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Revisiting the Role of Imported Inputs in Asian Economies*

Woocheol Lee†
Department of International Trade, Gyeongsang National University, South Korea

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Abstract

Purpose – Global production chains and their impacts on economic growth have drawn extensive attention from researchers. Close relationships among global production chains, export and economic growth have been illuminated, as evidenced by the fast and stable economic growth of East Asian economies. These economies perform various roles within global production chains using offshoring, in which the impact of import on domestic gross output is as strong as that of export. The impact of import on economic growth would depend on whether imported inputs substitute or complement domestic inputs production, which is likely to vary according to individual countries' functions within global production chains. The economic growth of concerned countries would also be diverse. However, little attention has been paid to the impact brought by imports compared to its significance.

Design/methodology – The principal methodology used in this paper is structural decomposition analysis (SDA), widely chosen to elucidate the impact of various factors on domestic gross output using input-output tables. This paper extracts trade data of six Asian economies from the World Input-Output Database (WIOD) 2016 release that covers 43 countries for the period 2000-2014. The extracted data is then categorised into 37 sectors. First, this paper calculates the Feenstra-Hanson Offshoring Index (OSI) of each country. It then applies SDA to measure the changes in each economy's gross output, export, import input coefficients, and domestic input coefficients. Finally, after taking the first difference from pooled time-series data, it estimates the correlations between imported input coefficients and OSI using the ordinary least square (OLS) method.

Findings – The main findings of this paper can be summarised as follows. Firstly, all six countries have increasingly engaged in global production chains, as evidenced by the growing size of OSI. Secondly, there are negative correlations in five countries except Japan, with sectoral differences. Thirdly, changes in import input coefficients are not negative in all six countries, indicating that offshoring does not necessarily substitute for domestic inputs production but does complement it and, therefore, fosters their economic growth. This is observed in China, Indonesia, Korea and Taiwan. Offshoring has led to an increase in the use of imported inputs, which has, in turn, stimulated domestic inputs production in these countries.

Originality/value – While existing studies focus on the role of export in evaluating the impact of participating global production chains, this paper explicitly examines the unexplored impact of import on domestic gross output by considering both the substitution and the complementary effect, using the WIOD. The findings of this paper suggest that Asian economies have achieved fast and stable economic growth not only through successful export management but also through effective import management within global production chains. This paper recommends that the Korean government and enterprises carefully choose offshoring strategies to minimise disruption to domestic production chains or foster them.

Keywords: Domestic Gross Output of Asian Economies, Imported Inputs Coefficients, Offshoring Index, Structural Decomposition Analysis, The World Input-Output Database,

JEL Classifications: C67, F62, O53

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† **First and Corresponding author:** w.lee226@gnu.ac.kr

1. Introduction

Export-led economic growth strategy is a key phrase to describe the fast economic growth of Asian economies over the last fifty years.[1] Numerous studies investigating the relationship between export and economic growth have found that fostering the export of high-technology-based manufacturing products is critical for achieving sustainable economic growth by extracting more benefits from exports. This is because not only are these products more income elastic, but the producers of them are also likely to capture a higher proportion of value-added (Hausmann, Hwang and Rodrik, 2007; Gouvea and Lima, 2010; Tajoli and Felice, 2018; Branstetter et al., 2021).

Meanwhile, import, the counterpart of export, receives less attention even though its impact on economic growth is just as strong. Imported inputs are commonly considered to have a negative effect on domestic gross output by substituting for domestic inputs production (Pal, 1991; Chenery, Shishido and Watanabe, 1962; Magacho, McCombie and Guilhoto, 2018). However, many economies import sophisticated inputs from other economies to complete the production process, then convert them as final products for domestic usage or exports. The impact of imported inputs is likely to depend on whether they substitute for domestic inputs production or complement it. If imported inputs substitute for domestic inputs production, then they would reduce gross output production and potentially hamper economic growth. Conversely, if imported inputs complement domestic inputs production, then gross output and economic growth would be enhanced. However, the impact of imported inputs on economic growth has been explored little.

An analysis of the impact of imported inputs on domestic gross output is increasingly required more than ever due to stylised facts observed in international trade. The rapid expansion of global production chains[2] led by leading transnational corporations (TNCs) makes it complicated to distinguish the impacts of import and export on domestic production. TNCs that have encountered profit squeeze due to shareholder primacy have found ways to cut costs through economies of scale and scope (Chandler 1990). One of these ways is offshoring and outsourcing (offshoring hereafter), which causes extensive fragmentation of production processes globally (Bogliacino, Guarascio and Cirillo, 2018; Durand and Gueuder, 2018; Demir, 2009; Milberg, 2004). As a result, the trade of intermediate goods worldwide has dramatically increased by a factor of 20 from 1988 to 2020.[3] The Trade in Value Added (TiVA) database published by the Organisation for Economic Cooperation and Development (OECD) and those studies that analysed the TiVA have contributed to understanding who the actual winners and losers are in international trade (Bohn, Brakman

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[1] Japan, the first generation, was a leading economy since 1930s, then followed by the so-called the four dragons, the second generation, since 1980s and then followed by another group of emerging economies, the third generation, since 1990s.

[2] Chains analysis originated from the work of Hopkins and Wallerstein (Hopkins and Wallerstein) within the framework of the world-systems which developed and diversified global commodity chains and global value chains. See Bair (2005) for a summary of the historical development of chain analyses. There are other terms used commonly to refer to this heavy interdependence of industries and countries over the process of production and consumption such as global division of labour, global supply chains and global value chains depending on focal topics. This paper uses global production chains because it analyses the impact of international trade on the changes in inputs rather than on the relationship between centre and periphery or value creation and value sharing.

[3] Calculated from the world intermediate goods trade data from the World Integrated Trade Solution (WITS) accessible at https://wits.worldbank.org.

and Dietzenbacher, 2021; De Marchi, Giuliani and Rabellotti, 2018; Kwon Taehyun and Ryou Jai-Won, 2015; de Vries et al., 2019). It remains unclear how imported inputs have functioned in the creation of value-added and the sharing of it.

Furthermore, the extent of each industry's engagement in global production chains varied, and the sectoral differences of each country are more significant than ever (Sturgeon and Memedovic, 2010; Feenstra and Hanson, 1996). Examining how sectors are interconnected has become a critical task in understanding the impacts that participating in global production chains has on economic growth. One of the approaches specialised in analysing the interdependence of sectors in an economy is input-output analysis, originating from the work of Leontief (1941). Unlike other analytical tools commonly adopted in economics, transactions of intermediate goods and associated technological changes among industries are at the centre of input-output analysis.

Asian economies have actively participated in global production chains and have shown fast economic growth based on the export-led growth strategy. They participated in global production chains not only as intermediate input producers but, more importantly, as key assemblers of those intermediate inputs from all over the world. Many production processes, especially low value-added ones, have been relocated from developed to developing economies in Asia (Humphrey, 2019; Kaplinsky, Morris and Readman, 2002; Pietrobelli and Staritz, 2018; Hart-Landsberg and Burkett, 1998). This relocation stimulates exports in developing Asian economies, but little research has been devoted to examining the impact of the involved imported inputs on these economies.

This paper applies a structural decomposition method to investigate the impact of imported inputs on technological change, export and the gross output of Asian economies. Kubo, Robinson, and Syrquin (1986) and Magacho, McCombie and Guilhoto (2018) developed frameworks to capture the interdependence of these variables by decomposing the changes in the gross output of an economy into changes in several components such as technology, final demand (exports, household and government spending) and *intermediate* demand. In these frameworks, substituting imports for domestic inputs production is often considered a negative impact of participating in global production chains. In contrast, promoting exports is considered positive, assuming that imports are likely to substitute domestic production perfectly. This assumption, however, may be misleading given the expansion of global production chains.

In input-output analysis, positive changes in the imports input coefficients matrix, indicating that the economy uses more imported inputs in domestic production, may happen for two entirely different reasons. On the one hand, a comparative disadvantage of import-competing inputs in the domestic economy can cause an increase in the use of foreign-produced inputs. As a result, the domestic sector would shrink. On the other hand, relocation of production processes from foreign countries to the domestic country can also result in an increased usage of imported inputs within the country. However, this is likely to have a positive impact if the production of domestic inputs is encouraged through forward and backward linkages. Substituting imported inputs for domestic inputs does not necessarily negatively impact economic growth. Any changes in the imported input coefficients would influence the domestic input coefficients, and both aspects need to be considered to understand the impacts of global production chains on economic growth.

This paper uses the World Input-Output Database (WIOD) for its analysis. International trade time series data that includes multiple countries based on standardised industrial classification are not commonly published, which makes it difficult to trace how different sectors in different economies are interconnected. The WIOD helps alleviate this issue by including the input-output data for 28 European Union countries and 15 other major countries from 2000 to 2014. This paper focuses on six Asian (China, Indonesia, India, Japan, Korea and Taiwan) and extracts their input-output data. The changes in gross output for each of these six economies are decomposed into technological changes in imported inputs, domestically produced inputs, and final demand and export of each economy from 2000 to 2014.[4]

This paper reports that the technical coefficient matrix of *imported* inputs experienced negative changes at the aggregate level in India, Japan and Korea, which contrasts with the finding of Magacho, McCombie and Guilhoto (2018), who found negative changes in the technical coefficient matrix of imported inputs for all sampled countries except Korea. On the other hand, positive changes in the technical coefficient matrix of *domestic* inputs were observed in China, Indonesia, Korea and Taiwan, while Japan and India showed negative changes. Meanwhile, changes in export growth were positive for all economies, and their magnitude was significant enough to offset the negative changes in the technical coefficient matrix of imported inputs.

These findings imply that middle-income economies participating in global production chains employed fewer imported inputs and more domestic inputs, leading to increased localisation and backward/forward linkages. In contrast, high-income economies like Japan and Korea used more imported inputs through offshoring. Specifically, data from China and India suggest that the negative impacts of offshoring on the input coefficients dissipated over time due to active input localisation. These tendencies were the most discernible in high and medium-high technology industries, such as electronics, machinery and vehicle manufacturing. These results indicate that the composition of exports matters.

This paper continues to introduce and review the literature on global production chains, offshoring and input-output analysis in Section 2. It explains the structure of the WIOD and the process of data extraction and then derives the structural decomposition model used in the paper in Section 3. Then, it reports the calculated offshoring index (OSI), decomposition results and regression results at each country's aggregate and sectoral levels, followed by the discussion of the decomposition results compared to existing works. Finally, it draws concluding remarks and points out the limitations of the paper in Section 5.

2. Structural Decomposition Analysis: A Literature Review

When developing Quesnay's *Tableau économique*, Leontief conducted an input-output analysis to investigate the interdependence of industries within an economy (Leontief, 1941; Leontief et al., 1953). He postulated that production coefficients could be statistically estimated and used to perform a comparative static analysis of an economy over time (Miller and

[4] One may question that the analysed period is outdated, and the analysis could have used the input-output dataset published by the Asian Development Bank to obtain the necessary data. The author is fully aware of these criticisms. Nonetheless, the author would like to explain the choice of the period and the dataset. This paper intentionally chose the period 2000-2014 from the WIOD for two reasons. Firstly, this paper aims to compare its results to those of Magacho, McCombie and Guilhoto (2018) to argue and emphasise the supplementary effect that they did explore enough. Secondly, for the same reason, it would be more consistent to obtain the data from the same dataset that they used.

Blair, 2022). Early works on decomposition mainly focused on technology and final demand, and now, the scope has been extended to environmental indicators and energy requirements.[5]

Structural decomposition analysis (SDA) was formally introduced by Skolka (1977), in which he isolated the impact of changes in economic structure, the final demand and technology, followed by his empirical analysis of Austria in which he explained the structural transformation in terms of changes in technology, domestic final demand, foreign trade and labour productivity (Skolka, 1989). Feldman, McClain and Palmer (1987) also decomposed the gross output change in the US in 1963 and 1978 into changes in final demand and input-output coefficients.[6] Any changes in input-output coefficients reflect various aspects of technology change, such as "changes in production recipes, substitutions caused by relative price changes, reduction in a sector's materials inputs per unit of output brought about by economies of scale, and so on" (Miller and Blair, 2022, 352).

Input-output coefficients can also change because of external shocks caused by international trade on the domestic economy. Technological shock entails changes in the way inputs are combined within an economy. Technology can affect the saving of imported or domestically produced inputs (Gilles, Deaza and Vivas, 2023). The saving of imported inputs has a positive impact, and the saving of domestically produced inputs has a negative impact on the gross output of an economy. Decomposing those external shocks on economic growth was developed (Chenery, Robinson and Syrquin, 1986; Pamukçu and de Boer, 1999; Skolka, 1989).

The substitution of imported inputs for domestic inputs was explicitly addressed in Magacho, McCombie and Guilhoto (2018). They noted that the substitution between domestic suppliers and imports influences an economy via two channels. Firstly, it may cause irreversible damage to countries' systems of innovation. The substitution is likely to deprive the opportunity of 'learning-by-producing' (Pisano and Shih, 2009; Andreoni and Chang, 2018). Secondly, it may stimulate the export of an economy by improving its competitiveness. To evaluate the ambivalent impact of the substitution, they measure the changes in imported input coefficients and the growth rate of export.

They, nonetheless, did not develop their interpretation of the changes in technical coefficients enough to encompass the complicated impacts of global production chains on domestic absorption. Offshoring, a primary form of materialisation of global production chains (Milberg, 2008; Milberg and Winkler, 2013; Auvray and Rabinovich, 2019), was not considered carefully. Given widespread offshoring, developed economies are likely to experience negative changes in both imported and domestic input coefficients because offshoring relocates domestic production processes abroad, and therefore, linked domestic inputs production is expected to be contracted. On the other hand, developing countries are likely to experience positive changes in domestic input coefficients because 'offshored'

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[5] For example, a special issue of Economic System Research covered these topics. See Volume 28, No. 2, June 2016, and a special issue of Structural Change and Economic Dynamics was dedicated to the topic "Structural changes and carbon emissions in China" in September 2020.

[6] Thanks to the explanatory power of structural decomposition techniques in explaining the determinants of output growth, many different methods were developed and coexisted. This caused confusion in interpreting the determinants because of a wide variability in outcome was drawn from different methods, which call for unified theoretical basis (Rose and Casler, 1996). For example, Dietzenbacher and Los (1998) stated that they reviewed 24 different decomposition forms in the analysis of the Netherland and suggested to use the average of the two polar decompositions that leads to the average of the 24 decompositions.

production processes that did not exist within developing economies would be relocated to them. Interpreting the changes of imported input coefficients, however, is not straight-forward. If an economy mainly performs basic assembly tasks within global production chains, imported input coefficients are likely to have negative changes. If this economy performs learning effectively over time, this would not only invite further relocation of complex production processes from advanced economies but also localise some of these processes. In this case, imported input coefficients are likely to show positive changes.[7] The substitution effect can change over time, which is a critical feature explaining the sustained economic growth of Asian economies. The substitution effect is not necessarily harmful, as typically argued.

Few studies have adopted structural decomposition methods together with the multiregional input-output analysis to explain the impacts of international trade on the gross domestic output growth of Asian economies. For example, Pei, Oosterhaven and Dietzenbacher (2012) examined the Chinese input-output tables and concluded that the contribution of the high-tech sector's export to its economic growth was overestimated. Firmansyah and Oktavilia (2015) employed the Temporal Leontief Inverse analysis to trace the structural change in Indonesia's manufacturing sector from 1975 to 2005. Magacho, McCombie and Guilhoto (2018) included China, India and Korea as reference countries compared to the Brazilian economy. However, little has been examined on how participation in global production chains and offshoring have affected the technical coefficients of imported and domestic inputs in Asian economies.

3. Data Set, Structural Decomposition Method and Offshoring Index

3.1. The World Input-Output Database (WIOD) and the data set of this paper

This paper investigates how international trade affects input usage in Asian economies. To achieve this, data is needed on input transactions between countries. The most effective way to track these transactions is by analysing the World Input-Output Database (WIOD). The WIOD was developed to address the limitations of existing trade statistics, which do not collect information on the supplying industry or the use of inputs by importers (Timmer et al., 2015).[8] The WIOD provides an annual time series of world input-output tables (WIOTs) merged with national accounts data and international trade statistics, making it a powerful tool for analysing global production chains.

National input-output tables (NIOTs) allow researchers to capture industry interactions within a country. By reading the tables horizontally, researchers can calculate how other

[7] It is notable that the 'domestic' inputs do not necessarily mean the inputs produced by 'domestic' (indigenous) firms. Some domestic inputs are likely to be produced by multinational corporations operating in hosting countries. This issue can be captured by the analysis of value-added data base such as the OECD Trade-in-Value-added (TiVA). Related discourses are covered in De Marchi, Giuliani and Rabellotti (2018), Kwon, Taehyun and Ryou Jai-Won (2015) and de Vries et al. (2019).

[8] The WIOD is composed several components – world input-output tables (WIOTs), national input-output tables (NIOTs), exchange rates, international supply-use tables, national supply-use tables, input for supply-use tables and two satellite accounts – socio-economic accounts and environment accounts.

industries consume an industry's outputs. By reading the tables vertically, they can figure out how an industry uses inputs produced by other industries. The gross output of each industry is equal to the sum of all uses of the output from that industry.

WIOTs are broken down by the country and industry of origin. This allows researchers to trace the country of origin of specific inputs used in a particular industry. WIOTs are a powerful tool for analysing global production chains and the interdependence of national economies.

This paper uses the 2016 release of the WIOD, which covers 28 EU countries and 15 other major countries over the period 2000-2014. Six Asian economies included in the 2016 release are China, Indonesia, India, Japan, Korea and Taiwan. The values in the WIOTs are measured by free-on-board (FOB) prices and denominated in millions of US dollars. Data for 56 sectors are classified following the International Standard Industrial Classification (ISIC) revision 4. These sectors are then merged into 37 sectors to use in this paper for two reasons. Firstly, this paper's primary interest is the manufacturing sector rather than the agriculture and service sectors. Many industries in the service sector are rarely traded internationally, and the corresponding data is limited. Thus, the author collapsed some of the industries in the agriculture and the service sectors while keeping the manufacturing industries as they are. Secondly, an input-output analysis requires the calculation of an inverse matrix, the Leontief inverse. However, some service sectors' values are reported as zero, which causes the problem of a singular matrix. Collapsing the industries in the service sector is unavoidable to induce the Leontief inverse matrix.

This paper extracts the data of six Asian economies from the WIOTs. It decomposes the changes in gross output into changes in imported input, domestic input, final consumption and exports using structural decomposition analysis. As the WIOTs are published in current prices and previous-year-prices (PYP), the calculated changes in each component are converted by using the constant prices from the year 2000.

3.2. Drawing the Structural Decomposition Analysis Method and Offshoring Index

The fundamental information used in the input-output analysis is the flow of production from each industrial sector, considered as producers, to each of the sectors, itself and others, considered as consumers (Miller and Blair 2022). Any changes in final demand for an industry in an economy affect not only the production of the concerned industry but also that of other industries that are backwardly and forwardly linked, therefore also affecting the gross output of the economy.

It is possible to calculate the ratio of every input of a given output to form the A matrix. The elements of the A matrix represent the economy's production structure, or 'the production recipes' for each of the sectors in the economy (Miller and Blair 2022). Once the A matrix is obtained, it is possible to calculate the gross output change by using the Leontief inverse, which is expressed as $L = (I - A)^{-1}$. The relationship between gross output (x), the Leontief inverse (L) and final consumption (f) in the economy is expressed as a vector with the following: $x = Lf$. Any changes in x can be decomposed into a change in A and f.

This paper builds on the SDA method used in previous studies such as Magacho, McCombie and Guilhoto (2018) and Miller and Blair (2022). SDA is a useful technique for decomposing changes in input-output tables into various factors such as technological change, final demand and inter-industry relationships.

Using the basic Leontief model for two periods (0 and 1), the vector of gross output x over two periods can be written as follows:

$$x^1 = L^1 f^1 \text{ and } x^0 = L^0 f^0 \tag{1}$$

$$\Delta x = x^1 - x^0 = L^1 f^1 - L^0 f^0 \tag{2}$$

where L is the Leontief matrix composed of direct and indirect production coefficients, and f is the final demand vector. Commonly used forms of decomposition can be derived from Equation (2) using either year 0 values or year 1 values. Equation (3), for example, uses year 1 values for L and year 0 values for f.

$$\Delta x = L^1(f^1 - f^0) + (L^1 - L^0)f^0 = (\Delta L)f^0 + L^1(\Delta f) \tag{3}$$

$$\Delta x = (L^0 + \Delta L)f^1 - L^0(f^1 - \Delta f) = (\Delta L)f^1 + L^0(\Delta f) \tag{4}$$

Equation (4) shows that the change in gross output can be decomposed into two parts: one caused by the change in technology at a given final demand of year 1, and the other caused by the change in final demand at a given technology of year 0. Equation (3) expresses a similar relationship. It is worth noting that the calculation of the contribution from technology change and final-demand change is not identical unless there is no change in technology and final demand over the two periods.

To minimise the issue of calculation sensitivity, this paper adopts the mid-point weights from these two equations, which is considered the most appropriate approach for SDA (Dietzenbacher and Los 1998). The mid-point weight can be calculated by adding equations (3) and (4) and then dividing the sum by two, as shown in Equations (5) and (6).

$$2\Delta \mathrm{x} = (\Delta \mathrm{L})\mathrm{f}^0 + L^1(\Delta f) + (\Delta L)f^1 + L^0(\Delta f) \tag{5}$$

$$\Delta \mathrm{x} = \frac{1}{2}(\Delta \mathrm{L})(\mathrm{f}^0 + f^1) + \frac{1}{2}(L^0 + L^1)(\Delta f) \tag{6}$$

Equation (6) shows that changes in gross output can be decomposed into changes in the Leontief matrix and changes in final demand. It can be further transformed to related changes in the Leontief matrix and the input coefficients matrix. Following Magacho, McCombie, and Guilhoto (2018), A_n^t can be denoted as the national direct coefficients matrix and A_m^t as the direct coefficients matrix of imported goods. The total direct coefficients matrix A^t is the sum of A_n^t and A_m^t.

Post-multiplying $L^1 = (I - A_n^1)^{-1}$ by $(I - A_n^1)$ produces Equation (7), while pre-multiplying $L^0 = (I - A_n^0)^{-1}$ by $(I - A_n^0)$ leads to Equation (8).

$$L^1(I - A_n^1) = I = L^1 - L^1 A_n^1 \tag{7}$$

$$(I - A_n^0)L^0 = I = L^0 - A_n^0 L^0 \tag{8}$$

Post-multiplying by L^0 after rearranging Equation (7) to obtain

$$L^1 L^0 - L^0 = L^1 A_n^1 L^0, \tag{9}$$

Similarly, pre-multiplying by L^1 after rearranging Equation (8) to obtain

$$L^1L^0 - L^1 = L^1A_n^0L^0 \tag{10}$$

Finally, subtracting Equation (10) from (9) produces

$$\Delta L = L^1 - L^0 = L^1A_n^1L^0 - L^1A_n^0L^0 = L^1(\Delta A_n)L^0 \tag{11}$$

Equation (11) relates the change in L to the change in A. Specifically, ΔA is doubly weighted by the L in year 1 and by the L in year 0. Given $A_n^t = A^t - A_m^t$, A_n^t is replaced by $A^t - A_m^t$ as shown in Equation (12). After further rearrangement, Equation (13) is produced. Equation (13) decomposes the change in gross output into three components: the technological change (the first term), the substitution of domestic inputs (the second term) and the change in final demand (the third term).

$$\Delta L = L^1[(A^1 - A_m^1) - (A^0 - A_m^0)]L^0 = L^1(\Delta A)L^0 + L^1(-\Delta A_m)L^0 \tag{12}$$

$$\Delta x = \frac{1}{2}\{[L^1(\Delta A)L^0](f^0 + f^1) + [L^1(-\Delta A_m)L^0](f^0 + f^1) + (L^0 + L^1)(\Delta f)\} \tag{13}$$

Participation in global production chains can positively and negatively affect domestic gross output. On the one hand, it can lead to a negative substitution effect as domestic inputs are replaced by imported inputs. On the other hand, it can stimulate domestic gross output by fostering exports, one of the components of final demand. After further developing Equation (6), it is possible to decompose final demand into the contribution of exports and other components of final demand as follows:

$$\Delta x = \frac{1}{2}\{(\Delta \mathrm{L})(f^0 + f^1) + (L^0 + L^1)(\Delta f') + (L^0 + L^1)(\Delta \mathrm{EX})\}, \tag{14}$$

where $\Delta f'$ is the vector of final demand growth excluding exports and ΔEX is the vector of total export growth. The total export growth can be further divided into two components: the direct contribution from the growth of a specific sector and the indirect contribution of other sectors' export growth to the output growth of the specific sector. The indirect contribution is calculated by subtracting the direct contribution from the total export growth.

Equations (13) and (14) are used to calculate the year-to-year growth rates of components of gross output—A, A_n, A_m, f and EX—valued at the prices of the year 2000, following Magacho, McCombie, and Guilhoto (2018).[9] The results are reported in Table 3.

[9] For example, the growth rates over 2000–2002 based on the 2000 prices can be calculated as follows:

$$\Delta\% x^{2000-2002} = \left[\left(\frac{\Delta x^{2000-2001}}{x^{2000}}\right) + \left(1 + \frac{\Delta x^{2001-2002}}{x^{2001}}\right)\left(\frac{\Delta x^{2001-2002}}{x^{2001}}\right)\right] \times 100;$$

$$\Delta\% A^{2000-2002} = \left[\left(\frac{\Delta A^{2000-2001}}{x^{2000}}\right) + \left(1 + \frac{\Delta x^{2001-2002}}{x^{2001}}\right)\left(\frac{\Delta A^{2001-2002}}{x^{2001}}\right)\right] \times 100;$$

Finally, the offshoring index measures the extent to which each country engages in global production chains. The Feenstra-Hanson offshoring index is widely used in studies of global production chains. It calculates the share of imported input of total inputs in one industry (Feenstra and Hanson 1999; Milberg 2008; Milberg and Winkler 2013; Bogliacino, Guarascio, and Cirillo 2018; Auvray and Rabinovich 2019). This paper adopts the Feenstra-Hanson offshoring index (FHOI), which is expressed as

$$FHOI_{i,j,t} = \frac{Imported\ intermediate\ inputs_{i,k\neq j,t}}{Total\ intermediate\ inputs_{i,j,t}} \tag{15}$$

where *i* stands for the industry, *j (and k)* for country and *t* for time. The diagonal elements of the imported input matrix correspond to the numerators.[10]

4. Offshoring, Changes in Input Coefficients and Domestic Gross Output in the Asian Economies

4.1. The extent of participation in global production chains: Offshoring index

It is useful to know how deeply each economy is engaged in global production chains before examining changes in the coefficient matrices. These changes can be interpreted in various ways depending on the extent of each economy's participation in global production chains. Table 1 reports the FHOI for selected years. This paper assumes that the extent of offshoring was much stronger in high-income Asian economies. Notably, the index in China increased by 216% over the same period. Still, the index remained around 1.6 in 2014, which is significantly low compared to Korea (tenfold greater) or Taiwan (twentyfold greater). This indicates that high-income Asian economies imported a more significant portion of their total inputs than middle-income Asian economies, implying that the negative impact of A_m is likely to be stronger in the high-income economies.

Not surprisingly, the index in the agricultural sector either decreased or remained stagnant over the same period. It is apparent that the manufacturing sector shows the highest extent of offshoring in all economies. Among other sub-sectors, machinery and electronics belonging to high and medium-high technology sectors showed the strongest offshoring in all economies. The index in the service sector showed a moderate increase in all countries except Indonesia.

$$-\Delta\%A_m^{2000-2002} = \left[\left(\frac{-\Delta A_m^{2000-2001}}{x^{2000}}\right) + \left(1 + \frac{\Delta x^{2001-2002}}{x^{2001}}\right)\left(\frac{-\Delta A_m^{2001-2002}}{x^{2001}}\right)\right] \times 100;$$

$$\Delta\%f^{2000-2002} = \left[\left(\frac{\Delta f^{2000-2001}}{x^{2000}}\right) + \left(1 + \frac{\Delta x^{2001-2002}}{x^{2001}}\right)\left(\frac{\Delta f^{2001-2002}}{x^{2001}}\right)\right] \times 100\ ;$$

$$\Delta\%EX^{2000-2002} = \left[\left(\frac{\Delta EX^{2000-2001}}{x^{2000}}\right) + \left(1 + \frac{\Delta x^{2001-2002}}{x^{2001}}\right)\left(\frac{\Delta EX^{2001-2002}}{x^{2001}}\right)\right] \times 100.$$

[10] The denominator used in Feenstra and Hanson (1999) is 'non-energy intermediate' as their main interest is the impact of outsourcing on the wages in high-technology manufactures. This paper uses total intermediate inputs as the denominator because its analysis includes both manufactures and the service sector.

4.2. Relationship between offshoring and imported input coefficients

The import of inputs of a country is likely to differ not only based on how heavily it participates in global production chains but also on its functional roles within these chains. This paper presumes a correlation exists between imported input coefficients in a country and the extent of offshoring it engages in. The offshoring indices reported in Table 1 can serve as a proxy for participation in global production chains, demonstrating that all six examined economies have increasingly engaged in offshoring over the last 15 years.

While the main interest of this paper is the decomposition of gross domestic output into input coefficients, correlations between these two sets of data should be tested beforehand.[11] To test the existence of a correlation between offshoring and imported input coefficients, this paper estimates equations using an ordinary least square (OLS) method. Pooled time series data for six countries between 2000 and 2014 were processed by taking the first differences for estimation. The total number of observations is 84. The dependent variable is the changes in imported input coefficients, A_m, and the independent variables are changes in offshoring index at the aggregate level, industry level (agriculture, manufacture and service) and sector level (high tech and low tech).

The estimation results are summarised in Table 2. Statistically significant negative correlations are reported in the five countries examined, while a statistically insignificant negative relationship is reported for Taiwan, supporting this paper's presumption. This suggests that the more a country participates in global production chains, the more imported inputs are employed for gross domestic production.[12]

Furthermore, the relationship between offshoring and imported input coefficients is likely to vary across industries and sectors. For example, it is plausible to assume that the negative correlation is primarily attributed to the manufacturing sector rather than the agriculture and the service sectors. The estimates reported from row 2) to row 4) of Table 2 indicate that the manufacturing sectors have strong negative correlations to imported inputs coefficients in China, Indonesia, Japan and Taiwan. Meanwhile, in Korea, it is not the manufacturing sector but the service sector that strongly correlates negatively to imported input coefficients.

Sectors in the manufacturing industry can be grouped into a low and medium-low technology adopting group (*Low Tech*) and a high and medium-high technology adopting one (*High Tech*), following the categorisation of Magacho, McCombie, and Guilhoto (2018). Rows 5) and 6) of Table 2 indicate that significant relationships are detected only in Japan, Korea and Taiwan, which are high-income countries in the sample of this paper. The *Low Tech* sectors of Japan and Korea and the *High Tech* sector of Taiwan show significant negative correlations to the imported input coefficients, suggesting that imported inputs usage increased in the Low Tech sectors of Japan and Korea but in the High Tech sector in Taiwan.

This paper has provided two sets of evidence regarding offshoring. Firstly, it showed that offshoring has expanded in all six Asian economies. Secondly, the increasing offshoring has significant negative correlations to imported inputs usage in those economies. These two sets of evidence will be used together with input-output analysis to analyse the impacts of participating in global production chains on domestic gross output.

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[11] The details of the decomposition of imported input coefficients will be explored in the next section.

[12] It should be noted that the changes in imported input coefficients are negative numbers in the raw data set.

Table 1. Feenstra-Hanson Offshoring Index (FHOI) of Asian countries (selected years; the base year 2000)

	China				Indonesia				India			
	2001	2005	2010	2014	2001	2005	2010	2014	2001	2005	2010	2014
Agriculture/Mining	0.009	0.024	0.036	0.031	0.043	0.062	0.031	0.041	0.005	0.003	0.004	0.006
Manufactures	0.043	0.056	0.037	0.027	0.078	0.082	0.067	0.078	0.041	0.067	0.052	0.044
Low/med-low tech	0.028	0.024	0.015	0.012	0.057	0.047	0.041	0.053	0.035	0.063	0.050	0.034
High/med-high tech	0.062	0.090	0.057	0.041	0.124	0.148	0.118	0.128	0.049	0.072	0.055	0.059
Chemical	0.067	0.086	0.058	0.039	0.190	0.135	0.149	0.185	0.107	0.160	0.128	0.132
Electronics	0.187	0.221	0.177	0.136	0.045	0.089	0.224	0.216	0.111	0.117	0.091	0.094
Machinery	0.015	0.024	0.025	0.015	0.425	0.323	0.377	0.402	0.055	0.080	0.054	0.047
Transportation	0.017	0.028	0.021	0.018	0.265	0.367	0.119	0.128	0.033	0.078	0.067	0.071
Services	0.001	0.002	0.002	0.002	0.014	0.011	0.005	0.003	0.007	0.009	0.008	0.003
Aggregate	0.078	0.104	0.084	0.064	0.211	0.210	0.160	0.182	0.122	0.154	0.165	0.161
	Japan				**Korea**				**Taiwan**			
	2001	2005	2010	2014	2001	2005	2010	2014	2001	2005	2010	2014
Agriculture/Mining	0.059	0.104	0.130	0.194	0.020	0.017	0.023	0.020	0.071	0.084	0.082	0.066
Manufactures	0.027	0.035	0.038	0.053	0.099	0.081	0.082	0.079	0.218	0.204	0.194	0.191
Low/med-low tech	0.018	0.026	0.031	0.039	0.079	0.076	0.069	0.060	0.089	0.117	0.123	0.109
High/med-high tech	0.034	0.042	0.044	0.065	0.109	0.083	0.089	0.088	0.294	0.248	0.228	0.228
Chemical	0.047	0.066	0.071	0.087	0.126	0.127	0.115	0.104	0.274	0.259	0.236	0.226
Electronics	0.078	0.100	0.095	0.139	0.222	0.160	0.177	0.189	0.452	0.372	0.323	0.346
Machinery	0.024	0.033	0.032	0.050	0.043	0.038	0.045	0.050	0.086	0.101	0.100	0.092
Transportation	0.013	0.021	0.025	0.050	0.032	0.027	0.037	0.035	0.140	0.172	0.143	0.150
Services	0.004	0.005	0.006	0.005	0.007	0.007	0.004	0.004	0.012	0.018	0.019	0.020
Aggregate	0.063	0.090	0.102	0.147	0.193	0.184	0.221	0.218	0.300	0.326	0.336	0.336

Source: Author's calculation from the WIOD 2016 Release.

Table 2. Regression results between Am and offshoring indices (OSI) of six Asian economies

	China				Indonesia				India			
	Coeff.	**Std. Error**	**t-Stat.**	**Prob.**	**Coeff.**	**Std. Error**	**t-Stat.**	**Prob.**	**Coeff.**	**Std. Error**	**t-Stat.**	**Prob.**
1) OSI	-2.84***	0.63	-4.55	0.00	-1.10***	0.12	-9.11	0.00	-1.15***	0.22	-5.20	0.00
2) Agriculture	-1.37	1.52	-0.90	0.39	-0.27	0.49	-0.54	0.60	-5.50*	2.73	-2.01	0.07
3) Manufacture	-4.05**	1.29	-3.13	0.01	-1.59***	0.35	-4.56	0.00	-1.25	0.98	-1.28	0.23
4) Service	-13.07	49.33	-0.26	0.80	-6.97**	2.77	-2.52	0.03	-0.71	4.58	-0.15	0.88
5) High Tech	-2.00*	0.90	-2.22	0.05	-0.33	0.39	-0.84	0.42	-1.13	0.71	-1.58	0.14
6) Low Tech	-3.63	3.26	-1.11	0.29	-2.14*	1.05	-2.03	0.06	0.16	0.54	0.29	0.78

	Japan				Korea				Taiwan			
	Coeff.	**Std. Error**	**t-Stat.**	**Prob.**	**Coeff.**	**Std. Error**	**t-Stat.**	**Prob.**	**Coeff.**	**Std. Error**	**t-Stat.**	**Prob.**
1) OSI	-0.44***	0.07	-6.13	0.00	-1.19***	0.17	-7.00	0.00	-0.85	0.56	-1.52	0.15
2) Agriculture	-0.08	0.06	-1.38	0.19	-5.77**	1.67	-3.46	0.01	0.13	0.44	0.29	0.78
3) Manufacture	-1.02**	0.29	-3.46	0.01	-0.55	0.99	-0.56	0.59	-3.32***	0.67	-4.98	0.00
4) Service	0.78	1.36	0.57	0.58	-13.33**	4.80	-2.78	0.02	-4.89	3.65	-1.34	0.21
5) High Tech	-0.29	0.29	-1.03	0.32	-0.60	0.85	-0.71	0.49	-1.92***	0.47	-4.06	0.00
6) Low Tech	-0.95***	0.26	-3.60	0.00	-2.19**	0.64	-3.43	0.01	-1.24*	0.56	-2.19	0.05

Notes:
OSI refers to the offshoring index at the aggregate level. Agriculture indicates the OSI in the agricultural industry, and so on.
The dependent variables are the changes in each country's aggregated imported input coefficients (A_m). The total pool observations are 84, with six cross-sections.
Prob. indicates p-value. *p<0.1, **p<0.05 and *** p<0.01.
Source: Excerpted from the author's estimation results. The complete data set is readily available upon request.

Table 3. Decomposition of gross output growth in six Asian economies from 2000 to 2014

	China					Indonesia					India				
	$\Delta\%A_n$	$-\Delta\%A_m$	Δ%f	Δ%X	Δ%EX	$\Delta\%A_n$	$-\Delta\%A_m$	Δ%f	Δ%X	Δ%EX	$\Delta\%A_n$	$-\Delta\%A_m$	Δ%f	Δ%X	Δ%EX
Agriculture/Mining	**-32.2**	**7.2**	**152.7**	**120.5**	**38.3**	-7.6	**9.1**	**63.7**	**56.1**	**26.1**	**-31.7**	**-17.8**	**81.5**	**49.8**	**12.2**
Manufactures	**79.3**	**28.1**	**490.9**	**570.2**	**183.9**	-3.6	**0.7**	**91.4**	**87.8**	**38.5**	**-0.1**	**-1.2**	**232.2**	**232.1**	**56.8**
Low/med-low tech	50	16.7	371.7	421.7	120.5	-13.2	1.9	90.2	77.0	42.0	10.5	3.1	219.1	229.6	40.8
High/med-high tech	122.9	47.0	667.8	790.7	279.5	16	-2.3	94.4	110.4	31.6	-16.2	-7.3	251.9	235.7	81.1
Chemical	87.9	40.7	400.7	488.6	137.8	7.7	7.2	66.2	73.9	16.9	-26.2	-9.7	216.1	189.9	81.5
Electronics	199.1	78.2	862.0	1061.1	553.7	31.9	-56.4	116.7	148.6	62.2	13.5	0.4	294.9	308.4	68.1
Machinery	9.2	23.7	520.5	529.7	189.3	37.7	-40.7	25.6	63.3	-29.6	9	2.0	259.2	268.2	55.8
Transportation	231.7	22.6	1212.9	1444.6	215.4	32.8	44.9	157.6	190.4	64.7	-13.7	-8.6	319.3	305.6	100.9
Services	**-2.2**	**4.4**	**300.8**	**298.6**	**47.3**	17.1	**8.9**	**139.3**	**156.4**	**11.5**	**7.3**	**2.0**	**191.4**	**198.7**	**20.9**
Total	**25.9**	**14.5**	**358.6**	**384.5**	**102.6**	5.3	**6.0**	**108.4**	**113.7**	**23.7**	**-2.4**	**-3.0**	**185.7**	**183.3**	**31.2**
	Japan					**Korea**					**Taiwan**				
	$\Delta\%A_n$	$-\Delta\%A_m$	Δ%f	Δ%X	Δ%EX	$\Delta\%A_n$	$-\Delta\%A_m$	Δ%f	Δ%X	Δ%EX	$\Delta\%A_n$	$-\Delta\%A_m$	Δ%f	Δ%X	Δ%EX
Agriculture/Mining	**-15.3**	**-33.4**	**-5.3**	**-20.6**	**3.2**	**-2**	**44.2**	**18.2**	**16.2**	**9.7**	**-18.7**	**6.0**	**25.0**	**6.3**	**16.0**
Manufactures	**-15.4**	**-6.7**	**12.0**	**-3.4**	**16.8**	**5.7**	**-10.4**	**115.6**	**121.3**	**93.6**	**54.1**	**35.1**	**159.0**	**213.1**	**145.9**
Low/med-low tech	-17.7	-4.5	-1.1	-18.8	9.2	0.8	-5.5	42.6	43.4	28.6	25.7	25.9	49.4	75.1	42.8
High/med-high tech	-13.1	-8.9	25.0	11.9	24.5	8.6	-14.3	164.3	172.9	136.4	71.1	38.2	234.0	305.1	215.0
Chemical	-26.5	-10.9	9.1	-17.4	10.8	-34.9	-10.8	75.9	41.0	58.8	122.5	68.0	228.3	350.8	221.9
Electronics	6.3	-11.7	42.3	48.6	40.5	65.4	-27.2	293.5	358.9	254.2	45.1	27.7	276.4	321.5	258.4
Machinery	-9.6	-3.1	14.7	5.1	6.7	20.7	-13.8	117.5	138.2	88.4	1.2	12.5	81.7	82.9	42.0
Transportation	-18.9	-5.9	31.3	12.4	32.5	5	-3.5	154.8	159.8	123.5	13.1	-0.8	62.1	75.2	51.9
Services	**-5.1**	**-1.2**	**7.1**	**2.0**	**2.2**	**4.7**	**-1.0**	**66.4**	**71.1**	**21.4**	**8.1**	**3.7**	**57.6**	**65.7**	**31.0**
Total	**-8.5**	**-3.7**	**8.4**	**-0.1**	**6.8**	**5.1**	**-3.6**	**85.8**	**90.9**	**51.8**	**26.3**	**16.6**	**99.9**	**126.2**	**78.9**

Source: Author's calculation from the WIOD 2016 Release.

4.3. Structural decomposition of gross output: Changes in A_n, A_m and EX

4.3.1. Decomposition at the aggregate level

This paper, unlike Magacho, McCombie and Guilhoto (2018) who focused mainly on the changes in the negative substitution effect measured by A_m, considers that any changes in A_m unavoidably cause changes in A_n, given the heavily fragmented production processes and widespread offshoring within global production chains. The calculated results following the formula in equations (13) and (14) are presented in Table 3.

The growth of gross output ($\Delta\%X$) was the highest in China (384%) and the lowest in Japan (-0.1%) over the period 2000–2014. Changes in the technical coefficients matrix of imported goods ($-\Delta\%A_m$) were negative in India, Japan and Korea, whereas those were positive in China, Indonesia and Taiwan. The result shows that participating in global production chains resulted in positive substitution effects in China, Indonesia and Taiwan, whereas negative ones in India, Japan and Korea. This contrasts with the result of Magacho, McCombie and Guilhoto (2018) in which all examined countries recorded negative changes.

The substitution effect can be understood better when we consider changes in the national technical coefficients matrix ($\Delta\%A$) and those in the technical coefficients matrix of domestic goods ($\Delta\%A_n$) that were not explicitly considered in Magacho, McCombie, and Guilhoto (2018). All economies, except Japan, showed positive changes in $\Delta\%A$, implying that technological progress contributed positively to the economic growth of these economies. The contribution was minimal in India and was negative in Japan. Changes in A_n look have the same sign to changes in A_m. China, Indonesia and Taiwan recorded positive changes in both. India and Japan showed negative changes in both. Korea recorded positive $\Delta\%A_n$ and negative $\Delta\%A_m$.

This paper presumes that expanding global production chains are likely to lead to positive changes in both A_n and A_m in middle-income Asian economies because production processes are offshored to their economies. In contrast, negative changes are expected in high-income Asian economies because production processes are relocated out of their economies. India which recorded very low OSI and minimal technological progress does not fit this presumption.

The growth of exports ($\Delta\%EX$) in all countries was significantly large enough to mitigate the negative substitution effect. China recorded the highest growth, around 103%, and Japan recorded the lowest growth, around 7%. Korea and Taiwan, exemplary countries of export-oriented economic growth, recorded around 90% and 79% each, higher than the growth in Indonesia (about 24%) and India (about 31%). This suggests, different from the case of Brazil, that natural resources-endowed countries such as India and Indonesia in Asia did not experience sluggish export growth.

4.3.2. Decomposition at the sectoral level

It is revealed from Table 3 that negative technical changes occurred in the agriculture/mining sectors in all countries except Japan. The most significant negative change happened in Korea, followed by China. China and Japan reported negative technical changes in the service sector, while Indonesia, India, Korea and Taiwan reported positive technological changes.

In the manufacturing sector, positive changes were observed in the national technical coefficients matrix of China, India, Korea and Taiwan, while negative changes were observed in Indonesia and Japan. China and India showed positive changes in both A_n and A_m, indicating that less imported inputs and more domestic inputs were used. This suggests that the localisation of inputs happened in this sector in both countries. Among high-income economies, Taiwan showed the same feature.

Among the high and medium high technology sectors, the subsector showing the most significant technical change was transportation in China, electronics in Indonesia, India, Japan and Korea, and chemicals in Taiwan. Notably, the transportation sector in Japan, one of the largest car makers, showed negative national technical changes, domestic input technical changes and imported input technical changes. This implies that a large part of the production processes of the automobile industry had heavily been offshored. In contrast, the transportation sector in China experienced dramatic development with a 209% national technical change and a positive change in both technical coefficient matrices.

Although the electronics sectors have commonly contributed the most significant proportion of the export of Japan, Korea and Taiwan, there are some differences. The electronics sectors in Japan and Korea showed a negative substitution effect, while the technical coefficients matrix of domestic inputs recorded positive changes. The size of domestic technological change compared to the size of the negative substitution effect was much smaller in Japan (6.3% versus -11.7%) than in Korea (65.4% vs. -27.2%), which resulted in quite a significant positive technological change in Korea. On the other hand, Taiwan showed positive changes in both technical coefficient matrices.

4.3.3 Contribution of exports to final demand

The negative impact of participating in global production chains, captured by $-\%\Delta A_m$, can be attenuated if technological changes foster a country's export, which consequently enhances its economic growth. All six Asian economies recorded positive changes in exports in all three sectors, except for Indonesia's machinery sector, which recorded -29.6%. The contribution of export growth to economic growth is considerably higher in high-income and middle-income economies. The ratios of export growth to output growth vary from 0.6 to 0.68 in Japan, Korea and Taiwan, whereas those in China, Indonesia and India vary from 0.17 to 0.26.

The manufacturing sector showed the highest growth, implying that this sector led the output growth of these economies. As explained earlier, the electronics, transportation and chemical sectors grew the most. All of which belong to the high and medium-high technology industry. Furthermore, the export growth was significant enough to negate the negative substitution effect in Indonesia, Japan and Korea. The ratio of export growth to output growth in this sector was remarkably high—0.32 in China, 0.44 in Indonesia, 0.24 in India, 4.94 in Japan, 0.77 in Korea and 0.68 in Taiwan.

The export growth in the service sector in all countries except Japan recorded two-digit growth over the analysis period. This finding was noted by de Vries et al. (2019) who analysed the job creation within global value chains in eleven Asian economies. They stated that the demand for workers in R&D and logistics, marketing and sales activities also increased substantially through the relocation of intermediate and final stages of production. They estimated that offshoring would have increased demand for approximately 1.6 million R&D workers and 6.2 million logistics, sales and marketing workers in China, which is less apparent in India and Indonesia.

Table 4. Structural change in China, India and Korea over the period 1995-2014

	China				India				Korea			
	1995-2008		2000-2014		1995-2008		2000-2014		1995-2008		2000-2014	
	$-\Delta\%A_m$	$\Delta\%EX$	$-\Delta\%A_m$	$\Delta\%EX$	$-\Delta\%A_m$	$\Delta\%EX$	$-\Delta\%A_m$	$\Delta\%EX$	$-\Delta\%A_m$	$\Delta\%EX$	$-\Delta\%A_m$	$\Delta\%EX$
Manufactures	**-57.4**	**112.0**	**28.1**	**183.9**	**-21.5**	**39.9**	**-1.2**	**56.8**	**-8.2**	**92.0**	**-10.4**	**93.6**
Low/med-low tech	-29.3	88.5	16.7	120.5	-18.7	**38.0**	3.1	40.8	-10.8	45.3	-5.5	28.6
High/med-high tech	**-119**	**147.5**	**47.0**	**279.5**	**-29.6**	**44.6**	**-7.3**	**81.1**	**-0.6**	**136.4**	**-14.3**	**136.4**
Chemical	-71.4	103.8	40.7	137.8	-43.1	45.4	-9.7	81.5	-4.9	84.4	-10.8	58.8
Electronics	-99.0	107.4	78.2	553.7	-18.2	41.1	0.4	68.1	-6.0	92.4	-27.2	254.2
Machinery	-208.9	195.1	23.7	189.3	-65.4	52.8	2.0	55.8	26.6	176.2	-13.8	88.4
Transportation	-72.9	98.1	22.6	215.4	-13.8	45.1	-8.6	100.9	-6.4	121.1	-3.5	123.5
Total	**-46.0**	**83.3**	**14.5**	**102.6**	**-12.9**	**27.4**	**-3.0**	**31.2**	**-11.8**	**55.3**	**-3.6**	**51.8**

Source: The author extracted aggregate level results from Tables 4, 5 and 6 in Magacho, McCombie and Guilhoto (2018) and reconstructed Table 3.

4.4. Revised interpretation of the dynamics of the technical coefficients matrix

The technical coefficients evolve due to internal and external shocks. Whether participating in global value chains would lead an economy to positive changes in A_n would rely on the structural change of the corresponding economy. As mentioned earlier, the negative substitution effect is likely to occur in developing economies during the early stage of offshoring. Simple assembly-based production processes are relocated to these economies with massive intermediate imports. The substitution effect would be negative over this stage. As time passes, relocated production processes require a domestic labour force and domestically produced inputs. Experience in production would be accumulated to bring about learning-by-producing, which would lead to the localisation of inputs used to be imported together with backward and forward linkages that expand the scale and scope of domestically produced goods. Then, A_m either turns into positive or negative changes would be reduced, and A_n would be enhanced.

This paper and Magacho, McCombie and Guilhoto (2018) commonly examined three economies- China, India and Korea-. Hence, comparing the results in the two studies demonstrates structural changes in the technical coefficients matrix over the period 1996–2014 in these economies. Table 4 shows that the negative substitution effect was reported in almost every sector except Korea. China was the most negatively affected economy over the period 1995-2008. After a decade, a rather dramatic change happened. China was still the most affected economy, but positively over 2000-2014.

Table 4 highlights the manufacturing sector. China and India contrast with Korea. The manufacturing sector and its main sub-sectors showed a negative substitution effect during the first period (1995–2000) in all three economies. One exception was electronics in Korea. During the second period (2000–2014), the negative substitution effect in the manufacturing sector and many of its sub-sectors in China and India converted either into positive or significantly reduced negative changes. From the analysis of global value chain data, Marcato, Dweck and Montanha (2022) also show that China has achieved industrial densification by fostering domestic demand for final and intermediate goods and services produced domestically. At the same time, the export growth strengthened in the manufactures and its main sub-sectors. One exception is the machinery sector in China. Meanwhile, in Korea, a high-income economy, the negative substitution effect became apparent in the manufacturing sector, including electronics. Unlike the two middle-income economies, strong export growth is observed only in electronics. These two contrary structural changes tellingly show the dynamics of the technical coefficients of imported goods and domestic goods.

5. Concluding Remarks

This paper uses SDA to analyse the impact of participating in global production chains on the economic growth of six Asian economies—China, Indonesia, India, Japan, Korea and Taiwan—over the period 2000-2014, using data from the WIOD 2016 release. This paper applies the methodology developed by Magacho, McCombie and Guilhoto (2018) to decompose gross output into changes in the technical coefficient matrix of imported goods and export. The substitution effect caused by imported inputs is considered to have a negative impact on gross output, whereas export has a positive impact. This paper notes that the substitution effect is not always negative and can change over time as an economy participates in global production chains.

The findings of this paper are as follows. Firstly, the extent of participation in global production chains, as measured by the FHOI, was much more significant in high-income than middle-income economies. Table 1 shows that the FHOIs, both at the aggregate and sectoral level, were much higher in high-income economies such as Japan, Korea and Taiwan than in middle-income economies such as China, Indonesia and India.

Secondly, there are statistically significant negative correlations between offshoring and imported input coefficients. The manufacturing sectors of the six Asian countries showed strong correlations between offshoring and imported input coefficients (see Table 2). These results suggest that the manufacturing sectors of the Asian countries are at the centre of the expanding offshoring and global production chains, resulting in increased employment of imported inputs in the manufacturing sector.

Thirdly, offshoring influences the technical coefficients matrix of imported and domestic goods differently. Developing economies would face growing inflows of offshoring when they engage in global production chains, whereas developed economies would face increasing offshoring. This is likely to decrease the volume of imported input in developing economies, which leads to positive changes in the substitution effect (or the technical coefficients matrix of imported goods, written as A_m). Developed economies, on the other hand, are likely to witness the opposite situation. This caused the negative substitution effect in high-income economies. In contrast, it had a positive substitution effect in middle-income economies as shown in columns for $-\Delta\%A_m$ of each country in Table 3.

Fourthly, the relocation of production processes to developing economies is likely to increase the volume of domestically produced inputs (or the technical coefficient matrix of domestic inputs, written as A_n). Therefore, the negative substitution effect, if any, would be compensated by positive changes in A_n, in addition to changes in export growth. Columns for $\Delta\%A_n$ in Table 3 confirm notable positive changes in the technical coefficient matrix of domestic goods. These positive changes, together with positive export growth in all economies reported in columns for $\Delta\%EX$, contributed to the increase in gross output in columns for $\Delta\%X$.

Finally, structural change is most likely to occur as time passes. For example, learning-by-production or positive externalities caused by clustering production processes in specific locations can happen in developing economies as participation in global production chains strengthens. Backward and forward linkages would be followed, and the negative substitution effect is likely to be mitigated and eventually replaced by a positive substitution effect in many sectors. This paper compares the results of Magacho, McCombie, and Guilhoto (2018) with those reported in Table 3 to trace structural changes in China, India and Korea over two decades. The comparison, reported in Table 4, confirms that the negative substitution effect in China and India was either converted to positive one or was mitigated between 1995–2008 and 2000–2014.[13]

[13] A reviewer properly commented that this paper lacks policy analysis regarding the turn from a negative to a positive change in China and India. The author admits the importance of policy analysis.

The findings provide recommendations for the Korean government and firms. Korean firms, either as leading firms or as contractor firms, have taken advantage of global production chains (Cho Jung-Hwan, 2019), which is also shown by the decomposition result reported in Table 3. Nonetheless, it has been noted that offshoring to China and Southeast Asian economies such as Vietnam and Indonesia has disrupted domestic production chains. Given that Korean firms have benefitted from the relocation to China and the USA (Jung Ji-Eun and Hur Jung, 2019), it is expected that Korean firms' participation in production chains would be considerably affected by the Inflation Reduction Act of the United States. The findings of this paper show that offshoring is unavoidable. Still, the associated disruption of domestic production chains is avoidable, depending on how imported inputs are utilised within domestic production chains, as the Taiwanese economy has done.

Although this paper provides an overview of the impact of expanding global production chains by applying the method of SDA to six Asian economies, one may be interested in understanding how a single industry within a single economy would be affected by global production chains. This type of analysis can be conducted by using the methodology "average propagation lengths (APL)" (Romero, Dietzenbacher and Hewings 2009; Avelino, Franco-Solís and Carrascal-Incera 2021; Dietzenbacher, Romero and Bosma 2005), which can better capture the impact of fragmentation of production processes on individual economies. Additionally, the scope of this paper can be extended to ASEAN, which has become one of the biggest economic zones composed of developing economies, to test the transition of a negative substitution effect to a positive one. It can also be extended to a comparison to the global South. For example, Sousa Filho, Santos and de Santana Ribeiro (2021) analysed the Brazilian economy over the period 1990–2015 by using SDA, and their conclusion on the Brazilian economic growth was not different from Magacho, McCombie and Guilhoto (2018), whose analysis covered the period 1995–2008. This suggests that no such structural change in Brazil happened. Finally, there has been a new wave of deglobalisation since COVID-19 disrupted existing global production chains. This is likely to change the role of import in international trade and its impact on domestic gross output, which warrants further study.

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Nonetheless, this paper examines 37 sectors' data, and there is a limitation to cover industry-specific government policy, which is reserved as the topic for the following research.

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