{16}^{kt}x_6^t + f_1^{kk} + f_1^{ki} + f_1^{km} + f_1^{kp} + f_1^{ks} + f_1^{kt}$
··· Equation (11)

Similarly, it can be expressed as in Equation (12) for x_1^m.
In equation (12), if all items on the right side except the final demand are transposed to the left side, the following equation is obtained.

$z_{11}^{kk})x_1^k - z_{12}^{ki}x_2^i - z_{13}^{km}x_3^m - z_{14}^{kp}x_4^p - z_{15}^{ks}x_5^s – z_6^{kt}x_6^t = f_1^{kk} + f_1^{ki} + f_1^{km} + f_1^{kp} + f_1^{ks} + f_1^{kt}$
·· Equation (12)

Similarly, it can be expressed as in Equation (13) for $f_1^{mk} + f_1^{mi} + f_1^{mm} + f_1^{mp} + f_1^{ms} + f_1^{mt}$.
Then the input coefficient matrix Z^{kk}, Z^{ki}, Z^{km}, Z^{kp}, Z^{ks}, Z^{kt} can be expressed as follows.

$$Z^{kk} = \begin{bmatrix} z_{11}^{kk} & z_{12}^{kk} \\ z_{21}^{KK} & z_{22}^{kk} \end{bmatrix}, \quad Z^{ki} = \begin{bmatrix} z_{11}^{ki} & z_{12}^{ki} \\ z_{12}^{ki} & z_{22}^{ki} \end{bmatrix}, \quad Z^{km} = \begin{bmatrix} z_{11}^{km} & z_{12}^{km} \\ z_{21}^{km} & z_{22}^{km} \end{bmatrix}$$

$$Z^{kp} = \begin{bmatrix} z_{11}^{kp} & z_{12}^{kp} \\ z_{21}^{kp} & z_{22}^{kp} \end{bmatrix}, \quad Z^{ks} = \begin{bmatrix} z_{11}^{ks} & z_{12}^{ks} \\ z_{21}^{ks} & z_{22}^{ks} \end{bmatrix}, \quad Z^{kt} = \begin{bmatrix} z_{11}^{kt} & z_{12}^{kt} \\ z_{21}^{kt} & z_{22}^{kt} \end{bmatrix} \cdots\cdots \text{Equation (13)}$$

Similarly, if the input coefficient matrix Z^{ik}, Z^{ii}, Z^{im}, Z^{ip}, Z^{is}, Z^{it}, Z^{mk}, Z^{mi}, Z^{mm}, Z^{mp}, Z^{ms}, Z^{mt}, Z^{pk}, Z^{pi}, Z^{pm}, Z^{pp}, Z^{ps}, Z^{pt}, Z^{sk}, Z^{si}, Z^{sm}, Z^{sp}, Z^{ss}, Z^{st}, Z^{tk}, Z^{ti}, Z^{tm}, Z^{tp}, Z^{ts}, Z^{tt} expressed as Equation (14), the input coefficient matrix Z for the input output model of 6 countries and two sectors can be expressed as six partition matrices.

$$Z = \begin{bmatrix} Z^{kk} & Z^{ki} & Z^{km} & Z^{kp} & Z^{ks} & Z^{kt} \\ Z^{ik} & Z^{ii} & Z^{im} & Z^{ip} & Z^{is} & Z^{it} \\ Z^{mk} & Z^{mi} & Z^{mm} & Z^{mp} & Z^{ms} & Z^{mt} \\ Z^{pk} & Z^{pi} & Z^{pm} & Z^{pp} & Z^{ps} & Z^{pt} \\ Z^{sk} & Z^{si} & Z^{sm} & Z^{sp} & Z^{ss} & Z^{st} \\ Z^{tk} & Z^{ti} & Z^{tm} & Z^{tp} & Z^{ts} & Z^{tt} \end{bmatrix} \cdots\cdots \text{Equation (14)}$$

ANALYSIS

This paper mainly analyzed the top manufacturing ASEAN-5 countries that have the most active trade relations with South Korea. In addition, when analyzing major export items for South Korea's, the manufacturing industry is also taken into account (ASEAN & South Korea

e-Bangi Faculty of Social Sciences and Humanities Universiti Kebangsaan Malaysia
Journal of Social Sciences and Humanities
Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

in figures, 2019, Appendix A, B). The basic analysis of the industry-related model analyzed the ripple effect of production and the relationship between industries, that is, interdependence.

Table 3: South Korea's trade with ASEAN countries by country (million US $, %)

RANK	COUNTRY	2017			2018		
		Trade value	export value	import value	Trade value	export value	import value
1	Vietnam	63931 (41.7)	47754 (46.3)	16177 (29.5)	68263 (6.8)	48629 (1.8)	19632 (21.4)
2	Indonesia	17975 (20.7)	8404 (27.2)	9751 (15.5)	20034 (11.5)	8868 (5.5)	11160 (16.6)
3	Singapore	20557 (6.7)	11652 (-6.5)	8905 (30.8)	19830 (-3.5)	11850 (1.7)	7978 (-10.4)
4	Malaysia	16760 (11.4)	8045 (6.8)	8715 (16.1)	19201 (14.6)	8983 (11.7)	10206 (17.1)
5	Philippine	14269 (36.1)	10594 (45.5)	3702 (14.7)	15644 (9.4)	12061 (13.8)	3569 (-3.6)
6	Thailand	12672 (14.7)	7467 (15.2)	5205 (14.1)	14102 (11.3)	8507 (13.9)	5581 (7.2)
7	Myanmar	1037 (-15.0)	573 (-24.7)	463 (1.0)	1063 (2.6)	534 (-6.8)	536 (15.8)
8	Cambodia	865 (6.5)	604 (5.4)	261 (9.0)	984 (13.8)	661 (9.4)	314 (20.3)
9	Brunei	859 (10.3)	64 (-4.3)	795 (11.7)	669 (-22.1)	62 (-3.1)	610 (-23.3)
10	Laos	120 (-19.9)	92 (-27.1)	27 20.2)	105 (-11.5)	84 (-8.7)	30 (11.1)
	ASEAN	149970 (25.4)	95248 (27.8)	53822 (21.4)	159857 (7.2)	100240 (5.2)	59617 (10.8)

Source: K-stat

Note: () is the increase/decrease rate compared to the same period of the previous year. Ranking is based on the latest year's trade amount

Effect on Production Inducement

If the final demand is summarized using Equation (14) and Equation (12), it can be defined as Equation (15).

$(1 - Z^{kk})X^{k} - Z^{ki}X^{i} - Z^{km}X^{m} - Z^{kp}X^{p} - Z^{ks}X^{s} - Z^{kt}X^{t} = f^{j}$ ································Equation (15)

Here, $f^{j\circ} = f^{rk} + f^{ri} + f^{rm} + f^{rp} + f^{rs} + f^{rt}$ (however, $r = k, i, m, p, s, t$),

So $f = f^{kk} + f^{ki} + f^{km} + f^{kp} + f^{ks+} f^{kt}$

$f^{ik} + f^{ii} + f^{im} + f^{ip} + f^{is} + f^{it}$

$f^{mk} + f^{mi} + f^{mm} + f^{mp} + f^{ms} + f^{mt}$

$f^{pk} + f^{pi} + f^{pm} + f^{pp} + f^{ps} + f^{pt}$

$f^{sk} + f^{si} + f^{sm} + f^{sp} + f^{ss} + f^{st}$

$f^{tk} + f^{ti} + f^{\text{스}} + f^{\text{세}} + f^{ts} + f^{tt}$

e-Bangi Faculty of Social Sciences and Humanities Universiti Kebangsaan Malaysia
Journal of Social Sciences and Humanities
Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
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In the above equation, and f^{rs} ($r, s = k, i, m, p, s, t$) is the final demand vector for the output of country s of country r.

The total calculation vector can be expressed as

$$X = \begin{matrix} X^k \\ X^i \\ X^m \\ X^p \\ X^s \\ X^t \end{matrix} \text{ and } J = \begin{matrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{matrix}$$

Therefore, Equation (15) can be expressed as follows.

$$(I - Z)\, X = f \cdots\cdots \text{Equation (16)}$$

In addition, Equation (16) can be expressed in the following form again.

$$X = (I - Z)^{-1} f = Lf \cdots\cdots \text{Equation (17)}$$

X is the total calculation vector, Z is the input coefficient matrix, and f is the final demand vector. $(I - A)^{-1}$ means the LeonTF inverse matrix, which is the production induction coefficient matrix (L) that derives the output from the final demand.

Added Value Inducing Effect

Since production is triggered by final demand and added value is created, fluctuations in final demand are regarded as the source of fluctuations in added value. Therefore, the relationship between final demand and added value can be expressed as Equation (18). If the value-added rate of South Korea is $z^k{}_v$, the value-added rate of Indonesia is $z^i{}_v$, the value-added rate of Malaysia is $z^m{}_v$, the value-added rate of Philippines is $z^p{}_v$, the value-added rate of Singapore is $z^s{}_v$ and Thailand's value-added rate is $z^t{}_v$, then the value-added rate vector is $Z^j{}_v = V^j/X^j$. If the diagonal matrix of this equation is multiplied by equation (17) representing the production inducing effect, it can be expressed as the following equation.

$$\begin{matrix} V^k \\ V^i \\ V^m \\ V^p \\ V^s \\ V^p \end{matrix} = \begin{matrix} \widehat{Z^k}_v & 0 & 0 & 0 & 0 & 0 \\ 0 & \widehat{Z^i}_v & 0 & 0 & 0 & 0 \\ 0 & 0 & \widehat{Z^m}_v & 0 & 0 & 0 \\ 0 & 0 & 0 & \widehat{Z^p}_v & 0 & 0 \\ 0 & 0 & 0 & 0 & \widehat{Z^s}_v & 0 \\ 0 & 0 & 0 & 0 & 0 & \widehat{Z^p}_v \end{matrix} \quad \begin{matrix} L^{kk} & L^{ki} & L^{km} & L^{kp} & L^{ks} & L^{kt} \\ L^{ik} & L^{ii} & L^{im} & L^{ip} & L^{is} & L^{it} \\ L^{mk} & L^{mi} & L^{mm} & L^{mp} & L^{ms} & L^{mt} \\ L^{pk} & L^{pi} & L^{pm} & L^{pp} & L^{ps} & L^{pt} \\ L^{sk} & L^{si} & L^{sm} & L^{sp} & L^{ss} & L^{st} \\ L^{tk} & L^{ti} & L^{tm} & L^{tp} & L^{ts} & \bar{L}^{tt} \end{matrix} \quad \begin{matrix} f^{k\circ} \\ f^{i\circ} \\ f^{m\circ} \\ f^{p\circ} \\ f^{s\circ} \\ f^{p\circ} \end{matrix} \cdots\cdots \text{Equation (18)}$$

In the above equation, $\widehat{Z^j}_v$ is the diagonal matrix of $\widehat{Z^i}_v$, and $\widehat{A^j}_v L^j$ is called the value-added induction coefficient matrix, and when one unit of final demand occurs, it means the amount of added value that is directly or indirectly induced by the industry in the relevant country.

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

Forward·Backward Linkage Effects

Forward·backward linkage effects can be divided into a direct linkage and a total linkage. The direct relationship is obtained by the direct backward linkage and direct forward linkage of the input coefficients, respectively. The total linkage can be obtained from the total backward linkage and the total forward linkage of the LeonTF inverse matrix, respectively (Rasmussen, 1957).

$$BL(t)_j = \sum_{i=1}^{n} l_{ij} \ , \ FL(t)_i = \sum_{j=1}^{n} l_{ij}$$ ………………………………………………… Equation (19)

In cross-country analysis, interdependence can be analyzed by dividing into domestic sectors and inter-country sectors. Table 4 below shows the front-to-back relationship between countries and industries in South Korea in the six-country model.

Table 4. ROK's forward and backward relations

	Backward lingkage (BL)	Forward lingkage (FL)
Intra-national	$BL(t)_j^{kk} = \sum_{i=1}^{n} L_{ij}^{kk}$	$FL(t)_i^{kk} = \sum_{j=1}^{n} L_{ij}^{kk}$
Inter-national	$BL(t)^{ik}_j=\Sigma L^{ik}_{ij}$, $BL(t)^{mk}_j=\Sigma L^{mk}_{ij}$, $BL(t)^{pk}_j=\Sigma Lp^{ki}_j$, $BL(t)^{sk}_j=\Sigma L^{sk}_{ij}$, $BL(t)^{tk}_j=\Sigma L^{tk}_{ij}$	$FL(t)^{ik}_j=\Sigma L^{ik}_{ij}$, $FL(t)^{mk}_j=\Sigma L^{mk}_{ij}$, $FL(t)^{pk}_j=\Sigma Lp^{ki}_j$, $FL(t)^{sk}_j=\Sigma L^{sk}_{ij}$, $FL(t)^{tk}_j=\Sigma L^{tk}_{ij}$

In addition, an index indicating the degree to which one country's economic activities are related to the other country is obtained by calculating the relationship ratio of the other country to the total relationship. Equation (20) shows ROK's front-to-back relationship (Lee, 2002).

$BL(t)^{kk}_j$ / $[BL(t)^{kk}_j + BL(t)^{ik}_j + BL(t)^{mk}_j + BL(t)^{pk}_j + BL(t)^{sk}_j + BL(t)^{tk}_j]$
$FL(t)^{kk}_j$ / $[FL(t)^{kk}_j + FL(t)^{ik}_j + FL(t)^{mk}_j + FL(t)^{pk}_j + FL(t)^{sk}_j + FL(t)^{tk}_j]$ ………………………………………………………………………………………Equation (20)

In this study, the manufacturing sector, especially the machinery sector was extracted from 76 sectors of the Asian International Industry Association Table (Appendix C).

FINDINGS

Effect on Production Inducement

In order to analyze the economic impact on industries in ASEAN on South Korea industries, the production induction effect was investigated. In the process of calculating the production induction effect, the production induction coefficient for each country was estimated. The production induction coefficient refers to the unit of output that is directly or indirectly induced in each industrial sector to satisfy the increase in final demand by one unit and is also called

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

the inverse matrix coefficient because the inverse matrix is used in the derivation process. If this production inducement coefficient is calculated in advance, it is possible to independently estimate the final demand and measure the corresponding production level. By calculating the production induction coefficient, it is possible to calculate the magnitude of the production ripple effect between the six countries, taking into account the difference in economic scale between ASEAN-5 and South Korea.

The production inducement coefficient has the property of a multiplier that represents the ripple effect derived from final demand. It is also called a multisector multiplier or Leontief multiplier, distinguishing it from Keynesian investment multipliers. The total production induced in both countries shows the magnitude that is induced in the other country. It has the advantage of being able to accurately find out the ripple effect of production. Therefore, it is possible to clearly derive to what extent the domestic industry imports the intermediate goods of ASEAN country. In Table 5, the domestic and overseas total production inducement effect of the manufacturing industries in South Korea.

Table 5: Production-inducing effects of manufacturing in ROK

CODE	SOUTH KOREA					
	South Korea	Indonesia	Malaysia	Philippine	Singapore	Thailand
12	0.000071	0	0.028009	0.028013	0.00017	0
13	0.000003	0	0.000001	0.000001	0.000001	0.000001
14	0.000002	0	0	0	0	0
15	0	0	0.000002	0	0	0
16	0.000003	0	0	0	0.000002	0
17	0.000003	0	0.031	0	0	0
18	0.000011	0	0	0.000001	0.000014	0.000001
19	0.000001	0	0	0.000317	0.000004	0
20	0.000037	0	0.000003	0.000311	0.000003	0
21	0.000001	0	0	0	0	0
22	0.000004	0	0.000003	0	0.000007	0
23	0.000002	0	0.00002	0	0	0
24	0.000013	0	0.000014	0.000412	0.000005	0
25	0.000003	0	0	0	0	0.000009
26	0.000004	0.000001	0.000005	0	0	0.000001
27	0	0	0	0	0	0
28	0	0	0.000029	0	0	0.000001
29	0.000065	0.000015	0.000004	0.000068	0.000362	0.000044
30	0	0.000001	0	0	0	0
31	0.00001	0.000033	0.084697	0.015654	0.000352	0
32	0.000003	0	0.000023	0	0.000007	0

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

33	0.000001	0	0	0	0.000001	0
34	0	0.000002	0.000003	0	0	0
35	0	0.000001	0	0	0	0
36	0.000034	0.000001	0	0	0.000019	0
37	0.000007	0.000011	0.000142	0	0.000002	0.000001
38	0	0	0.000001	0.000007	0.000001	0
39	0.000007	0	0.001603	0	0.000021	0.000001
40	0.000004	0.000001	0.000001	0	0.000001	0.000001
41	0	0	0	0	0	0
42	0	0	0	0.000135	0.00001	0.000006
43	0	0	0.00004	0	0	0.000001
44	0.000001	0	0	0	0.000051	0
45	0	0	0	0	0	0
46	0.000001	0.000001	0	0.000002	0.000006	0.000002
47	0	0	0.000004	0	0	0.000004
48	0	0	0.000001	0	0.000001	0.000001
49	0	0	0	0	0.000001	0
50	0.000008	0.000037	0	0	0.000004	0.000001
51	0.000002	0	0.000008	0	0	0.000003
52	0	0	0.00959	0.000001	0.000001	0
53	0.000001	0	0.000067	0.000336	0.000001	0
54	0.000001	0	0	0	0.000003	0
55	0	0	0	0	0	0
56	0.000027	0	0.498405	0.000001	0	0
57	0.000001	0	0.001774	0	0	0
58	0.000008	0	0.001602	0	0.000001	0.000001
59	0.000002	0.000001	0.000015	0	0.000003	0
60	0.00001	0.000001	0.000001	0	0	0

Analyzing at the production-inducing effects of the South Korean manufacturing industry on the ASEAN countries, impact can be seen in flour, tobacco, chemical fertilizers, herbicides, other electronic products, and motorcycles by item. South Korea's production-inducing effect on the flour processing industry appears to be large in Malaysia in and the Philippines. This means that South Korea's manufacturing technology has an economic effect on the production of flour in Malaysia and the Philippines on an intermediate basis. In addition, it seems that only South Korea's production inducement effect on Malaysia is relatively significant. Through this, promoting cooperation between South Korea and Malaysia seems to be positive in terms of economic impact. Malaysia as aims to promote the development of the manufacturing industry at the national level, and it is pushing for diversification of trade with

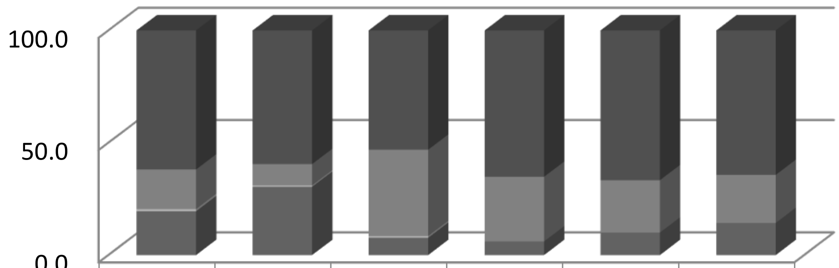
Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

Northeast Asian countries. Therefore, it is necessary South Korea takes into account of this development. Hence, efforts to improve relations between South Korean manufacturing industry and domestic industries in Malaysia is key for future cooperation.

Value Added Inducement Effect

The method of decomposing the added value included in export can grasp the elaborate flow of the movement of final and intermediate goods. Wang, Wei, and Zhu (2013) attempted to decompose the added value of exports between countries and industries, and decomposed the added value included in exports into a total of 16. Total exports can be largely divided into domestic value added (DVA), returned domestic value added (RDV), foreign value added (FVA), and returned domestic value added (RDV). Domestic added value refers to the added value that is finally consumed after being directly exported to the importing country or a third country. The added value returned to ROK was directly exported to the importing country, but later returned to the home country through several channels, indicating the added value consumed. Foreign value-added is foreign value-added included in export, and refers to intermediate goods procured from a direct importing country or a third country included in the production of export products. Redundant calculation refers to the value of the value added to export due to repetitive movement of intermediate goods between the origin and importing countries of production.

Figure 1: Decomposition of Value Added Exports to ASEAN of South Korea (2017, %)



	Vietnam	Singapore	Indonesia	Philippine	Malaysia	Thailand
PDC	61.9	59.5	53.1	65.2	66.7	64.3
RDV	17.6	9.5	38.5	28.8	23.3	21.4
FVA	1.0	0.6	0.8	0.0	0.0	0.0
DVA	19.5	30.4	7.7	6.1	10.0	14.3

Source: Jung et al,. (2019); ADB-MRIO (2017)
Note: DVA=Domestic Value Added, FVA=Foreign Value Added, RDV= Returned Domestic Value-Added, PDC= Purely Double Counted Terms.

Figure 1 shows the decomposition of South Korea's export value added by country in the ASEAN region.Vietnam, Singapore, and Indonesia are the places where South Korea's domestic value-added exports are high. In the case of Vietnam and Singapore, the proportion of double-counted exports (PDC) included in South Korea's exports is high, which means a high international division of labor relations between South Korea and the two countries.

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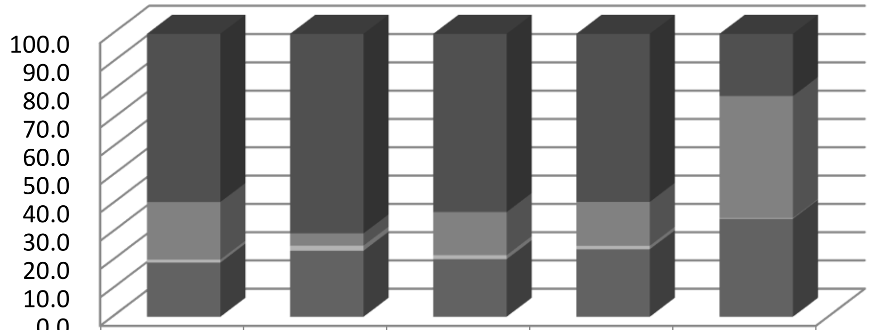
Journal of Social Sciences and Humanities

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

Conversely, the redundant added value included in South Korea's exports to Indonesia is relatively low, meaning that the progress of international division of labor between South Korea and Indonesia is low. In addition, the share of foreign value added (FVA) included in Indonesia’s exports is high.This is an industry in which Indonesia has to procure raw materials such as petroleum refining from abroad.

South Korea's exports to Thailand are relatively small compared to other ASEAN countries, but the proportion of redundant calculations in exports is high, indicating a relatively high linkage between South Korea and the global value chain.

Figure 2: Decomposition of Value Added Exports to Vietnam of South Korea by manufacturing sector (2017, %)



	Primary metalworking process	Garment, Clothing	Electronic component	Chemical	Cokes, petroleum refine
DVA	59.4	70.5	63.0	59.4	22.0
FVA	20.4	4.3	15.3	15.5	43.1
RDV	1.0	1.8	1.4	1.2	0.3
PDC	19.2	23.3	20.4	23.9	34.6

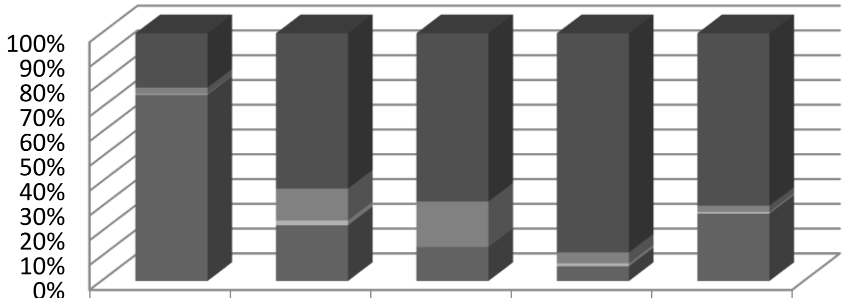
Source: Jung et al., (2019); ADB-MRIO (2017)
Note: DVA=Domestic Value Added, FVA=Foreign Value Added, RDV= Returned Domestic Value-Added, PDC= Purely Double Counted Terms.

Figure 2 shows the decomposition of added value by industry in Vietnam's exports from South Korea. Vietnam's major export industries from South Korea are metal processing, clothing, electronic parts, chemicals, and coke and petroleum refining. All five industries have a high proportion of redundant calculation exports (PDC), indicating high global division of labor in South Korea and Vietnam. In particular, in the case of the coke petroleum refining industry, the proportion of exports calculated by overlapping is about 36.6% of the total exports, showing a high figure. South Korea exports the most in the primary metalworking industry to Vietnam.Value-added exports (DVA) account for about 60%, foreign value-added value (FVA) is 20%, and export share (PDC) calculated in duplicate is about 20%.

e-Bangi Faculty of Social Sciences and Humanities Universiti Kebangsaan Malaysia
Journal of Social Sciences and Humanities

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

Figure 3: Decomposition of Value Added Exports to Singapore of South Korea by manufacturing sector (2017, %)



	Cokes, petroleum refine	Electronic component	Car, transportation	Leasing service	Shipping industry
DVA	21.9	62.7	67.9	88.4	69.6
FVA	2.6	12.9	18.2	4.4	2.5
RDV	0.3	1.9	0.1	1.2	0.7
PDC	75.2	22.5	13.9	5.9	27.2

Source: Jung et al,. (2019); ADB-MRIO (2017)
Note: DVA=Domestic Value Added, FVA=Foreign Value Added, RDV= Returned Domestic Value-Added, PDC= Purely Double Counted Terms.

South Korean exports to Singapore are the largest in the coke-petroleum refining industry. In particular, in the case of the coke-petroleum refining industry, the ratio of double value export calculation (PDC) is 75.2%, showing a high figure. This means that the connection between South Korea's oil refining industry and Singapore's global value chain is very high. The proportion of domestic value-added (DVA) in South Korea's exports to Singapore's oil refining industry is about 22%, which is a low figure. In addition, South Korea's exports to Singapore's electronic components and water transport industry are highly redundant, showing a clue to the international division of labor between South Korea and Singapore. In the case of South Korea's exports to Singapore rental services, the proportion of domestic value-added (DVA) is very high (88.4%).

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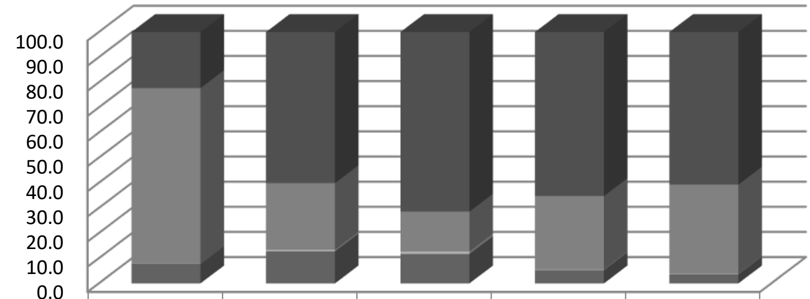
Journal of Social Sciences and Humanities
Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

Figure 4. Decomposition of Value Added Exports to Indonesia of South Korea by manufacturing sector (2017, %)



	Cokes, petroleum refine	Electronic component	Car, transportation	Leasing service	Shipping industry
DVA	22.3	60.1	71.4	65.2	60.7
FVA	69.9	26.5	15.9	29.2	35.6
RDV	0.1	0.6	0.9	0.3	0.2
PDC	7.8	12.8	11.7	5.3	3.6

Source: Jung et al,. (2019); ADB-MRIO (2017).
Note: DVA=Domestic Value Added, FVA=Foreign Value Added, RDV= Returned Domestic Value-Added, PDC= Purely Double Counted Terms.

South Korea's major export industry to Indonesia is coke-petroleum refining (see Figure 3-21). Most of South Korea's petroleum refinery exports to Indonesia are processed exports using foreign intermediate goods. The proportion of foreign value-added (FVA) included in exports is about 70%. In the case of the chemical and apparel manufacturing industries, the proportion of double-counted exports (PDC) is higher than that of other major export industries, suggesting the division of labor between South Korea and Indonesia in the two industries.

The above analysis was conducted focusing on Vietnam, Singapore, and Indonesia, which appear to have the highest proportion of added value among South Korea's exports to ASEAN. ASEAN member countries generally have a small share of domestic value added and a large share of foreign value added. This means that the dependence on foreign intermediate goods is higher in the production of export products. In addition, the high proportion of redundant calculations, which means repetitive movement of intermediate goods, means that the degree of global division of labor is high. However, the proportion of indirect value-added exports and overseas value-added use compared to total exports is not high. This means that technology transfer such as construction of local production bases, local expansion of parts procurement companies, and localization of intermediary goods procurement has not been successful.

Forward / Backward Linkage Effects

Based on the analysis model presented, the forward and backward linkage effects of five ASEAN countries and South Korean manufacturing industries were calculated. This article attempts to find the interdependence of each country based on the results derived from

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

empirical analysis. The large backward linkage effect on the home country means that it has a high production capacity, and it can be said that it has a self-supporting industrial structure. The effect of backward linkage on the partner country is as follows. Assuming South Korea and Indonesia, it is to determine to what extent South Korea's industrial production is causing Indonesia's industrial production.

First of all, in this article, I analyzed the backward linkages effect. The domestic backward linkage effect refers to the backward linkage effect of a country's industry linkage analysis. Therefore, this paper attempts to analyze how much the demand of the domestic industry affects the overall production of the other country's industry by analyzing the effect of backward linkage on the other country. Taking South Korea as an example, this indicates how much of a single unit of demand in the South Korean manufacturing industry affects ASEAN-5's entire industry.

Table 5 shows the size of the backward linkage effect and forward linkage effect of the manufacturing industries in South Korea. From the table, it can be seen that the manufacturing industries in South Korea have a greater backward linkage effect and forward linkage effect on Malaysia.

Table 6: Backward linkage effect and Forward linkage effect of South Korea on ASEAN+5

BL(t)	South Korea	South Korea	-0.000329
		Indonesia	6.77626E-21
		Malaysia	0.568503
		Philippine	-0.043729
		Singapore	0.000292
		Thailand	-0.000039
FL(t)	South Korea	South Korea	-0.364111134
		Indonesia	-0.04778567
		Malaysia	1.508825987
		Philippine	-0.219866305
		Singapore	0.330791728
		Thailand	-0.207854606

When analyzing backward linkage effect of the South Korean manufacturing industry, it appears that Philippines is the lowest (-0.04). On the other hand, the coefficient of influence on Malaysia is 0.6, indicates that it has the highest economic impact on Malaysia economy from trade with South Korea. From this, it can be inferred that there is a high degree of trade connection between ROK and Malaysia in the manufacturing sector.

The forward linkage effect within the country includes the feedback effect section through the spread of production to the other country. In addition, the forward linkage effect from the partner country is an indicator of whether the production activity of the partner country has a greater influence on the production activity of which industry in the country. However, in the analysis of international industry relations, it is common to find the international industry

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

relations by placing a greater weight on the backward linkage effect than on the forward linkage effect.

When analyzing at the forward linkage effect of the South Korean manufacturing industry by country, it appears that the factor of the forward linkage effect on the South Korea is the lowest (-0.36), indicating that the domestic manufacturing intermediate goods do not have a significant impact on the development of the manufacturing industry.

As the South Korean manufacturing industry has a high forward effect on the Malaysian manufacturing industry (1.5), it can be seen that the input of intermediate goods in South Korea not only develops other industries, but also increases the manufacturing exports of South Korea, the more positive the Malaysian manufacturing production is. It indicates that the industries related to intermediate goods in South Korea show higher dependency on international export. The backward and forward linkages when compared and contrasted have shown clearly how much interdependence there is between the South Korean ASEAN manufacturing industry.

CONCLUSION

This study empirically analyzed the characteristics of the interdependence relationship between South Korea and ASEAN manufacturing industries in the framework of inter-regional industry association analysis using the “Asian International Industry Association Table” as basic statistical data. To this end, the “Asian International Industry Association Table” composed of 10 countries, which is the basic data, was integrated into the ASEAN and South Korean models, and analyzed to include the manufacturing industry in 76 basic divisions. The empirical analysis results of this study can be summarized as follows.

At the production-inducing effects of the South Korean manufacturing industry on ASEAN member countries, larger effects can be seen in products such as flour, tobacco, chemical fertilizers, herbicides, other electronic products, and motorcycles. South Korea's production-inducing effect on manufacturing industry appears to be relatively large in Malaysia by country. This means that South Korea's manufacturing technology has an economic effect on the production in Malaysia on an intermediate basis.

In addition, the forward linkage effect of South Korea on Malaysia is relatively high compared to other ASEAN member countries, indicating that it has the highest economic impact on the Malaysian economy from trade with South Korea. And the South Korean manufacturing industry has a high forward effect on the Malaysian manufacturing industry, it can be seen that the input of intermediate goods in South Korea not only develops other industries, but also increases the manufacturing exports of South Korea. On the other hand, in terms of decomposition of value added exports to ASEAN from South Korean manufacturing sectors - South Korea's domestic value-added exports are higher in Vietnam, Singapore, and Indonesia.

When comparing trade volume in Table 3, South Korea has a strong dependence on trade with several ASEAN countries. However, as a result of the empirical results, it can be seen that the production inducement effect between Malaysia and South Korea and the effect of forward and backward linkage industry are higher, and so is the dependence on industry. Therefore, since the bilateral FTA between South Korea and Malaysia has not yet been

Special Issue: Vol. 19. No.2 (2022) 96-115. ISSN: 1823-884x
Theme: Community Development, Education, Socio-Economic and Social Transformation

concluded, it is necessary to diversify economic cooperation between South Korea and ASEAN member countries.

In addition, through the value-added analysis, the research finds that the localization process in ASEAN is weak, including the construction of local production bases, local advancement of parts procurement companies, and localization of intermediate goods procurement. This means that the trade structure between South Korea and ASEAN countries needs to be diversified. For a win-win situation, South Korean companies which focus on importing raw materials from ASEAN should develop high-value-added industries in the structure of exports to ASEAN,

Similarly, ASEAN member countries should nurture and develop local infrastructure and technical manpower in order to expand the production network with South Korean companies. In addition, despite the global economic downturn, both countries can be expected to strengthen cooperation through multilateral organizations such as the ASEAN-South Korea Council and ASEAN+3 in order to achieve economic development through rapid promotion of joint initiatives.

The empirical analysis results of this study has the following significance. Unlike previous studies focusing on domestic analysis, this study derives more detailed comparison and analysis results on the interdependence relationship between the manufacturing industry in South Korea and ASEAN countries and related industries by using the international industry-related analysis framework. This allows for more objective and balanced discussions on the status and interdependence of the South Korean economy on the East Asian market, which is in the midst of international competition. However, due to data acquisition, limitations of this article is that it uses the “2017 International Industry Association Table” instead of latest statistics. In addition, since industries were extracted from 76 basic classifications according to the industry study table, the fact that they are partially inconsistent with the OECD classification criteria is another limitation of this study.

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Theme: Community Development, Education, Socio-Economic and Social Transformation

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