The Effect of the Network Structure and Nature of International Production Chains (IPCs) on East Asia's Trade in Automobile Industry

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DOI: https://doi.org/10.37178/ca-c.21.5.030

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Abstract

This study sought to examine the effect of network structure and nature of IPCs on bilateral trade, with a specific focus on the automobile industry using the panel data methodology. Using the data, a deeper understanding of the determinants behind the development of East Asia's IPCs in several ways. Firstly, apart from the economic size of the exporting and importing nations, distance, per capita income, FTA, government policies, language, and FDI, it was found that the network structure and the network nature also played a significant role in determining the level of East Asia's trade in the automobile industry. Specifically, a nation witha high degree of trade integration with its trading partners in IPCs appeared to be poised to increase its exports and imports of automobile products, and the same can be said of a nation with a high dominating power in IPCs. Secondly, it was also found that network structure had an impact on determining the level of automobile trade when we considered in our analysis a nation's position in the IPCs. In particular, even

hough both "middle" and "bottom" nations may become the main importer of automobile parts and components (APC), the amount of APCimported from their partner(s) may be different. This could be the result of "middle" nations importing APC for export and domestic use, while "bottom" nations imported these products for local demands only. To improve on the added value from the IPCs as well as to stimulate trade in this region, some suggestions were provided regarding policies for the nations under study.

Keywords: Network structure; International Production Chains; East Asia; Automobile Industry;Gravity model.

Introduction

An important feature in the ongoing process of globalisation is the international production chains(IPCs). This is defined as the organisation of the production process by firms into multiple stages.Different nations carry out different stages with cost advantages, but all the stages ultimately leadto the same final product(s). Examples of IPCs can be found in many industries. We can see one particular example in the computer industry. The so-called Chinese-made Lenovo laptop is assembled into a recognizable computer in China although parts and components of that machinewere produced in different nations. The hard drive was produced in Singapore, the motherboard was made in Japan, the memory was made in Republic of Korea, the display panel was assembled in Taiwan, and the microprocessor was made in Malaysia.

IPCs was first identified in the early 1990s. Since then, the phenomenon has continued to developacross both space and time. It was only noticeable in the electronics and clothing industries, but over the years it has spread to many other industries such as automobile, sports footwear, office equipment, camera, and watches, etc.[1-3]. Simultaneously, the participation of nations in IPCs has also increased. Currently, the phenomenon has been developed by means of three different phases. The first phase would involve developed nations to move a small part of the production process to a low-cost developing nation and then they would re-import those assembled components to be incorporated in the final product. The second phase would involve an increase in the nations' participation in IPCs as each of them would specialise in different stages of the production process. In this respect, a product normally crosses many nations before it becomes a finished product. The third phase would involve manufacturers in developed nations to start moving their final assembly of many consumer durable products (such as automobiles, computers,television, and cameras) overseas to make use of low-cost labour and/or to be closer to the markets; [4, 5].

For some 30 years, the East Asian region has experienced a massive expansion of IPCs which wasaligned with a significant change in the structure and nature of East Asia's trade networks. These changes are due to the action of foreign firms which extended the geographic coverage of their production, while at the same time integrated their old stand-alone operations in individual host nations into complex IPCs [6]. These conditions have driven many researchers such as [7, 8];

[9] and [10] to analyse the determinants of IPCs' development in East Asia. Nonetheless, in their

structure and nature of IPCs. As such, this study aimed to fill the gap by examining empirically the effect of recent changes in trade structure and nature of IPCs on bilateral trade, with a precisefocus on the automobile industry.

This paper is divided into seven sections which are structured as follows: Section 2 discusses somepertinent issues related to the gravity model. Section 3 discusses data description and sources. Sections 4 and 5 respectively discuss the methodology and estimation framework. Sections 6 discusses the regression results. Section 7 presents the conclusion.

The Gravity Model

The gravity model is widely used in international trade research. The model is originally derived from the "Law of Universal Gravitation" by Newton in 1687. According to this law the gravity force, F_{iiii} (in newtons), between two objects is directly proportional to each body's mass, M_1 and

M_2 (in kg) but inversely proportional to the distance between their respective centres of gravity (inmetres) as shown in equation (1):

$$F_{iiii} = G \frac{M_1 M_2}{D_{iiii}^2} \quad (1)$$

In the 1860s, the law has been adapted in the study of human behaviour and it has been widely used in the field of social sciences [11] [12]. [13] and [14] were among the early researchers who applied the gravity model in the field of economics. Since then, the gravity model has been used widely in the empirical studies of migration, tourism, and investment.

Regarding international trade, the gravity model can be expressed in the same notation as equation

(1) but *Mi* and *Mj* need to be replaced by the "economic mass" or national income of the two nations. In this aspect, the trade volume between two nations is assumed to be directly proportionalto the national income of each nation, and inversely proportional to the distance between the nations' respective 'economic centre of gravity', generally their capitals. This indicates that the nations with a larger economy prefer to trade higher in absolute terms, while distance would depress trade. The gravity model of international trade can be generalised as:

$$M_{iiii} = K(Y_{ii})^{\beta 1}(Y_{ii})^{\beta 2}(DDDs_{iiii})^{\beta 3} \quad (2)$$

where,

M_{ij} : volume of imports into nation *i* from nation *j*

Y : nation *i*'s GDP

Y_{ii}: nation *j*'s GDP

$DDDs_{ii}$: geographical distance between the two nations' capitals.

Equation (2) then can be transformed into the linear form as:

$$\ln XXM_{iiii} = \alpha + \beta_1 lnY_{ii} + \beta_2 lnY_{ii} + \beta_3 lnDDDs_{iiii} + \mu_{iiii} \quad (3)$$

where μ_{iiii} is a disturbance term and α=ln(K). This basic gravity model can provide us with relatively good results for the estimation. However, there are many other factors which can influence trade levels. For example, Linnemann [15] has included population as an additional measure to capture the effect of economic size in his augmented gravity model. On the other hand,Frankel, and Wei [16] used per capita income instead of population in the augmented gravity modelto capture the size effect. Many studies such as [17]have included severaldummy variables such as sharing common border, speaking the same language and being a member of a trade agreement to capture the specific effects of those dummies.

The gravity model had been criticized in the early stage as it lacked a theoretical background. [18] was the first economist who provided theoretical foundation for the gravity model by building on Armington's assumption that products were differentiated by nation of origin. Sincethen, the theoretical dimension of the gravity model has been analysed widely by many authors torender a theoretical foundation for the gravity model and endorse its use in international trade studies. A few examples can be seen in the following studies. [19] in his study established the gravity conditions from exchange models with item separation and expanding returns to scale. Deardorff [20] revealed that the gravity was in line with the theoretical variationsput forward in the Ricardian and H–O models. [21] found a link between the monopolistic competition model and gravity model based on a research on eighteen industrial nations. [22] proved that only two important theories namely, H-O model and increasing returns, were enough to explain the success of the gravity equation. In a more recent study, Cardinale and Scazzieri [23] argued that since the early 17th-century, discussions of market regulation, promotion of industry and international trade were conducted with specific focus on national welfare. Simply put, international trade has a welfare impact on the population of a nation.

Data Description and Sources

The nations involved in this analysis were Japan, China, the Republic of Korea, Thailand, Indonesia, Malaysia, the Philippines, Singapore, and Vietnam, while their main trading partners are listed in Table 1. The data for this analysis were taken from the years 1990 to 2017.

Table 1. List of Nations Chosen for the Empirical Studies

Nation *i*	Nation *j*	
China	Australia	Netherlands
Indonesia	Austria	New Zealand
Japan	Belgium	Norway
Republic of Korea	Brazil	Oman
Malaysia	Canada	Pakistan
Singapore	Chile	Panama
Philippines	China	Philippines
Thailand	Denmark	Portugal
Vietnam	Finland	Russian Federation
	France	Saudi Arabia
	Germany	Singapore
	Greece	South Africa
	India	Spain
	Indonesia	Sweden
	Ireland	Switzerland
	Israel	Thailand
	Italy	Turkey
	Japan	United Arab Emirates
	Rep. of Korea	United Kingdom
	Kuwait	United States
	Malaysia	Vietnam
	Mexico	

The four dependent variables in this study are: (1) export of APC; (2) import of APC; (3) export of final automobiles (FA); and (4) import of FA. Those trade data (in current US dollars) were acquired from the UN Comtrade. In fact, the trade data obtained from UN Comtrade were inconsistent and unreliable for direct use. Thus, in order to confirm that all bilateral trade data usedin this study were consistent, we reconciled the existing data using the procedures of [24].Commodities included under APC comprised chassis, bodies, and other parts and accessories, while commodities under FA consisted of track-laying tractors, wheeled tractors, passenger vehicles, goods-transport vehicles, special purpose vehicles, public service vehicles, and road tractors. We chose SITC Revision 2 in this study to classify the commodity group for a few reasons. Firstly, unlike the SITC Revision 1, SITC Revision 2 is detailed enough to distinguish traded P&C from finished products. Moreover, it also has detailed commodity classification, particularly in the machinery and transport goods (SITC 7). Secondly, unlike the HS and SITC Revision 3, SITC Revision 2 also provides the broadest nation and period coverage [25]thereby allowing one to analyse trade in final goods and P&C between 1990 and 2017. Meanwhile,the explanatory variables in this study for the models of export of APC, import of APC, export ofFA, and import of FA are listed in Table 2.

Table 2. Description of the Explanatory Variables

Variable	Description	Unit	Source
Yit	Gross domestic product of nation *i*	Current USD	WDI
Yjt	Gross domestic product of nation *j*	CurrentUSD	WDI
Dis_{ij}	Distance. It measured by the direct distance between capitals of nation *i* and *j*	kilometres	CEPII
PCY_{it}	Per capita income of nation *i.* The value of PCY_{it} have beencalculated by using the following formula: $PCY_{it} = \frac{F_{it}}{population}$	CurrentUSD	Author's calculation
PCY_{jt}	Per capita income of nation *j.* The value of PCY_{jt} have beencalculated by using the following formula: $PCY_{it} = \frac{F_{jt}}{population}$	CurrentUSD	Author's calculation
ΔPCY_{ijt}	Absolute different in per capita income. The value of ΔPCY_{ijt} can be calculated by using the following formula: $\Delta PCY_{ijt} = PCY_{it} - PCY_{jt}$		Author's calculation
RLC_{ij}	Relative Labour Cost. Relative labour cost (adjusted for exchange rate differential) is calculated based on the following formula: $RCL_{ij} = \frac{W_{ij}}{W_{jj}} . E_{ij}$ where, W_{ij}= manufacturing wage index for nation *i* (1992=100), W_{jt}= manufacturing wage index for nation *j* (1992=100), and E_{ij}= nominal bilateral exchange rate expressed as the value of nation *i*'s currency in terms of nation *j*'s currency.	-	The US Bureau of Economic Analysis (manufacturingwages) and IFS (exchange rate)
LAN_{ij}	Common language. The dummy will take the value of one if both nations share a common language, and zero otherwise.	-	CEPII
FTA_{ijt}	Free trade agreement. The dummy variable takes the value of one if both nations in each pair belong to the same FTA,and zero otherwise.	-	ADB
ISI_{it}	Dummy of import substitution industrialisation policy. Thedummy variable takes the value of one if nation *i* implementing ISI policy, and zero otherwise.	-	Various sources
EOI_{it}	Dummy of export orientation industrialisation. The dummy variable takes the value of one if nation *i* implementing EOIpolicy, and zero otherwise.	-	Various sources

FDI_{it}	Japanese foreign direct investment. The time series data forJapanese FDI outflows are inconsistent due to the action of the Japanese Finance Ministry of releasing BOP-based FDI	USD	Ministry of Finance, Japan
	to replace the old FDI statistics (FDIS) starting from 2005. FDIS and BOP-based FDI have been compiled by means of different compilation methodologies. In the case of FDIS, the data have been obtained from a compilation of figures reported by investors covering only investments over 100 million yen. In contrast, data for the BOP-based FDI have been obtained from financial transactions, and they are more comprehensive compared to those of FDIS. In addition, data in FDIS always have a positive value as they are generated from the total amount of reported investmentby investors. On the other hand, data for the BOP-based FDI are compiled based on accounting rules and they can be recorded in negative values owing to withdrawal of investment. Due to these differences, we have split both types of dataset into FDI_A_{it} and FDI_B_{it} in the analyses.		
DEA	Developing East Asia (DEA) as the exporter (importer) of automobile product. The aim of including this variable in our export (import) models is to capture the role of DEA as the centre of production for Japanese APC and FA. Nations categorised under DEA are Thailand, China, the Philippines, Malaysia, Indonesia, and Vietnam. Thisselection is based on the criterion of annual Gross National Income (GNI) per capita as provided by the World Bank (2013). Under this criterion, Japan, the Republic of Korea, and Singapore have been categorised under developed East Asian nations. DEA will take a value of one if nation *i* is characterised as developing East Asia, while developed East Asia will take a value of zero.	-	The World Bank
TOP_{it}	Dummy of 'top' position of a nation in the IPCs. We followed Abdul-Aziz et al. [26]to identify the nations'position in the IPCs. The dummy variable takes the value of one if nation *i* occupied the top position, and zero otherwise.	-	Author's calculation
MID_{it}	Dummy of 'middle' position of a nation in the IPCs. The dummy variable takes the value of one if nation *i* occupiedthe middle position, and zero otherwise.	-	Author's calculation

BOT_{it}	Dummy of 'bottom' position of a nation in the IPCs. Thedummy variable takes the value of one if nation *i* occupied the bottom position, and zero otherwise.	-	Author's calculation
ND_{it}	Network density. Network density is the actual links in terms of potential links in a network. It is included in our model to capture the effect of each nation's integrated degree in a network on export and import of APC and FA. Network density can be calculated using the following formula: $ND_{it} = \frac{1}{2(N-1)} \sum_{ij=1}^{N} a_{iij} + a_{jji}$	-	Author's calculation
	to replace the old FDI statistics (FDIS) starting from 2005.FDIS and BOP-based FDI have been compiled by means of different compilation methodologies. In the case of FDIS, the data have been obtained from a compilation of figures reported by investors covering only investments over 100 million yen. In contrast, data for the BOP-based FDI have been obtained from financial transactions, and they are more comprehensive compared to those of FDIS. In addition, data in FDIS always have a positive value as theyare generated from the total amount of reported investmentby investors. On the other hand, data for the BOP-based FDI are compiled based on accounting rules and they can be recorded in negative values owing to withdrawal of investment. Due to these differences, we have split both types of dataset into FDI_A_{it} and FDI_B_{it} in the analyses.		
A	Developing East Asia (DEA) as the exporter (importer) of automobile product. The aim of including this variable in our export (import) models is to capture the role of DEA asthe centre of production for Japanese APC and FA. Nations categorised under DEA are Thailand, China, the Philippines, Malaysia, Indonesia, and Vietnam. Thisselection is based on the criterion of annual Gross National Income (GNI) per capita as provided by the World Bank (2013). Under this criterion, Japan, the Republic of Korea, and Singapore have been categorised under developed East Asian nations. DEA will take a value of one if nation *i* is characterised as developing East Asia, while developed East Asia will take a value of zero.	- he World Bank	

OP_{it}	ummy of ‘top’ position of a nation in the IPCs. We followed Abdul-Aziz et al. [26]to identify the nations’ position in the IPCs. The dummy variable takes the value of one if nation *i* occupied the top position, and zero therwise.	uthor’s calculation
MID_{it}	ummy of ‘middle’ position of a nation in the IPCs. The ummy variable takes the value of one if nation *i* occupiedthe middle position, and zero otherwise.	uthor’s calculation
BOT_{it}	ummy of ‘bottom’ position of a nation in the IPCs. The dummy variable takes the value of one if nation *i* occupied he bottom position, and zero otherwise.	uthor’s calculation
ND_{it}	etwork density. Network density is the actual links in terms of potential links in a network. It is included in our model to capture the effect of each nation’s integrated degree in a network on export and import of APC and FA. Network density can be calculated using the followingformula: $D_t = \frac{\sum_{i=1}^{N} a_{iij}+a_{jji}}{2(N-1)}$ here, a_{iiii} and a_{iiii} take the value of one if there exist areciprocal relationship between nation *i* and nation *j*.	uthor’s calculation

DII_{it}	Domination intensity index. We add DII^{XX} to the export models and D^{M} to the import models to capture the effect of dominating power on both exports and imports of APC and FA. Domination intensity index can be calculated usingthe following formula: $DII^{XX}_{ii} = \sum_{ii=1}^{N} \left(\frac{XX_{iijj}}{XX_{WW}} \right)$; $DII^{M}_{ii} = \sum_{jj=1}^{N} \left(\frac{M_{jjii}}{M_{tot}} \right)$ $\frac{M_{iijj}}{\sum_{jj=1}^{N} XX_{jjii}}$ $\sum_{ii=1}^{N} \left(\frac{M_{iijj}}{M_{WW}} \right)$ $\frac{XX_{jjii}}{\sum_{jj=1}^{N} XX_{tot}}$ where, X_{iiii}=exports of APC (FA) from nation *i* to nation *j*, X_W= total world exports of APC (FA), M_{iiii} =imports of APC (FA) of nation *i* from nation *j*, M_W=total world imports of APC (FA), X_{iiii}=export of APC (FA) from nation *j* to nation *i*, X^{tot}=total exports of APC (FA) of nation *j*, M_{iiii}=import of APC (FA) of nation *j* from nation *i*, M^{tot}=total import of APC (FA) of nation *j*. We predict that both DII^{XX}_{ii} and D^{M}_{ii} will have a positive sign due to the fact that a nation whichhas a larger dominating power as an exporter (importer) would export (import) more to (from) its trading partner(s) compared to those with a smaller dominating power.	-	Author's calculation

Methodology

The panel data methodology was chosen as it had an advantage over cross-section methodology. This is true because the panel data approach can overcome the heterogeneity problem by allowing for individual and year-specific effects. The panel data analysis technique is adopted due to its control on serial correlation [27]. Simultaneously, by applying panel data methodology we can also monitor the unobserved trading-partner-pairs'

individual effects. Hence, in this study weapplied this methodology to our dataset to estimate four gravity models for East Asia, namely thegravity model of East Asia's export of APC, the gravity model of East Asia's import of APC, thegravity model of East Asia's export of FA, and the gravity model of East Asia's import of FA.

We followed the specification in [10]to develop model (4) below. This study thus contributed some new addition such as the inclusion of: (i) the dummies of top, middle and bottomto take into account the position of each nation in the IPCs, and (ii) the node density and domination intensity index to capture the effect of each nation's integrated degree and dominationdegree, respectively. In addition, the relative labour cost was also added in as one explanatory variable in this study. The inclusion of this variable was based on the standard comparative

advantage explanation of trade flows. Therefore, we expected the relative labour cost to be one ofthe major factors impacting IPCs. What follows is the gravity model for exports.

$$\ln X_{iiit} = \alpha + \beta_1 lnY_{iit} + \beta_2 lnY_{iit} + \beta_3 lnDDDs_{iiii} + \beta_4 lnPCY_{iit} + \beta_5 lnPCY_{iit} + \beta_6 ln|\Delta PCY_{iiit}| + \beta_7 lnRLC_{iiit} + \beta_8 LAN_{iii} + \beta_9 FTA_{iiit} + \beta_{10} EOI_{iit} + \beta_{11} lnFDI\_A_{iit} + \beta_{12} lnFDI\_B_{iit} + \beta_{13} DEA(x) + \beta_{14} lnFDI\_A_{iit} * DEA(x) + \beta_{15} lnFDI\_B_{iit} * DEA(x) + \beta_{16} MID_{iit} + \beta_{17} BOT_{iit} + \beta_{18} ND_{iit} + \beta_{19} lnDII^{XX}_{iit} + \beta_{20} T + u_{1iiit}$$

where,

X_{iiit}	: exports of nation *i* to nation *j*
Y_{iit}	: nation *i*'s GDP
Y_{iit}	: nation *j*'s GDP
$DDDs_{iiit}$	: geographical distance between the two nations' capitals.
PCY_{iit}	: income per capita of exporting nation *i*.
PCY_{iit}	: income per capita of importing nation *j*.
$\|\Delta PCY_{iiit}\|$	: absolute difference in income per capita between *i* and *j*
LAN_{iii}	: dummy of common language
RLC_{iiit}	: Relative labour cost of nation *i*
FTA_{iiit}	: dummy of free trade agreement
EOI_{iit}	: dummy for EOI policy
FDI_A_{iit}	: Japanese FDI outflow in automotive industry to nation *i* between 1990 and 2004
FDI_B_{iit}	: Japanese FDI outflow in automotive industry to nation *i* between 2005 and 2017
$DEA(x)$	: dummy of DEA as the exporting nation
$FDI\_A_{iit} * DEA(x)$	: interaction term for FDI_A in export model
$FDI\_B_{iit} * DEA(x)$	: interaction term for FDI_B in export model
MID_{iit}	: dummy for middle position
BOT_{iit}	: dummy for bottom position
ND_{iit}	: node density
DII^{XX}_{iit}	: domination intensity index for exporter
T	: time effects
u_{1iiit}	: error term

The gravity model for the import is shown below.

$$\ln M_{ijit} = \alpha + \beta_1 lnY_{it} + \beta_2 lnY_{jit} + \beta_3 lnDDDs_{ijij} + \beta_4 lnPCY_{it} + \beta_5 lnPCY_{jit} + \beta_6 ln\Delta PCY_{ijit} + \beta_7 lnRLC_{ijit} + \beta_8 LAN_{ij} + \beta_9 FTA_{ijit} + \beta_{10} ISI_{it} + \beta_{11} lnFDI\_A_{it} + \beta_{12} lnFDI\_B_{it} + \beta_{13} DEA(m) + \beta_{14} lnFDI\_A_{it} * DEA(m) + \beta_{15} lnFDI\_B_{it} * DEA(m) + \beta_{16} MID_{it} + \beta_{17} BOT_{it} + \beta_{18} ND_{it} + \beta_{19} lnDII^m + \beta_{20} T_{it} + u_{2ijit}$$

where,

M_{ijit}	: imports of nation *i* from nation *j*
DII^m_{it}	: domination intensity index for importer
ISI_{it}	: dummy for ISI policy
$DEA(m)$	: dummy of DEA as the importing nation
$FDI\_A_{it} * DEA(m)$	: interaction term for FDI_A in imports model
$FDI\_B_{it} * DEA(m)$	: interaction term for FDI_B in imports model
u_{2ijit}	: error term

and the rest of the variables and parameter symbols are defined as in the above equations.

Estimation Framework

A common problem is zero trade flow; this occurs when we make an estimation using a log-linearmodel as the zero values would become undefined. As this problem occurred in our dataset, we considered discarding those zero trade values from our sample to avoid this problem. We used the Breusch-Pagan test in this study to detect the presence of heteroscedasticity, while variance inflation factor (VIF) and tolerance would be used to detect the presence of multicollinearity. Themulticollinearity problem occurs in a model if the value of VIF equals or greater than 10 or the value of tolerance less than 0.10. As the data contained time-invariant variables such as distance, dummy of language and dummies of nations' position in IPCs, it was a good idea to choose the Least Squares Dummy Variable (LSDV) rather than "within" estimator. This was because those time-invariant would be dropped when we regressed using the "within" estimator. Additionally, the nation dummies and time dummies included in a LSDV model could be used to capture nationeffects and time effects. In fact, the presence of these two effects can reduce the possibility of endogeneity bias.

Regression Results and Discussion

In Table 3, the results are provided for the augmented gravity specification estimated with LSDV.In the table, the results for the export models of APC and FA are reported in the second and fourthcolumns respectively, while results for the import models of APC and FA are reported in the thirdand fifth columns respectively. We used a robust standard error in each model due to the presenceof heteroscedasticity and autocorrelation problems. The value of R-squared above 0.60 showed that in each model, the gravity models explained more than 60 percent of the bilateral exports andimports of both APC and FA.

According to the results in Table 3, both Y_i and Y_{iit} had a positive and significant association with exports and imports for both APC and FA, as predicted by the theory. This showed that strong economic growth experience by East Asian nations and their trading partners could increase tradein APC and FA between them. Meanwhile, the results also revealed that in both APC and FA cases, distance had a negative and significant effect on exports and imports. This implied that tradecosts (such as transportation and transaction costs) were one of the important factors affecting trade in East Asia, and nations in this region trade more with nations which are located near them.

An important variable which is affecting trade in East Asia is per capita income (cf. Table 3). As stated by Head [15], in the case of APC, this variable became the proxy of superior transportationand communication infrastructure. In the case of FA, it became the proxy of the consumers' purchasing power and sophistication of consumer tastes in wealthier nations. Based on the results,

PCY_i and PCY_{iit} had positive signs and were significant in almost all model at least at the 5 percent significance level. This showed that an increase in the quality of transportation and communicationin nation *i* and nation *j* as well as an increase in the purchasing power and sophistication of consumer tastes in wealthier nations could facilitate trade in APC and FA between nations under study. On the other hand, the coefficients of ΔPCY_{iiit} had a negative sign and were statistically significant at least at 5 percent level in almost all models. These results revealed that nations withsimilar factor endowments would trade more with each other as asserted in the Linder hypothesis. Additionally, the negative sign of the coefficient of ΔPCY_{iiit} also suggested that horizontal intra- industry trade between developed nations seemed to account for much of the trade in automobile products compared to vertical intra-industry trade between developed and developing nations.

The coefficients of RLC_{iii} were statistically highly significant with the expected sign in both export and import models for both APC and FA. These findings revealed that relative labour cost differentials were among the important factors behind cross border trade for both products. In addition, the size of coefficients of RLC_{iii} was somewhat similar in all models. This might imply that there existed an interconnectedness between import and export of APC as well as a certain

dependence of export of FA on import of APC. The results in Table 3 also indicated that common language coefficient had the anticipated positive sign and was significant statistically in both export and import models for APC and FA. These findings suggested that the use of a common language could facilitate trade. On the other hand, the coefficients of FTA were significant statistically and had an expected positive sign in the export and import models of APC and FA. This implied that when two East Asian nations became members of an FTA, bilateral trade betweenthem would increase.

Both ISI and EOI policies which represented government policies and programmes seemed to be vital factors in the development of a nation's automobile trade. Based on the results, ISI_{it} produced the expected negative effect on the imports of FA (cf. Table 3). These results showed that ISI development strategy decreased the import of FA in East Asia. On the other hand, there was no statistical evidence that showed the effect of this strategy on the imports of APC.

Additionally, the results in Table 3 also implied that EOI policies positively affected the exports of APC and FA. This meant that EOI strategy facilitated the export of APC and FA in East Asia. Simply put, government effort in supporting the automotive industry, such as reducing tariff rates,providing subsidised loans, tax exemptions and expanding infrastructure and estates, managed to develop that industry, and thus increased exports.

Undoubtedly, other than government policies, Japanese MNCs have played a prominent role in stimulating auto trade in the East Asian region, as well as assisting many nations in this region todevelop their own automobile industry. As a matter of fact, two factors may be complementary inthat government policies facilitate FDI as necessary for the development of the automobile industry in East Asia. As shown in Table 3, in the case of export of APC, variables FDI_A_i and

FDI_B_{it} had a negative sign and were also significant, at least at 10 percent significant level. These

results indicated that when Japanese FDI outflows to developing East Asian nations increased, it would lead to a reduction in the Japanese export of APC worldwide.

As seen in equations (4) and (5), interaction term between Japanese FDI outflow and DEA were also added to the models. For the interaction analysis, we split the impact of Japanese FDI outflowinto two categories: (i) its impact on the export of DEA's APC (as well as FA), and (ii) its impacton the export of Japanese APC as a base category (FA). From the export side of APC, $FDI\_A_i *$

$D(x)$ and $FDI\_B_{it} * DEA(x)$, were statistically significant with a positive sign (cf. Table 4).

These results showed strong evidence in these data that the Japanese FDI outflow to DEA for bothperiods had a different effect on the export of APC from either Japan or DEA. However, as indicated in Tables 4 and 5, the size of the different effect in both periods were too small (i.e. 0.008and 0.003 respectively). As such, we can conclude that when the outflow of Japanese FDI to DEArises, the export of DEA's APC to the global market was smaller than the export of Japanese APCworldwide.

Table 3. Augmented Specification Estimated by LSDV for 1990-2017

Explanatory Variables	APC		FA	
	lnX_{iiit}	lnM_{iiit}	lnX_{iiit}	lnM_{iiit}
$Constant$	13.603*	-29.823***	-14.805*	-35.047***
lnY_{it}	0.443***	0.384***	0.301*	0.443***
lnY_{iit}	0.809***	1.572***	0.083***	1.461***
lnD_{iiit}	-0.963***	-1.351***	-0.487**	-1.279***
$lnPCY_{it}$	0.172***	0.344***	0.262***	0.159***
$lnPCY_{iit}$	-0.187***	0.008	0.262***	0.674***
$ln\Delta PCY_{iiit}$	0.035	-0.033	-0.215***	-0.338***
$lnRLC_{iiit}$	-0.187***	0.332***	-0.218***	0.298***
LAN_{iii}	0.775***	0.363***	-0.097	-0.265***
FTA_{iiit}	0.904***	1.599***	0.534***	0.421***
EOI_{it}	0.301**	-	0.390***	-
ISI_{it}	-	0.302	-	-0.347***
$lnFDI\_A_{it}$	-0.227**	0.065	0.215	0.351
$FDI\_A_{it} * DEA(x)$	0.235**	-	-0.072	-
$FDI\_A_{it} * DEA(m)$	-	-0.054	-	-0.346
$lnFDI\_B_{it}$	-0.210*	0.187	0.571	0.352
$FDI\_B_{it} * DEA(x)$	0.213**	-	-0.083	-
$FDI\_B_{it} * DEA(m)$	-	-0.177	-	-0.326
MID_{it}	-0.199***	0.491*	-1.926***	0.444***
BOT_{it}	-0.792***	0.344**	-2.537***	1.182**
ND_{it}	0.992***	1.543**	3.321***	-0.766
$lnDII^{xx}_{it}$	0.412***	-	0.309***	-
$lnDII^{m}_{it}$	-	0.477***	-	0.379***
Nation Dummies				
$DEA(x)$	-4.046**	-	1.521	-
$DEA(m)$	-	1.921	-	5.279
Time dummies	YES	YES	YES	YES
No of Obs.	5742	5031	4263	4179
R^2	0.641	0.618	0.653	0.602
Adjusted R^2	0.639	0.616	0.652	0.601
F	155.36	68.18***	195.12***	87.81***
RMSE	1.811	2.258	2.164	2.254

*Notes: ***, ** and * denote as significance at 1 percent, 5 percent and 10 percent respectively*

Table 4. Summary Results for log of FDI_Ait and the Interaction Variables

Model		Main effect of lFDI	Interaction effects*
Export	APC	- 0.227	-0.227 + 0.235 = 0.008
	FA	0.215 (insignificant)	Irrelevant due to the insignificant of interaction terms
Import	APC	0.065 (insignificant)	
	FA	0.351 (insignificant)	

*Notes: (1) * Refer to the dummy of DEA (DEA(x)) = 1 if nation i = China, Indonesia, Malaysia, The Philippines, Thailand and Vietnam, while = 0 if nation i = Japan, Republic of Korea and Singapore.*

(2) In the import model the dummy of DEA is DEA(m)

(3) FDI_A_{it} refers to the Japanese FDI to DEA between 1990 and 2004.

Table 5. Summary Results for log of FDI_B_{it} and the Interaction Variables

Model		Main effect of lFDI	Interaction effects*
Export	APC	- 0.210	-0.210 + 0.213 = 0.003
	FA	0.571 (insignificant)	Irrelevant due to the insignificant of interaction terms
Import	APC	0.187 (insignificant)	
	FA	0.352 (insignificant)	

*Notes: (1) * Refer to the dummy of DEA (DEA(x)) = 1 if nation i = China, Indonesia, Malaysia, The Philippines, Thailand and Vietnam, while = 0 if nation i = Japan, Republic of Korea and Singapore.*

(2) In the import model the dummy of DEA is DEA(m)

(3) FDI_B_{it} refers to the Japanese FDI to DEA between 2005 and 2017.

In table 5, as predicted, the IPCs' structure (which were proxies by the position of East Asian nations in the automobile production chain) appeared to be an important determinant in the development of a nation's automobile trade. This was due to our finding that a nation's position dummy had an expected sign and was statistically significant at least at the 5 percent level in all models. As shown in Table 3, the export of APC and FA by "middle" and "bottom" nations was less than the export of both products by a "top" nation. The estimated coefficients of "middle" forthe export of APC and FA were -0.199 and -1.926, respectively. These figures suggested that exports of such products were well over half and five times smaller than that of the export by "top"nations, respectively. On the other hand, in the case of "bottom" nations, the coefficients of exportof both APC and FA were -0.792 and -2.537, respectively. This showed that exports of such products were respectively well over two-fold and six-fold smaller than the exports of such products by "top" nations.

In contrast, Table 3 showed that the imports of APC and FA for both "middle" and "bottom" nations were greater than imports by "top" nations of both products. The estimated coefficients of"middle" for the import of APC and FA were 0.491 and 0.444, respectively. This showed that theimports of APC and FA by a "middle" nation were respectively well over 1.6 times and 1.5 timesgreater than the import of the same products by "top" nations. On the other hand, the coefficientsof import of APC and FA for "bottom" nations were 0.344 and 1.182, respectively. This suggestedthat imports of both products were respectively 1.4 times and tripled the imports by "top" nationsof APC and FA.

The above findings provided us with pertinent information about the strength of the role(s) playedby a group of nations based on their position in IPCs. In the case of “middle” nations, their roles as exporter of both APC and FA were greater compared to “bottom” nations but less than the “top”nations, while their roles as importer of APC were greater compared to both “bottom” and “top” nations. On the other hand, their role as importer of FA was smaller than the “bottom” nations butgreater than the “top” nations. It is interesting to note that the roles of “middle” nations as exporter of APC were slightly smaller compared to the “top” nations, while the roles of the “bottom” nationsas exporter of FA were much smaller compared to the “top” nations.

An important determinant of a nation’s automobile trade is the nature of IPCs, which are proxies by network density and domination intensity indices. Network density represents a nation’s degreeof integration in a network. As shown in Table 3, we found that network density for nation *i* had apositive sign and was significant at least at the 5 percent level in almost all models. This suggestedthat the more integrated a nation is in the network, the more it trades with other nations in that network. In terms of APC, a one-unit increase in a nation’s degree of integration had led to an increase in both exports and imports of more than double. Meanwhile, the increase of one unit in a nation’s integrated level had led to an increase in the export of FA by nine-fold. This result indicated that the nation with the highest integrated degree in IPCs could benefit more from its exports of FA compared to trade in APC.

The dominating power of a nation as an exporter of APC and FA was represented by the value of

DII^{XX}, while the dominating power of a nation as an importer of APC and FA was represented by

DII^{m}. As shown in Table 3, we found that DII^{XX} and DII^{m} for nation *i* had a positive sign and were

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significant at the 1 percent level in all models. An increase of 1 percent in the export dominating power of both APC and FA had led to an increase of 0.41 percent and 0.31 percent in exports of both products, respectively. In contrast, a 1 percent increase in the import dominating power of both APC and FA had led to an increase by 0.48 percent and 0.38 percent in imports of both products, respectively.

Conclusion and Policy Implication

The study sought to examine empirically the effect of structure (in the form of vertical specialisation) and nature of IPCs on bilateral trade, with a detailed focus on the automobile industry. The findings of this study provided a deeper understanding of the determinants behind the development of East Asia's IPCs in several ways. Firstly, apart from the economic size of theexporting and importing nations, distance, per capita income, FTA, government policies, language,and FDI, we found that the network structure (represented by nations' position in IPCs) and the

network nature (represented by the network density and a nation's dominating power) also playeda significant role in determining the level of East Asia's trade in the automobile industry. Specifically, a nation with a high degree of trade integration with its trading partners in IPCs seemed ready to increase its exports and imports of automobile products, and the same can be saidof a nation with a high dominating power in IPCs.

Secondly, we also found that network structure had an impact on determining the level of automobile trade when we took into account in our analysis the nation's position in the IPCs. In particular, even though both "middle" and "bottom" nations may serve as the main importer of APC, the amount of APC imported from their partner(s) may be different. For instance, we foundthat "middle" nations such as Thailand and China imported more APC than "bottom" nations suchas Malaysia and Vietnam. We believed this to be a result of "middle" nations importing APC for export and domestic use, while "bottom" nations imported these products for local demands only.

As such, we suggested some policies based on the data above for top, middle, and bottom nationswith a view to improving the value added from IPCs as well as to stimulate trade in this region. For the top nations (i.e., Japan and the Republic of Korea), they should evaluate the investment climate in developing nations before deciding to invest in any of those nations. In particular, theyshould consider investing in developing nations which are attractive in terms of cost of labour, market size and prospects for growth, political and economic stability, predictable rules for investment and a legal framework, availability of infrastructure, stability of the tax system, and productivity of labour. Nations with only the advantage of cheap labour or a large local market may not necessarily be attractive for investment if it has weak infrastructure (road, electricity, and telecommunication), high financing constraints, weak institutions, as well as a lack of skills in some developing nations. To put it simply, a long checklist of location advantages and service links must be prepared by top nations in order to improve their value added from IPCs.

Additionally, for the purpose of cost reduction, production expansion and investment efficiency, top nations should select certain operations that need to be moved to a new location. The differences in terms of location advantages that exist in the network should be exploited in order to gain profit from the IPCs. For instance, the presence of a large pool of skilled labour at affordable cost in Thailand should be taken advantage of by top nations to produce diesel engine and body panel. Conversely, unskilled labour in Vietnam should be exploited to produce simple manufacturing products such as wire harness and wiper arm. Concurrently, top nations should also expand negotiation over FTAs to encourage host nations (especially middle and bottom nations) to reform their policies in favour of creating

an IPCs-friendly environment. In this regard, firms inthe top nations must be more active in efforts to improve the business environment in the East Asian region.

For the middle nations (i.e., Thailand, China, the Philippines, and Indonesia), flexible andsupportive policies which are aligned with the interest of firms from the top nations should be

expanded to a greater extent. This is vital because firms from top nations such as Japan were crucialin bridging productive resources among nations and facilitating industrialisation as in bringing capital and technology into the host nations. In this aspect, middle nations should not only offer fiscal incentives such as exemption or reduction in import duties and corporate income tax, but should also offer a range of non-tax incentives for investment based on location such as permission to bring in foreign workers, owning land, and taking or remitting foreign currency abroad. Additionally, foreign businesses should be entitled to a 100-percent foreign ownership. This attractive incentive is important to attract firms from top nations to expand their operations in the middle nations. This action would lead to improvement in the middle nations' dynamic comparative advantage and in turn would bring further development to the middle nations' automobile industry.

To avoid lagging behind, bottom nations (i.e., Malaysia, Singapore, and Vietnam) should participate actively in the automobile production networks, just as they have done in their electricsand electronics industry. This is because participation in IPCs is very important for expanding theirexport of automobile products. To do so, bottom nations should invite export-oriented foreign companies by providing them with a world-best location advantage. In this regard, bottom nationsshould eliminate or reduce trade and investment barriers in the auto industry, enhance human capital skills, and improve technological advancement in communication. Additionally, local firmsin bottom nations should also engage themselves in exporting activities that are within IPCs.

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