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Economic Integration in ASEAN+3 : A Network Analysis

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Abstract

This paper analytically and graphically explores the characteristics of ASEAN+3's trade and Foreign Direct Investment integration over the 1990~2012 period by applying the tools of network analysis. Our results find evidence that the degree of trade and Foreign Direct Investment integration varies among ASEAN+3 member countries over the observation period. Second, ASEAN+3's intra-regional trade network seems to be more densely connected than its intra-regional Foreign Direct Investment network. Third, we reveal that large and/or advanced countries seem to be better linked and form a sub-regional bloc of tightly connected economies only in terms of export absolute value. Therefore, ASEAN+3 has been experiencing a widening gap in the trend and patterns of intra-regional trade and Foreign Direct Investment among its member countries at different levels of economic development.

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I. Introduction

Southeast Asian countries formed a political, economic, and cultural alliance on August 8, 1967, called the Association of Southeast Asian Nations (ASEAN)¹. Since its establishment, ASEAN has promoted an open-regionalism principle to ensure trade liberalization among its member countries and enhance trade and investment integration with particular non-members. Based on the principle of open market economy and a rule-based system, ASEAN has become a dynamic trade zone and an important region for foreign investors to place their real and portfolio investments.

Apart from the initiatives given above, ASEAN has also committed to the extension of the ASEAN Free Trade Area (AFTA) to non-member countries. According to ASEAN members, who are opposed to the direct Bilateral Free Trade Agreement (BFTA) between an individual member country and a non-member country, this extension of AFTA through an ASEAN+X framework model has been the best way to strengthen ASEAN's regional cooperation with non-members. The ASEAN countries' economic performances in the last decade explain the attractiveness of the ASEAN+X framework and the willingness of non-members countries to join it. (Verico 2013, Kusnadi and Sitorus 2014). Besides, the member countries comprise the third largest population in the world, after China and India, which means that ASEAN possesses an important potential market demand and a large potential productive labor supply. In addition, the comparative advantages among ASEAN countries may allow development of complementary production networks in Southeast Asia. In other words, these features allow ASEAN to expand its regionalism to other Asian countries and then to establish BFTAs with non-member countries to expand its economic cooperation. Among several ASEAN cooperative frameworks (notably ASEAN+1's, ASEAN+6) ASEAN+3, which covers ten ASEAN member states and three East Asian countries (China, Japan and Korea), has been considered as the most successful model of the ASEAN+X framework

¹ The five ASEAN founding members are Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Membership has now extended to include Brunei Darussalam, Laos, Cambodia, Myanmar, and Vietnam.

(Kawai and Wignaraja 2007, Verico 2013, Kusnadi and Sitorus 2014). ASEAN+3 also represents the latest shift of East Asian regional cooperation from trade and investment to financial cooperation. According to Urata (2007), free trade arrangements in the East Asian region through ASEAN+3 attempt to promote trade creation instead of trade diversion. Still, a better understanding of the integration process and its evolution within the ASEAN or the ASEAN+3 framework is opportune.

The present paper attempts to gain a better understanding of economic integration in ASEAN+3 by employing a network analysis. Network analysis has recently been employed in the related literature to study the relevant issues of international trade (Fagiolo *et al.* 2007, Iapadre and Tajoli 2014). Network analysis is primarily effective in demonstrating trade relations as a network in which countries play the role of nodes, and a link indicates the presence of an import/export relation between any two countries. Fagiolo *et al.* (2007) argue that a network approach enhances our understanding of international economics because it allows investigation of the whole structure of interactions among countries and exploration of connections, paths, and circuits. The authors also indicate that while standard statistics are only able to capture the first-order relationships, a network analysis can analyze the second- and higher-order relationships. Furthermore, according to Kali and Reyes (2007), the statistical properties of network analysis can also explain the dynamics of macroeconomic variables related to globalization, growth, and financial contagion.

Employing a network analysis, the present paper has a threefold purpose. The first is to advance our understanding of the interdependence among ASEAN+3 countries through the construction of a series of network indicators. The second is to identify the countries that play central roles in the ASEAN+3 economic network. Lastly, we investigate whether ASEAN and ASEAN+3 are complementary or substitutes. Our empirical study also seeks to contribute to the related literature in two ways. First, to the best of our knowledge, the detailed network analysis on trade integration in ASEAN+3 presented in this paper is unprecedented. Second, we extend the network approach to analyze the investment connection, which is captured by Foreign Direct Investment (FDI) flows among ASEAN+3 countries.

The remainder of this paper is organized as follows. Section II outlines the concerned literature on network analysis. Section III provides an overview on ASEAN+3's integration process in terms of both trade and investment. Section IV explains the methodological approach. Section V presents and analyzes the empirical results. Section VI provides the concluding remarks.

II. Network Analysis in Economic Integration

Since long time ago, international economists have considered international trade as a network (Rauch 2001, Chaney 2011, De Benedictis *et al.* 2013). From a network perspective, the trade flow of goods and services between two countries can be simply described by a link (edge) connecting two vertices representing the two trading countries. Considering trade flows as a network allows us to analyze either the relationship between the countries in the network or the overall network structure. Consequently, network analysis has been widely used in the literature to investigate international trade relations. In a seminal paper, Snyder and Kick (1979) address world system/dependency theories of differential economic growth among countries. The authors present a block-model of the world system based on four types of international networks: trade flows, military interventions, diplomatic relations, and conjoint treaty memberships. Through this model, Snyder and Kick provide strong evidence for a core–semi-periphery–periphery network structure of international trade. Following this work, Smith and White (1992) use a quantitative network analysis of international commodity trade flows of 1965, 1970, and 1980 to measure the structure of the world economic system and to identify the roles of each nation in the global division of labor. They find evidence of the change both in the overall structure of the world economy and the positions of particular countries. This change can be characterized by (i) an enlargement of the core countries, (ii) a reduction of within-core distance, and (iii) the progressive marginalization of peripheral countries. In contrast with the two aforementioned studies, Kim and Shin (2002) focus on the issue of globalization and regionalization by applying social network analysis for longitudinal data on international commodity trade. Three important findings can be drawn from this work. First, the world became increasingly globalized between 1959 and 1996. Second, the structure of the world trade network became decentralized over time. Third, intra-regional density and ties are greater than inter-regional density and ties. In the same vein, Kastle *et al.* (2006) operate and measure the concept of globalization using complex systems network analysis with longitudinal trade data over the 1938~2003 period. The authors argue that while some important aspects of the international trade network have been remarkably stable over the period of interest, several network measures have changed substantially over the same time. The architecture of globalization is also examined in Kali and Reyes (2007), who map the topology of the international trade network and also provide new network-based

measures of international economic integration at both the global system-wide and local country levels. On the one hand, the authors demonstrate that in terms of participation and influence in the network, global trade is hierarchical, with a core–periphery structure at meaningful levels of trade, although smaller countries’ economic integration into the network increased considerably over the 1990s. On the other hand, the position of a country in the network has substantial implications for economic growth, and the network position of a country is a substitute for its physical capital but a complement to its human capital. Benedictis and Tajoli (2010) also employ the tools of network analysis to assess the characteristics of international trade networks. The authors suggest that the structure of international trade networks differs across manufacturing industries that employ different types and amounts of intermediate inputs. Accordingly, the structure of some industries’ trade flows gives rise to a dense, widespread network with many links, whereas other industries experience a centered network, organized around hubs that centrally coordinate the flows. The authors also find evidence of a positive correlation between the use of differentiated intermediate inputs and the network complexity. In a subsequent work, Benedictis and Tajoli (2011) analyze the evolution of the world trade structure. On the one hand, they study the role of the entrance of a number of new important players into the world trading system in changing the main characteristics of the existing structure of world trade. On the other hand, the authors aim to address the question of whether the changes in the world trade structure are related to the multilateral or the regional liberalization policies. The authors find that the level of world trade integration has been increasing but is still far from being complete, with the exception of some areas that have experienced a strong heterogeneity in the countries’ choices of partners. Moreover, they also describe the relevant role of World Trade Organization (WTO) in trade integration. More recently, Iapadre and Tajoli (2014) analyze the role played by the Brazil, Russia, India and China (BRIC) in the world trade network, as well as in their regions. They find that the regional role played by each of the BRIC is different. China plays a role of *export hub* in South East Asia, importing intermediate goods from the rest of the region and exporting final goods to the rest of the world, while Brazil, India and Russia seem to be the dominant *local suppliers* in their regions, exporting to the region and importing from the rest of the world. Iapadre and Tajoli (2014) also conclude that the BRIC are the most globalized countries in terms of connectivity to the world trading system in each of their respective regions. In the international economics literature, network analysis has been also used to study other relevant issues apart from trade integration. For instance, Fagiolo *et al.* (2007) employ both binary and

weighted network approaches to compare the degrees and patterns of trade and financial integration. The authors show that the trade network is almost fully connected, whereas international financial integration is less pervasive. In addition, the level of international financial integration varies with asset type: it is the highest for long-term debt contracts, somewhat lower for equities, and rather low for short-term debt. In contrast with Fagiolo *et al.* (2007), Kali and Reyes (2010) use these network-based measures of connectedness to explain stock market returns during the financial crisis, revealing that a financial crisis is amplified if the epicenter country is better integrated into the trade network. However, an affected country may dissipate the negative impact if it is well integrated into the network. The authors also explain the role of network analysis in providing an improved explanation of financial contagion.

Overall, the existing literature reveals that using network analysis to analyze international trade issues might yield interesting insights. However, until now, the tools of network analysis have been mostly applied to study the trade network structure at the world level. Therefore, we use network analysis to shed light on the changes in the trade network structure at the regional level through a case study of ASEAN+3. In addition, the present paper also contributes to the existing literature by employing network analysis to gain a better understanding of economic integration in ASEAN+3 in terms of FDI flows.

III. ASEAN+3 Integration

We begin with a discussion on the globalization level of each country in ASEAN+3. It is noteworthy that globalization can be interpreted as manifold dimensions. As defined by Dreher *et al.* (2008), globalization includes three dimensions: economic globalization²; social globalization³; and political globalization⁴. Dreher *et al.* (2008) also introduce the KOF Index of Globalization covering all three dimensions of globalization. The KOF index defines globalization as the process of creating networks of connections

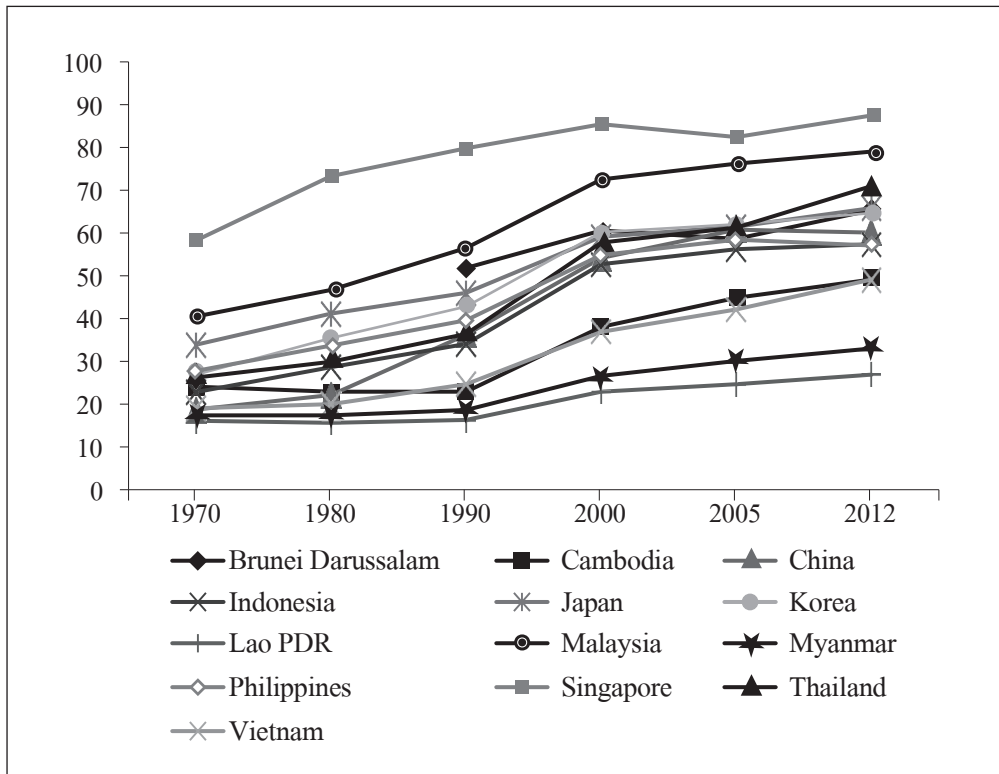
² Economic globalization is characterized as long distance flows of goods, capital, and services as well as information and perceptions that accompany market exchanges.

³ Social globalization is expressed as the spread of ideas, information, images, and people.

⁴ Political globalization is defined as a diffusion of government policies.

among actors at multi-continental distances, mediated through a variety of flows including people, information and ideas, capital, and goods.

Figure 1. KOF globalization index of ASEAN+3



(Note) KOF index of Globalization was introduced and described by Dreher *et al.* (2008). The overall index covers the economic, social and political dimensions of globalization.

(Source) Authors' creation from KOF Index.

In Figure 1, all ASEAN+3 countries show a substantial increase in the KOF index over the 1970–2012 period. Despite a common increasing trend, Figure 1 also displays the heterogeneity of globalization processes among ASEAN+3 countries. China experienced a remarkable change in its KOF index, starting from the lowest level in 1970 to remain constant over a longer period. By contrast, the KOF index of countries with a low economic development level, such as Lao PDR and Myanmar, has remained low. This is probably due to the fact that the globalization process seems to be more favorable in countries with strong economic performance.

Table 1. Share of ASEAN+3’s trade flows

(%)

| Year | Exports | | | | Imports | | | |
|------|---------|---------------------|---------|---------------------|---------|---------------------|---------|---------------------|
| | ASEAN | | ASEAN+3 | | ASEAN | | ASEAN+3 | |
| | World | East Asia & Pacific | World | East Asia & Pacific | World | East Asia & Pacific | World | East Asia & Pacific |
| 1980 | 3.7 | 25.5 | 12.8 | 88.4 | 3.4 | 26.2 | 12.9 | 90.7 |
| 1990 | 4.3 | 25.3 | 13.3 | 78.7 | 4.2 | 29.7 | 14.2 | 80.8 |
| 2000 | 5.7 | 27.4 | 16.7 | 80.9 | 5.2 | 32.1 | 16.1 | 80.7 |
| 2005 | 6.1 | 24.8 | 20.4 | 83.1 | 5.6 | 30.2 | 18.4 | 81.6 |
| 2010 | 6.5 | 22.2 | 25.0 | 85.3 | 6.0 | 28.1 | 21.2 | 82.3 |
| 2013 | 6.7 | 21.3 | 26.9 | 85.8 | 6.2 | 26.3 | 23.6 | 82.9 |

(Source) Authors’ computation from WDI data.

We now turn our attention to ASEAN+3 integration in terms of both trade and FDI flows at the regional level. In fact, ASEAN+3 has long enjoyed a market-driven expansion of trade and FDI. Over the past two decades, the region’s trade and FDI have expanded rapidly. As shown in Table 1, ASEAN+3’s exports rose from 12.8% of the world total exports in 1980 to 26.9% in 2013, whereas its imports expanded from 14.2% to 23.6% during the 1990~2013 period. ASEAN+3 has also played a central role in regional trade integration. In 2013, the share of ASEAN+3 in regional exports and imports reached 85.8% and 82.9%, respectively.

Table 2. Share of ASEAN+3's FDI inflows

(%)

| Year | FDI inflows | | | | FDI outflows | | | |
|------|-------------|---------------------|---------|---------------------|--------------|---------------------|---------|---------------------|
| | ASEAN | | ASEAN+3 | | ASEAN | | ASEAN+3 | |
| | World | East Asia & Pacific | World | East Asia & Pacific | World | East Asia & Pacific | World | East Asia & Pacific |
| 1980 | 4.4 | 47.9 | 9.2 | 54.0 | - | - | - | - |
| 1990 | 6.3 | 43.3 | 14.6 | 64.5 | - | - | - | - |
| 2000 | 1.8 | 14.6 | 12.1 | 49.8 | - | - | - | - |
| 2005 | 3.2 | 22.2 | 14.2 | 89.6 | 1.4 | 19.0 | 7.4 | 99.4 |
| 2010 | 5.8 | 19.7 | 29.3 | 75.5 | 3.5 | 23.9 | 14.5 | 68.6 |
| 2013 | 7.4 | 20.5 | 36.1 | 78.3 | 3.6 | 15.9 | 22.4 | 81.9 |

(Source) Authors' computation from WDI data.

ASEAN+3 has also been the most important FDI destination. FDI flows into ASEAN+3 more than doubled from 14.6% of the world total FDI inflows in 1990 to 29.3% in 2010 and reached its peak of 36.1% in 2013, whereas outward FDI of ASEAN+3 considerably increased from 7.4% to 22.4% of the world total outflows over the 2005~2010 period.

Table 3. Structure of ASEAN+3 trade activities

(% of total trade flows)

| Partners | 2000 | | 2005 | | 2010 | |
|-------------|--------|--------|--------|--------|--------|--------|
| | Export | Import | Export | Import | Export | Import |
| Intra-ASEAN | 22.8 | 21.1 | 25.3 | 24.5 | 28.2 | 26.6 |
| Extra-ASEAN | 77.2 | 78.9 | 74.7 | 75.5 | 71.8 | 73.4 |
| China | 3.5 | 5.2 | 8.1 | 10.6 | 11.3 | 12.4 |
| Japan | 12.3 | 18.8 | 11.2 | 14.1 | 11.1 | 10.8 |
| Korea | 3.5 | 4.4 | 3.8 | 4.1 | 4.8 | 5.5 |

(Source) Authors' computation from ASEAN Secretariat.

ASEAN+3's global expansion of trade has been accompanied by rising intra-regional concentration of trade activities. As reported in Table 3, ASEAN+3's trade activities are significantly characterized by trade flows between its member countries. For instance, intra-regional exports as a share of ASEAN's total exports increased from 22.8% in 2000 to 28.2% in 2010, while intra-ASEAN imports also expanded from 21.1% to 26.6% in the same period. In addition, trade flows between ASEAN countries and China, Japan, and South Korea have also experienced a substantially upward trend over the last decade, which can probably be attributed to the establishment of ASEAN+3 in 1997.

Table 4. FDI sources of ASEAN+3

(% of total inward FDI)

| Country sources | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|-----------------|------|------|------|------|------|------|
| Intra-ASEAN | 10.0 | 13.9 | 12.7 | 20.1 | 13.8 | 16.1 |
| Extra-ASEAN | 90.0 | 86.1 | 87.3 | 79.9 | 86.2 | 83.9 |
| China | 1.5 | 1.8 | 2.3 | 4.0 | 10.9 | 3.8 |
| Japan | 16.3 | 18.4 | 11.7 | 8.8 | 9.8 | 11.0 |
| Korea | 1.3 | 2.2 | 3.6 | 3.4 | 3.5 | 4.9 |
| EU | 27.7 | 23.6 | 24.6 | 14.9 | 23.9 | 22.3 |
| US | 7.9 | 5.4 | 11.0 | 7.5 | 10.7 | 11.3 |

(Source) Authors' computation from ASEAN Secretariat.

In contrast with intra-regional concentration of trade activities, the main sources of ASEAN+3's inward FDI come from both intra- and extra-regional countries. Table 4 shows that firms from the major industrialized countries are the main investors in ASEAN. Indeed, multinational firms from the European Union (EU), the United States (US), and Japan provided around 40% of the total inward FDI into ASEAN over the 2005~2010 period. On the other hand, firms from ASEAN countries have also begun to invest in other member countries. For instance, intra-ASEAN FDI flows peaked at 20.1% in 2008 and then dropped to 16.1% in 2010 due to the global financial turmoil. Overall, the recent share of intra-ASEAN FDI flows is still lower than that of extra-ASEAN FDI flows.

According to Kawai and Wignaraja (2007), several factors can explain the expansion of trade and FDI among ASEAN+3 economies. First, ASEAN+3 economies have pursued trade and investment liberalization as part of their outward-oriented trade and FDI policies within the multilateral framework. Second, investing in ASEAN+3 allows multinational firms to expand their production networks and supply chains throughout this dynamic region. Third, improving physical and digital connectivity and developing logistics support services in East Asia over the past two decades have reduced trade costs of conducting cross-border business and, thus, encouraged trade and investment activities in the region. Fourth, the remarkable economic growth of China, the largest emerging market, has also been considered as an important factor contributing to closer economic linkages among ASEAN+3 member countries.

In sum, since 2000, ASEAN+3 has experienced remarkable growth in terms of exports and inward FDI. However, the degrees of intra-regional trade and FDI integration have been heterogeneous (see Appendix 1). For instance, the share of intra-ASEAN exports to Gross Domestic Produce(GDP) in Cambodia increased from 11.75% to 21.67% during the 2000~2013 period, while this figure in Singapore rose from 81.67% to 88.75% during the same period. Moreover, Appendix 1 also shows that Singapore has the most favorable effect in the region, with the highest ratio exports and in-ward FDI by GDP. In contrast, the plus three countries (China, Japan, and South Korea) have lower ratios because of their supply roles in ASEAN+3. Regarding the Cambodia, Laos, Myanmar and Vietnam (CLMV), these members have remained FDI receivers and have gradually increased their intra-regional exports.

IV. Methodology

In this paper, to achieve our research objectives, we employ a broad set of indicators that have been widely utilized in the literature.

A. Intensity indices

According to Iapadre and Tajoli (2014), the trade intensity is an alternative and simpler approach than the well-known gravity model, in which the intensity indices are measured by a comparison between actual bilateral trade and a properly defined benchmark. Iapadre and Tajoli (2014) also argue that trade intensity indices can be used to assess possible hierarchical structures in the geography of international trade, such as core–periphery or hub-and-spoke patterns. On the other hand, intensity indices also allow investigation of the tendency of countries belonging to the same region to trade relatively more between each other (intra-regional trade) than with the rest of the world (inter-regional trade) (Iapadre and Plummer 2011).

Trade intensity can be considered as being equivalent to the revealed comparative advantage index developed by Balassa (1965). In this vein, trade intensity is formulized as follows:

$$I_{ij} = \frac{S_{ij}}{W_{ij}} = \frac{T_{ij} / T_{iw}}{T_{wj} / T_{ww}} \tag{1}$$

where S_{ij} is a partner country j 's share of the reporting country i 's total trade, W_j is its share of the world trade, T_{ij} is the total bilateral trade between reporting country i and partner country j , T_{iw} is trade between reporting country i and the world, T_{wj} is trade between country j and the world, and T_{ww} is the total world trade.

Contrary to the abundant literature on the trade intensity indices, there is no clear theoretical foundation for the FDI intensity. Consequently, to measure the intensity of FDI relationship, we reuse the idea of a bilateral trade intensity index to construct our FDI intensity indices as follows:

$$IF_{ij} = \frac{SF_{ij}}{WF_{ij}} = \frac{TF_{ij} / TF_{iw}}{TF_{wj} / TF_{ww}} \quad (2)$$

where SF_{ij} is a partner country j 's share of the reporting country i 's total FDI, WF_{ij} is its share of the world FDI, TF_{ij} is total FDI flows between reporting country i and partner country j , TF_{iw} is FDI flows between reporting country i and the world, TF_{jw} is FDI flows between country j and the world, and TF_{ww} is the total world FDI.

To calculate the FDI intensity, we use FDI stocks instead of FDI flows for two reasons. First, FDI stocks represent the long-term investment position of the host and home country, whereas FDI flows represent the annual investment position, especially in the case of small countries. Second, the value of FDI stock, which is accumulated flows, is positive in almost all cases. By contrast, calculating the FDI intensity in the case of disinvestment, in which the value of FDI flows is negative, is not an easy task. According to Iapadre (2006), the traditional specifications of intensity indices as formularized above suffer from some limitations: (i) the range of bilateral intensity indices is not homogeneous across a region and is asymmetric around a geographic neutrality threshold, and (ii) it is difficult to interpret the dynamic changes in intensity indices. To resolve these problems, Iapadre (2006) and Iapadre and Tajoli (2014) present another indicator, namely the bilateral Revealed Trade Preference (RTP) index among the member countries of a region. This index is constructed from the homogeneous bilateral intensity index (HI_{ij}) and the complementary extra-bilateral intensity index (HE_{ij}):

$$\left\{ \begin{array}{l} HI_{ij} = \frac{S_{ij}}{V_{ij}} = \frac{T_{ij} / T_{iw}}{T_{oj} / T_{ow}} \\ HE_{ij} = \frac{1 - S_{ij}}{1 - V_{ij}} \end{array} \right. \quad (3)$$

where T_{oj} is trade flows between the rest of the world (excluding country i) and country j and T_{ow} is trade flows between the rest of the world and the world. Based on the values of HI_{ij} and HE_{ij} , the RTP index is given as follows:

$$RTP_{ij} = (HI_{ij} - HE_{ij}) (HI_{ij} + HE_{ij}) \quad (4)$$

The RTP index varies from -1 (no bilateral trade) to +1 (only bilateral trade) and is equal to zero in the case of geographic neutrality. According to Iapadre and Tajoli (2014), this index is perfectly symmetric across partner countries and independent of country size. The authors also argue that the RTP index can be also used to map the intensity of trade within a region r . In this case, Equation (4) becomes

$$RTP_{ir} = (HI_{ir} - HE_{ir}) (HI_{ir} + HE_{ir}) \tag{5}$$

On the other hand, we can also determine separately the revealed import and export preference indices (RXP_{ir} and RMP_{ir} , respectively). These two indicators are used to calculate the revealed trade leadership index (Iapadre and Tajoli 2014) as follows:

$$RTL_{ir} = \frac{RXP_{ir} - RMP_{ir}}{2} \tag{6}$$

The index allows determination of the role (*local supplier* versus *export hub*) of each member country in a specific region.

B. Weighted network analysis indicators

Network analysis is an application of network theory used to analyze the relational data. De Benedictis *et al.* (2013) show that network analysis provides fundamental information on the dyad ij ; i.e., network analysis is a useful approach to assess the relationship between countries in terms of both trade and FDI.

We consider the ASEAN+3 trade network to be a weighted network since, in the binary trade matrix, 100% of links are bilateral and each node has exactly the same number of links. By contrast, concerning FDI networks, we refer to both binary and weighted network analysis because, in the binary FDI matrix, approximately 55% are bilateral relations and each node has different number of links. In addition, both trade and FDI networks are considered as directed complete networks, primarily because in ASEAN+3 trade and FDI network, every node (or every country) is directly connected to every other node (or other country) in both directions.

To gain a better understanding of the connectivity in the ASEAN+3 network, we use a broad set of centrality measures that have been widely used in the concerned

literature (Freeman 1978, Newman 2001, Bogartti 2005, Opsahl 2010). The centrality approach, which is based on the number of trade or FDI links of a given country (binary or unweighted network) and their strength (weighted network), assesses how well connected a country is to the rest of the network and how influential a country is for a specific region. According to Jackson (2010), centrality measures can be classified into four main groups: i) degree centrality assessing how a node is connected to others, ii) closeness centrality showing how easily a node can be reached by other nodes, iii) betweenness centrality describing how important a node is in terms of connecting other nodes, and iv) eigenvector centrality measure (or the Bonacich centrality) referring to how important, central, influential, and tightly clustered a node's neighbors are. In this paper, we only focus on two indicators—the degree centrality and the eigenvector centrality—for several reasons. First, all links in ASEAN+3 network are directed between two countries. Second, the transactions between countries are independent. Third, there is no node (or country) that is a part of transactions among two nodes.

Finally, in the weighted networks, we calculate either the absolute values (e.g., flows of exports and stocks of FDI) or the relative ones (e.g., flows of exports by GDP and stocks of FDI by GDP), which allows us to avoid the excessive impact of country size; moreover, it also allows better determination of the specialization in the overall process of production.

1. Degree centrality

Degree centrality is the simplest measure of a node's position in a network. In a binary network, the degree centrality corresponds to the number of connections of each node. In a weighted network, the links between nodes are not equivalent and weighted according to their strength.

In a given network, N is the total number of nodes (countries), and a_{ij} is the element in the trade adjacency matrix A , in which i is the row-indicator corresponding to exporting countries and j is the column-indicator corresponding to importing countries. If $a_{ij} = 1$, the two countries i and j are trade partners. If $a_{ij} = 0$, the two countries i and j are not trade partners. In a weighted network described by $N \times N$ with the weight matrix $A = [a_{ij}]$, $a_{ij} > 0$ if the link i to j exists, otherwise $a_{ij} = 0$. In an unweighted (or binary) network, the centrality of node is measured by the number of the connections between nodes as

$$C_D = \sum_{j \neq i}^N a_{ij} \quad (7)$$

Because of the dependence of degree centrality measure on the number of existing nodes in a network, it is difficult to compare networks of different node sizes. According to De Benedictis *et al.* (2013), it is usually better to calculate the normalized version of C_D as follows:

$$C_D^N = \frac{\sum_{j \neq i}^N a_{ij}}{(N-1)} \tag{8}$$

This indicator ranges from 0 to 1, implying that the closer the degree centrality is to 1, the more a country is directly connected to the rest of the network. In a directed network, we distinguish in-degree centrality and out-degree centrality. In our case, the out-degree centrality is the total number of countries to which country i exports its products, whereas the in-degree centrality is the total number of countries that export their products to country i :

$$\left\{ \begin{array}{l} C_{D-out}^N = \frac{\sum_{j \neq i}^N a_{ij}}{(N-1)} \\ C_{D-in}^N = \frac{\sum_{j \neq i}^N a_{ji}}{(N-1)} \end{array} \right. \tag{9}$$

The ratio of these two indicators indicates the relative connectivity of a country in terms of inflows (with a ratio greater than 1) or outflows (with a ratio smaller than 1). Normalizing the number of links in Equation (7) by the total number of links L in the network gives the following measures:

$$\left\{ \begin{array}{l} C_{D-out}^P = \frac{\sum_{j \neq i}^N a_{ij}}{L} \\ C_{D-in}^P = \frac{\sum_{j \neq i}^N a_{ji}}{L} \end{array} \right. \tag{10}$$

In a weighted network, we can also determine the strength centrality (C_s) with respect to trade volumes between two countries as follows:

$$\left\{ \begin{array}{l} C_{S-out}^N = \frac{\sum_{j \neq i}^N w_{ij}}{(N-1)} \\ C_{S-in}^N = \frac{\sum_{j \neq i}^N w_{ji}}{(N-1)} \end{array} \right. \quad (11) \quad \text{and} \quad \left\{ \begin{array}{l} C_{S-out}^P = \frac{\sum_{j \neq i}^N w_{ij}}{\sum_i \sum_j w_{ij}} \\ C_{S-in}^P = \frac{\sum_{j \neq i}^N w_{ji}}{\sum_j \sum_i w_{ij}} \end{array} \right. \quad (12)$$

where w_{ij} is, for example, the exports or the exports by GDP from country i to country j , w_{ji} is the imports of country i from country j , and $\sum_i \sum_j w_{ij} = \sum_i \sum_j w_{ji}$ are the in-strength and out-strength by total network trade. In general, the degree and the strength centrality take into consideration the direct links of a node and its nearest neighborhood but ignore the position of a node in the network's structure.

2. Eigenvector centrality

The eigenvector centrality index, introduced by Bonacich (1972), measures the importance of a node in terms of its connection to other central nodes (Iapadre and Tajoli 2014). It assigns relative scores to all nodes in the network based on the principal that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. Mathematically, the eigenvector centrality of country i is defined as the sum of the centrality of its neighbors j scaled by a constant. In an undirected network with adjacency matrix A , the measure (C_E) is computed as follows:

$$C_E(i) = \lambda^{-1} \sum_j a_{ij} C_E(j) \quad (13)$$

In a directed network, we can also distinguish

-hub centrality: this indicator allows determination of the high hub score country, which is the key exporter or investor in the network:

$$C_{E-hub}(i) = \beta \sum_j a_{ij} C_{E-ortho}(j) \quad (14)$$

-authority centrality: this indicator allows determination of the high authority score country, which is the key importer of the main destination of investment in the network:

$$C_{E-ortho}(i) = \alpha \sum_j a_{ij} C_{E-hub}(j) \quad (15)$$

Overall, we use the above-listed indicators to analyze the structure of the ASEAN+3 network in terms of both trade and FDI integration.

V. Results

In this section, we report and analyze the results of this network analysis of trade and FDI integration in ASEAN+3. To calculate all network analysis indicators listed above, we collect our panel data from different international data sources: UN Comtrade, Organization for Economic Co-operation and Development (OECD), ASEAN, and United Nations Conference on Trade and Development (UNCTAD).

A. Trade integration

As mentioned above, we used a network analysis to study the structure of trade integration in ASEAN+3. Appendix 2 reports the trade intensity indices. We also report the values of trade balance to compare the role of each ASEAN+3 member country in regional trade system and the world trade system. First, looking at ASEAN's Revealed Trade Leadership (RTL) indices, Singapore, Thailand, Malaysia, and Indonesia can be seen as intra-regional *local suppliers* because their intra-regional trade leadership is positive, especially over the 1990~1997 period. By contrast, small and less-developed countries, such as Cambodia and Lao, have been considered as intra-regional *export hubs*. Interestingly, Malaysia has experienced a downward trend in intra-regional trade introversion since the country is exporting more to the world and becoming an *export hub* in ASEAN. For instance, since 1998, Malaysia's RTL value has been slightly negative, while its trade balance with the world has been significantly positive.

Second, the participation of China, South Korea, and Japan has influenced the picture of intra-regional trade relations. China and Japan have been important intra-regional *export hubs* but played a relevant role in supplying goods and services to the rest of the world (except in the case of Japan over the 2011~2013 period). Over the 2011~2013 period, we also observe that South Korea, which was an intra-regional *export hub*, turned into a *local supplier* due to opposite change in its intra-regional import and export

preferences. Regarding the role of founding ASEAN country members, Singapore maintains its role as *local supplier* and its facilitator at regional and global levels. On the other hand, after the implement of ASEAN+3, both intra-regional import and export preferences of most ASEAN countries, with the exception of Brunei Darussalam, have dropped due to the market share of the large economies (China, Japan, and South Korea).

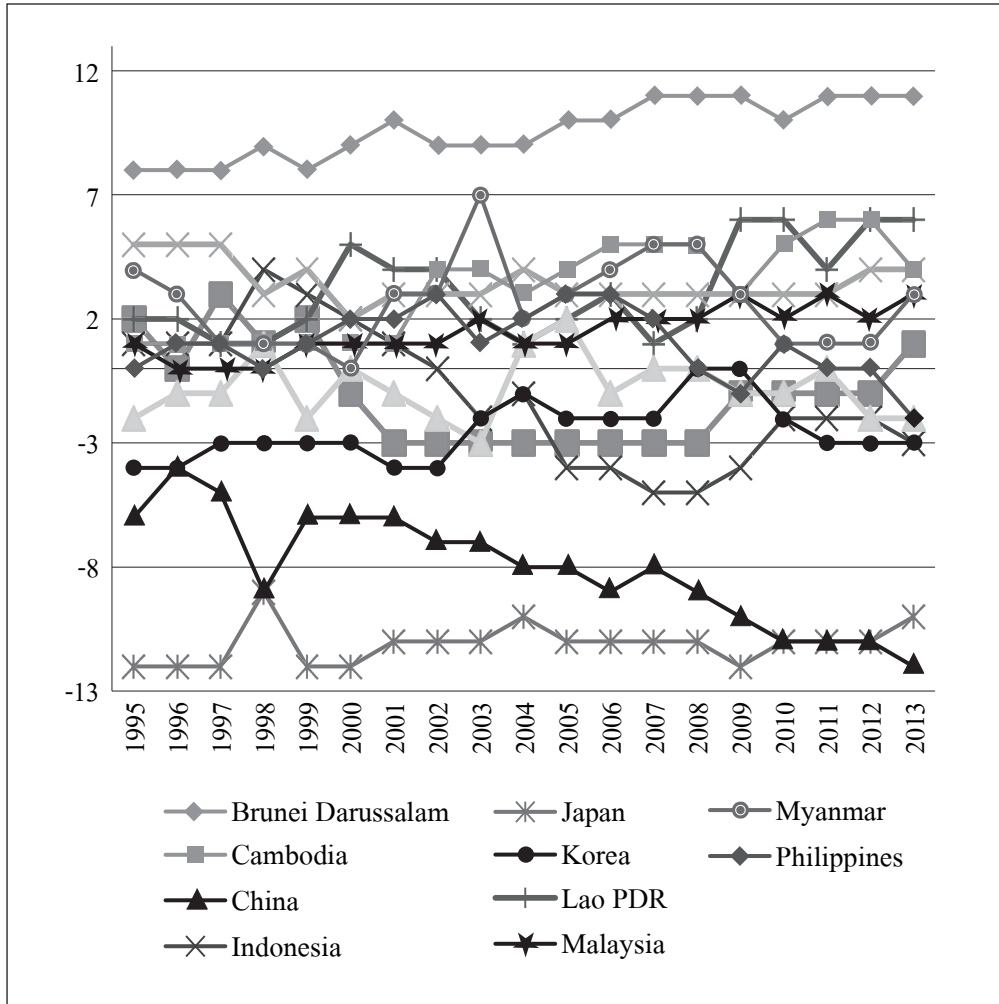
The patterns of ASEAN+3's trade network are also reflected through a set of centrality indices. As mentioned in the methodological section, each country in ASEAN+3 maintains a bilateral trade relationship with other member countries. Therefore, we only compute the weighted degree centrality index, which is formulated in Equation (11). The result is reported in Appendix 3.A, in which the weighted degree centralities are summarized in columns n-outdegree and n-indegree. For instance, the average flow of Japan's exports and imports is 7,915.29 and 6,111.64 million US dollars, respectively, over the 1990~1997 period. Together with the weighted degree centrality indices, rankings indicate the integration level of each country in ASEAN+3's trade network. Furthermore, we can also observe the changes in ASEAN+3's trade structure over the observation period. According to Appendix 3.A and using the flows of exports as the weights for the network, China, Japan, and South Korea are the most integrated countries in the regional trade network. In particular, Japan and South Korea have always played a central role in the trade network in both with or without ASEAN+3 creation cases. Unsurprisingly, the role of China in the regional trade network has changed since 2006 because of its official integrated activities into ASEAN+3. As shown in Appendix 3.B, when taking into account the flows of exports by GDP, the roles of China and Japan appear much more asymmetric. They rank second and first in terms of in-degree, respectively, but 12th and 13th for the out-degree. This result clearly shows that China and Japan are the main importers in the ASEAN+3 area, but they mainly export outside the ASEAN+3. Therefore, China and Japan, because of the importance of their exports and imports, are the more central countries in the network and practice a strategy different from that of ASEAN for their sales in foreign markets. These results confirm previous ones concerning their roles as intra-regional *export hubs*. Regarding other member countries, founding ASEAN member countries such as Singapore and Malaysia have also maintained an important position in the regional trade system. The trade position of Singapore in the weighted network is opposite to the Chinese one (see Appendix 3.B and Figure 2)—that of an important exporter to the ASEAN+3 countries and a less central importer. Compared with Singapore, Brunei Darussalam is not a central country in terms of absolute values of exports and imports from and to ASEAN+3 countries, but

the country also experiences a strong asymmetric position, ranking second in the out-degree measure and 13th in the in-degree. By contrast, Figure 2 shows a more symmetric position in the Trade Network of other ASEAN+3 countries, such as South Korea, which, however, tends to be outside-ASEAN market-oriented, like China and Japan. As for Indonesia, it moved from an export-oriented position within ASEAN+3 to an import-oriented one, in the same manner China did. Meanwhile, with the small value of degree centrality indices, less-developed countries, such as Cambodia, Lao, and Myanmar, have only played a peripheral role in the ASEAN+3 network, with no clear positions.

Figure 2. Evolution of the asymmetry

(In the rank of the weighted degree centrality indexes)

(Rank in out-degree – Rank in in-degree)



(Source) Authors' creation.

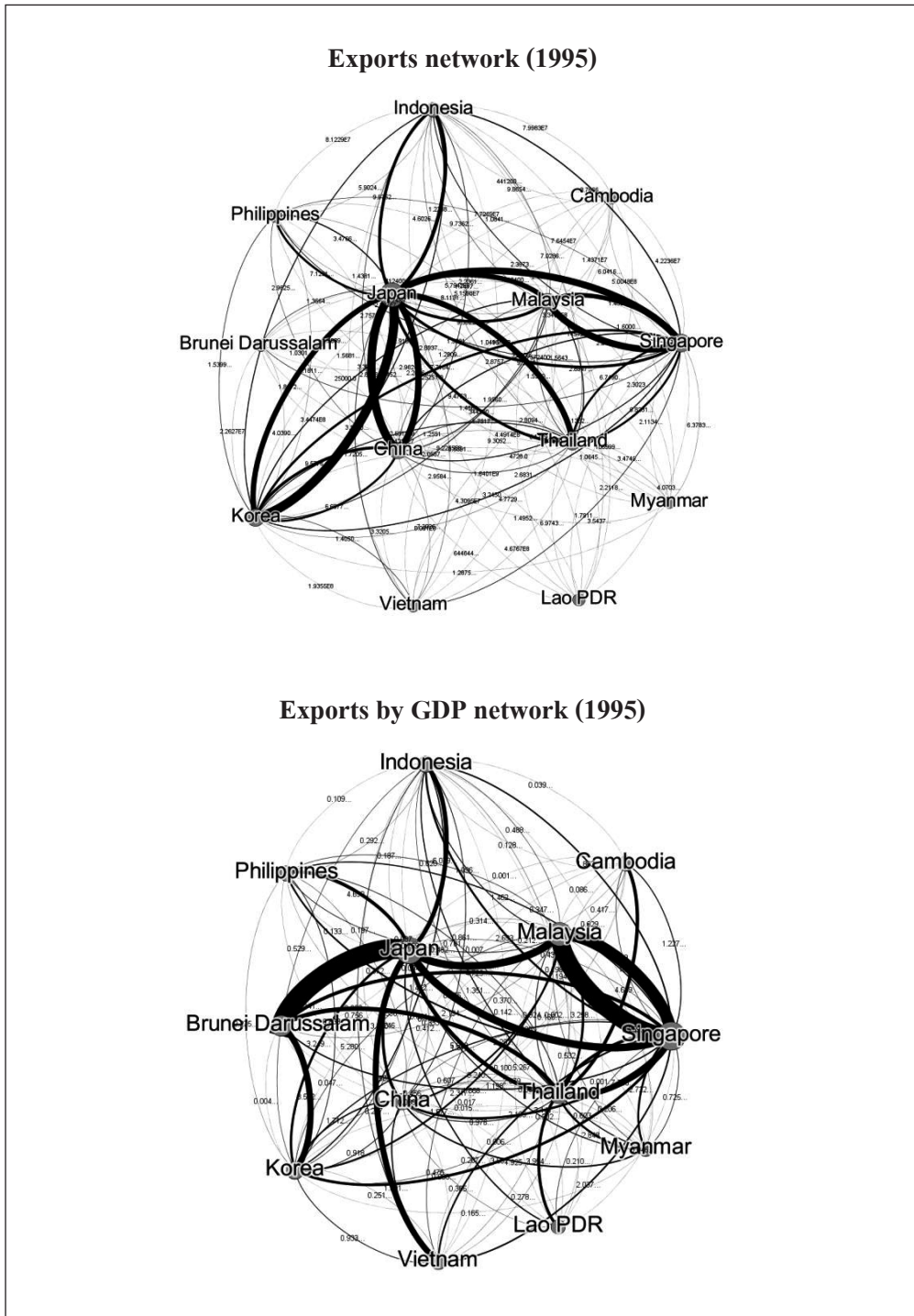
The core-periphery picture of ASEAN+3's trade network is also drawn by the weighted eigenvector index. This index allows analysis of the interdependence among ASEAN+3 countries and determination of the countries that play the most central role in ASEAN+3 economic network. We present the results of eigenvector centrality indices in Appendix 4.A and Appendix 4.B in which the country with the highest value of eigenvector centrality is the most connected one in the network.

Again, two stories can be formed depending on the ways we weight the network.

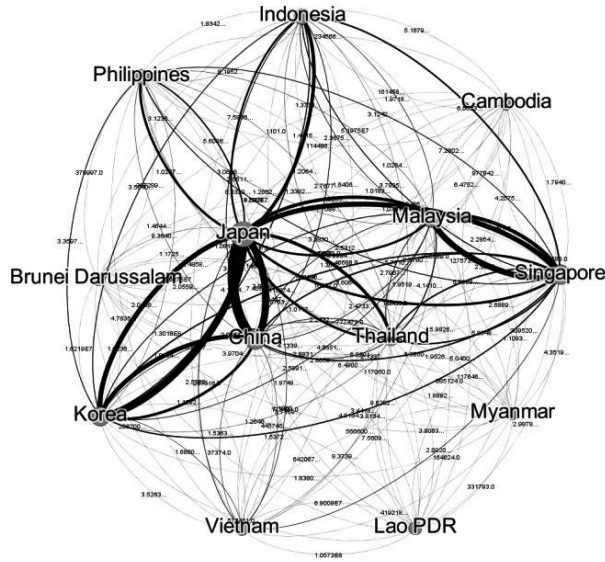
Using the absolute values of exports from a country to another one, the eigenvector, hub, and authority indices are reproduced in Appendix 4.A. In Appendix 4.B, similar calculations are made using the relative values (e.g., X/GDP) to take into account the country size. As expected, looking at the eigenvector centrality index in Appendix 7.A, Japan is ranked first during the 1990~2005 period, meaning that this country is very well connected to all other countries in the region. During the 1990~1997 period, with the value of normalized index of 55.53, South Korea ranks second because of its strong link with Japan, the most important node in the network. Following South Korea, Singapore is ranked third, confirming that it is well connected to Japan and South Korea, as well as other central countries in ASEAN+3. Over the 1998~2005 period, China improved its positions in the network, rising from the fourth to the second most central node. Since 2006, with the official integration in ASEAN+3, China has occupied the most central role. By contrast, small countries, such as Cambodia, Lao, Myanmar, and Vietnam, lag far behind China, as well as Japan and South Korea, in terms of influence. Besides the eigenvector index, Appendix 4.B also reports the values of hub and authority centrality indices describing the trade-flow direction: countries with a high hub value are key exporters, whereas countries with a high authority value are main import destinations. In this regard, Japan plays a role as the first hub in ASEAN+3, followed by China, South Korea, and Singapore. Regarding the authority index, again, the China–Japan–South Korea triangle dominated as countries with the highest scores.

The results on authority index and eigenvector index reported in Appendix 4.B do not change the main previous conclusions. However, with respect to the hub index and as measured by their values of exports by GDP, China, Japan, and, to a less extent, South Korea, no longer export to the ASEAN+3 countries; i.e., they are strongly specialized as hubs only for regions outside the ASEAN+3 region. The Philippines, Malaysia, Vietnam, and Brunei Darussalam are the key exporters to the region, whereas the positions of Cambodia, Lao PDR, Thailand, and Myanmar are more symmetric.

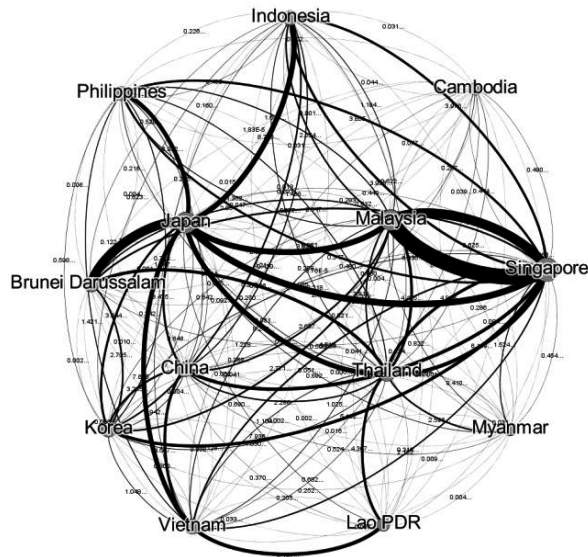
Figure 3. Evolution of trade and share of trade to GDP



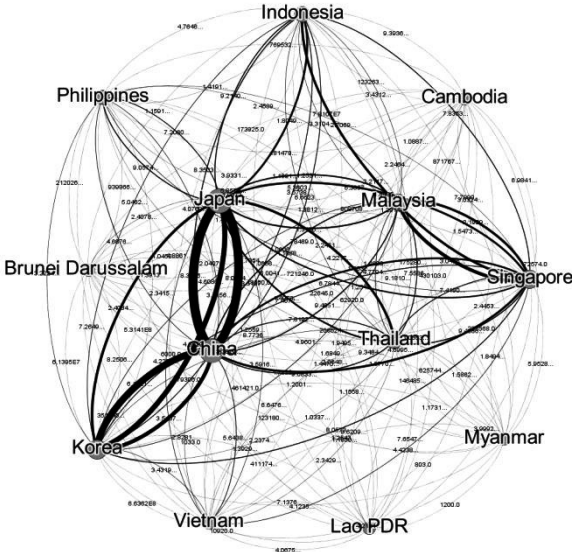
Exports network (2000)



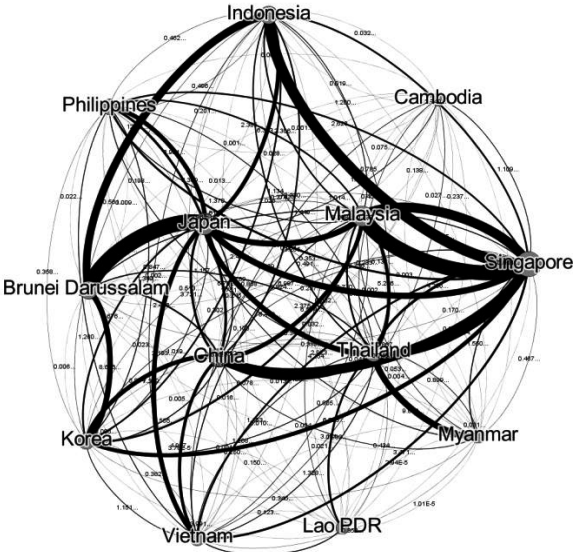
Exports by GDP network (2000)

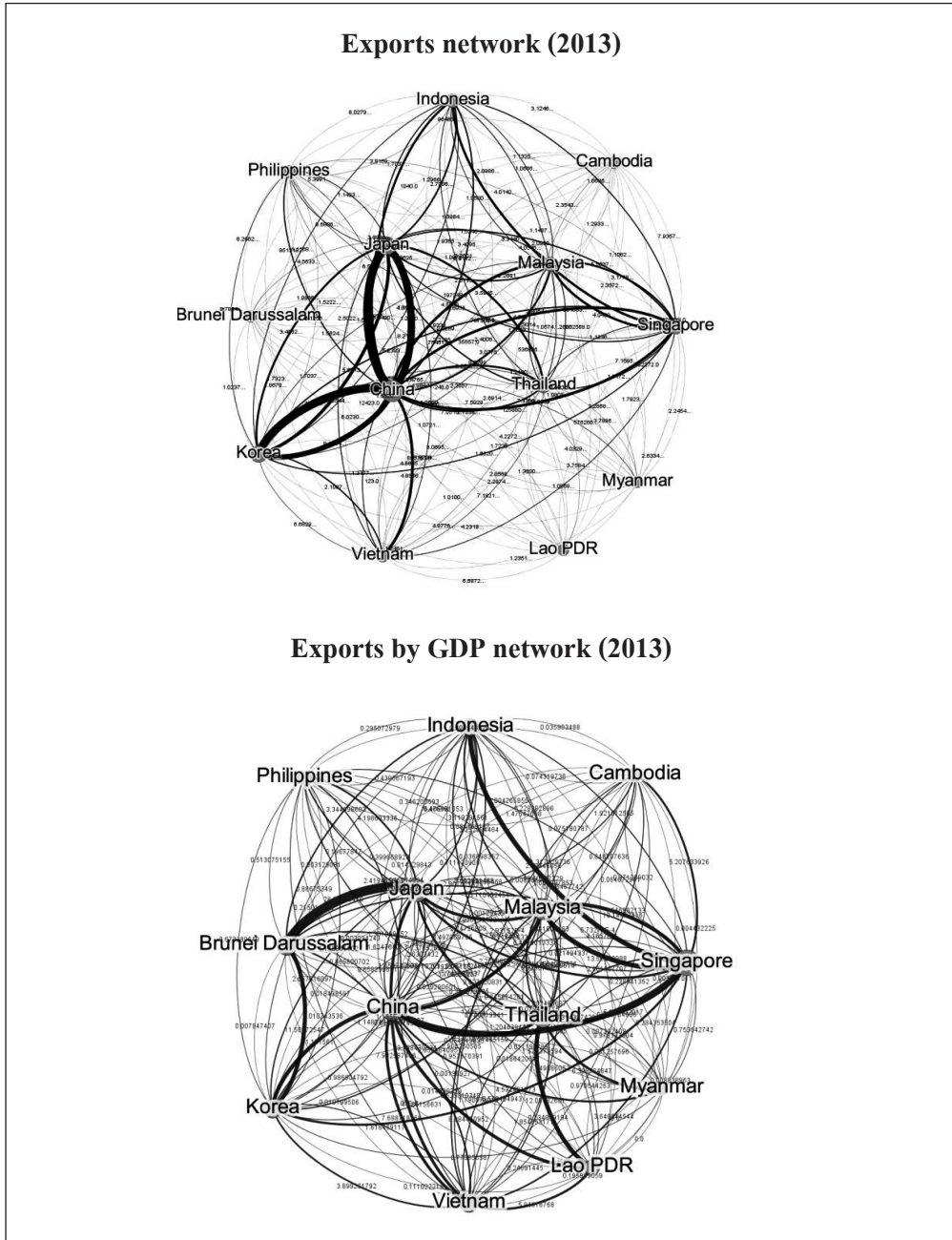


Exports network (2005)



Exports by GDP network (2005)





(Note) The size of the links in the different networks is proportionally scaled based on the values of each specific year. For example, the number of strong links in the 2005 GDP network is less than in the 1995 one due to a more important increase of the trade between China, Japan and Korea, in comparison with the evolution of the trades with Singapore, Indonesia and Vietnam. This does not mean that the volume of trade with Singapore, Indonesia and Vietnam reduced. Furthermore, the links are directed links with a clockwise direction that should be interpreted as from - to.

(Source) Authors' creation by using Gephi software.

Apart from the results discussed above, intra-regional trade connectivity can be also visualized through the use of mapping, which shows the intense relationships among member countries. As displayed in Figure 3, each country is represented by a node and labeled with its name. The size of its ties is related to the strength of trade flows between two countries in comparison with other trade flows. The picture of ASEAN+3's trade relationships highlights some significant trends through the milestone years of 1995, 2000, 2005, and 2013: (i) the leading roles of China, Japan, and South Korea in intra-regional trade; (ii) the change in trade structure before and after the official implementation of ASEAN+3; and (iii) an increasing trend in connectivity to the network of peripheral countries, such as the Philippines, Vietnam, and Cambodia. Figure 3 also shows that in 1995, some founding ASEAN countries—notably, Singapore, Malaysia, and Thailand—were still closed to the China–Japan–South Korea triangle and dominated the ASEAN trade system. However, 10 years later, these three countries moved further from the central positions. Similarly, the group of small countries has remained at an important distance from the central network. Overall, despite a rising trend in intra-regional trade integration level, the participation of large and/or advanced countries—notably, Japan, China, and South Korea—in a common trade bloc, i.e., ASEAN+3, seems to dominate trade flows from small and less-developed countries.

B. FDI integration

As mentioned in the introduction section, this paper also applies the tools of network analysis to investigate intra-regional FDI connections. We start with a discussion on the FDI intensity indices of ASEAN. First, as reported in Appendix 5, the level of intra-regional FDI integration is quite different across the 10 member countries. For instance, Brunei Darussalam and Singapore's linkages in terms of FDI inflows with ASEAN member countries appear relatively weak as the indices of intra-regional inward FDI preference are negative, whereas the main FDI destinations of these two countries are ASEAN regions. By contrast, Thailand has experienced a robust connection with ASEAN since both indices of intra-regional FDI preferences are strongly positive. Second, there is no common and pronounced tendency of regional FDI integration. For instance, intra-regional FDI preferences have declined for Singapore, particularly on the outward FDI side, while the opposite trend is true for Malaysia. Third, our empirical results confirm the dominant role of five ASEAN founding members as FDI local

suppliers, as the preference index is higher for outward FDI than for inward FDI.

We now turn our attention to the changes in intra-regional FDI integration due to the expansion of ASEAN AFTA (from ASEAN to ASEAN+3). On the one hand, as shown in Table 4, ASEAN+3 is characterized by extremely high rates of intra-regional inward FDI preference (except in the case of Brunei Darussalam). On the other hand, the extension of ASEAN seems to have altered the structure of FDI introversion in East Asia. First, the participation of China, South Korea, and Japan in the ASEAN+X framework model has modified the position of some ASEAN countries in the regional FDI mapping. For instance, instead of being a main FDI supplier in ASEAN, Thailand has become a FDI destination in ASEAN+3. Second, the newcomer countries, China in particular, have become the main rivals of ASEAN countries in attracting intra-regional FDI. Third, China can be seen as an FDI hub in ASEAN+3, which could be explained by the fact that the larger host country's market may be associated with higher FDI due to larger potential demand and lower costs due to scale economies.

While the results of intensity indices allow evaluation of the tendency of intra-regional FDI, those of centrality indices are used to assess whether FDI connectivity in the network is evenly distributed. To begin with, we report the degree centrality measures in Appendix 6, in which we distinguish between weighted and unweighted networks. The first index is degree centrality measuring how well connected a country to the rest of the ASEAN+3 network. We find that in terms of both inward and outward FDI, large and/or advanced economies are ranked in the higher positions. Among others, Singapore has attained the best place in the network. In contrast with advanced countries, developing countries appear less connected to the system due to their less open economies. On the other hand, Appendix 6 shows that the FDI position of each country in ASEAN+3 does not change much over the time (except in the case of South Korea).

The second index is strength centrality, which weights the FDI links according their value in current US dollars. Appendix 6 draws a slightly different picture about FDI positions in the ASEAN+3 network. In terms of inward FDI, China has maintained the first rank throughout the observation period, followed by Indonesia over 2001~2006 and by Singapore over the recent period. On the other hand, Japan and Singapore play a central role in supplying FDI flows to the ASEAN+3 network. In addition, we also reveal that the most important FDI flows are mainly transferred between large and/or advanced member countries. In other words, small and less-developed countries are only considered as satellites in the regional FDI network.

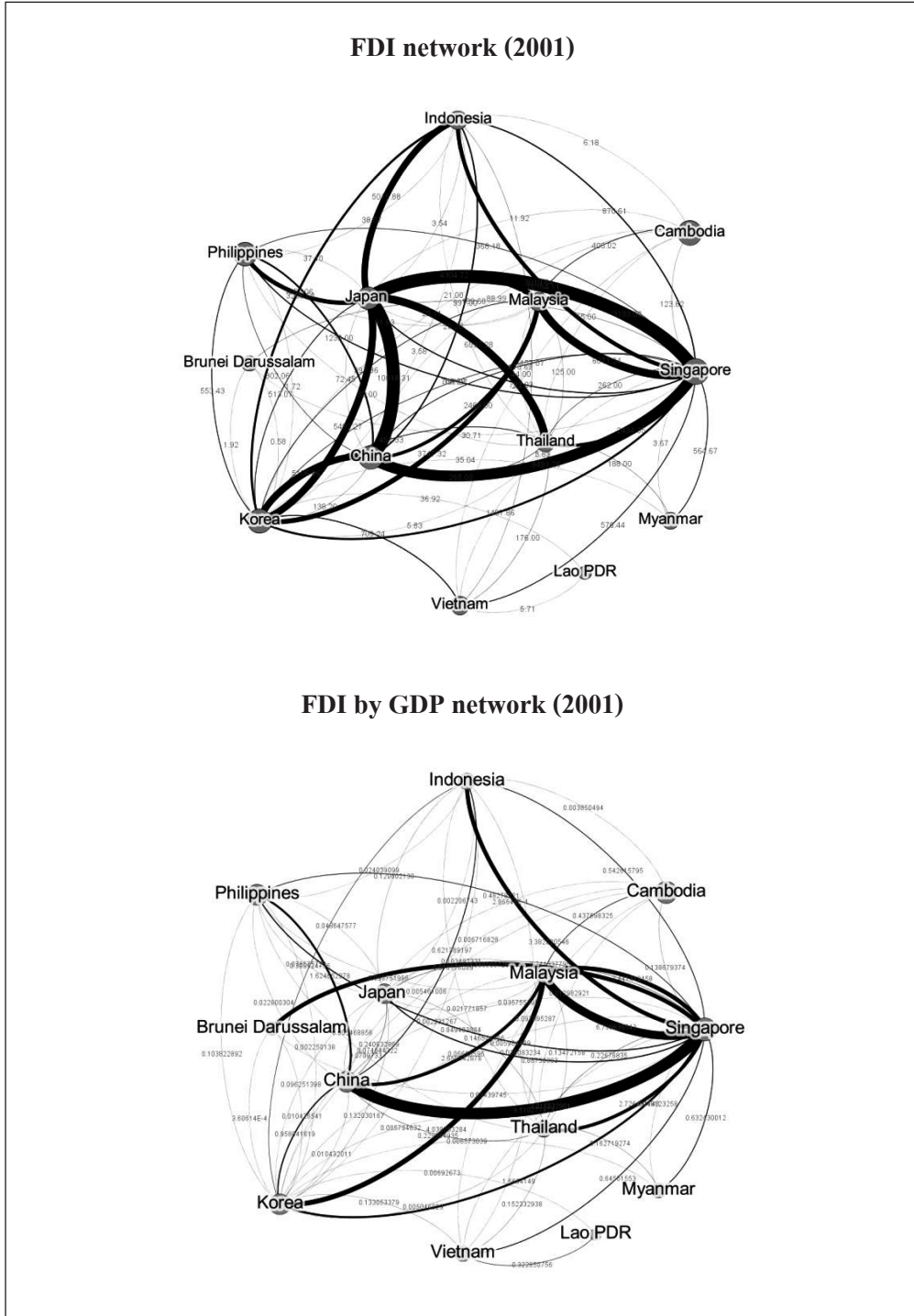
Consideration of the weighted network as measured by the stock of FDI by GDP

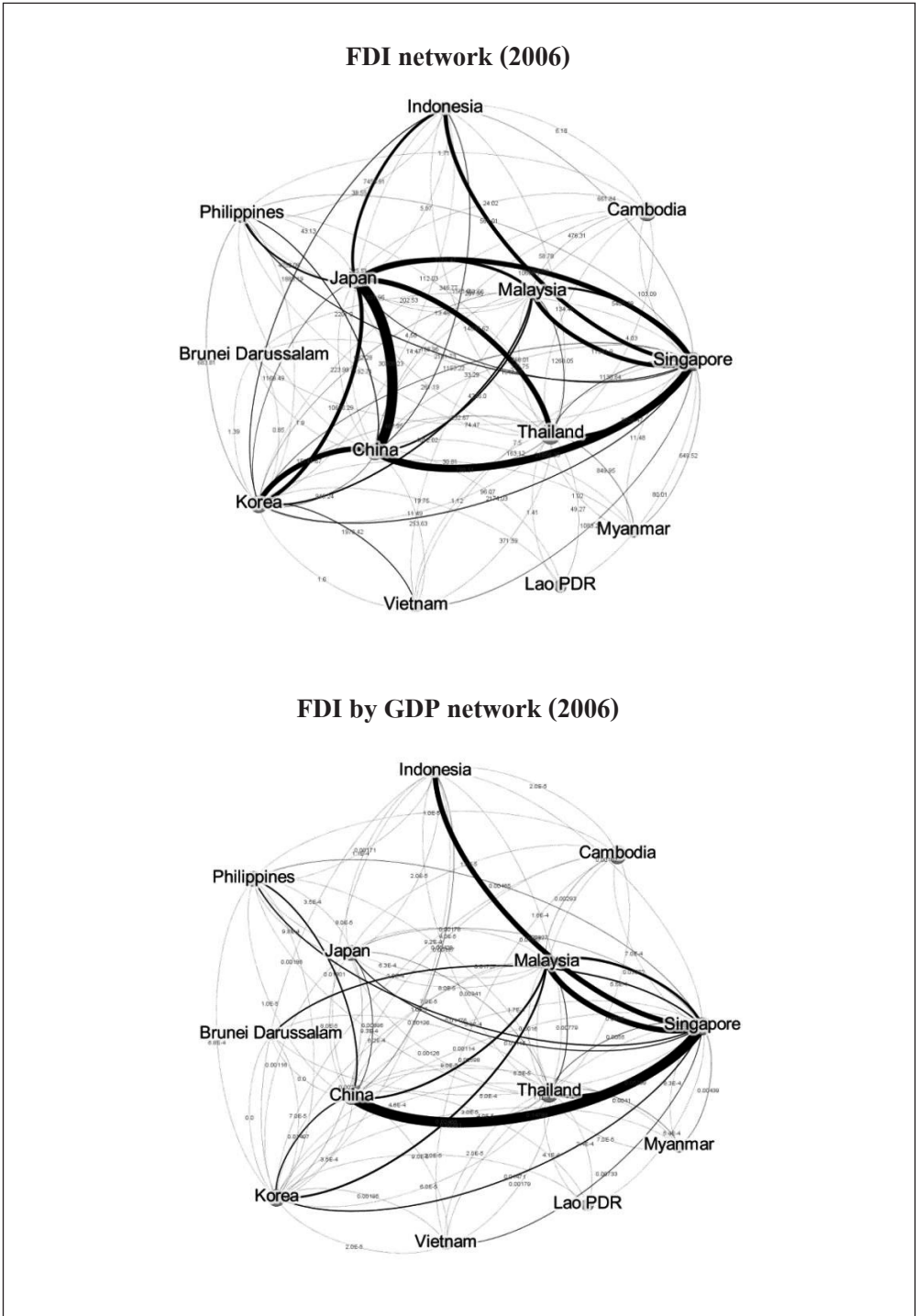
does not change the previous results (see the last part of Appendix 6). The potential asymmetric position is enforced. Hence, China, which ranked five in out-degree and one in in-degree, now ranks nine and one, respectively. The position of Japan is more strongly impacted, moving from the first position in terms of main capital supplier to the ASEAN+3 region to fifth when taking into account its level of wealth as measured by GDP. Singapore is now ranked first as a capital exporter in ASEAN+3.

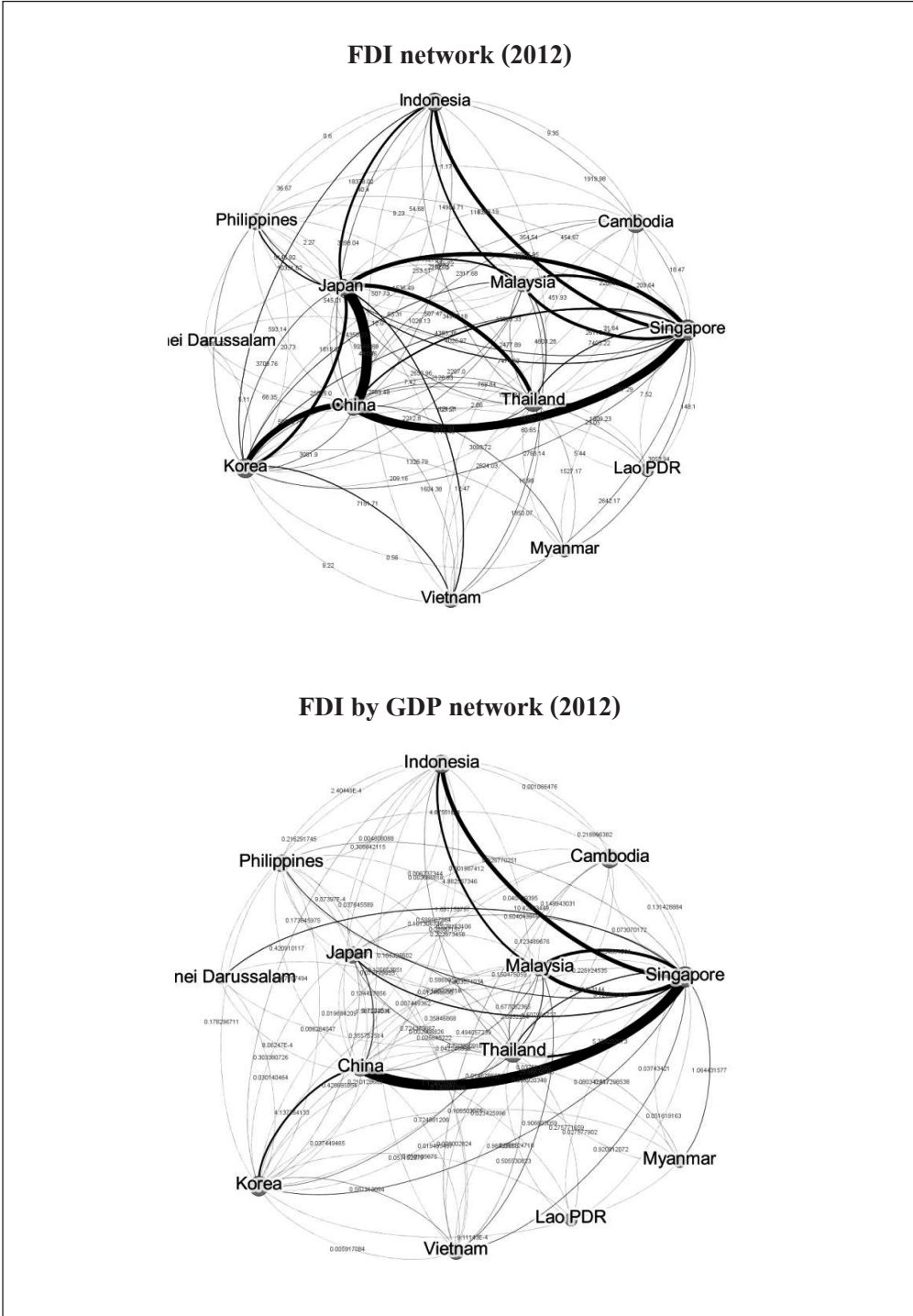
The last set of centrality indicators, which are reported in Appendix 7.A and Appendix 7B, assesses not only the number and amount of connections but also the influence of each country on a specific network. The values of eigenvector centrality confirm that the most important FDI positions in FDI network are assumed by large and/or advanced economies—China and Japan in particular. Nevertheless, the position is not as strong when considering the absolute values (Appendix 7.A), rather than the relative ones (Appendix 7.B). Either way, it means that these countries are not only very well connected but also have FDI links with most relevant players in the regional network. By contrast, developing countries are only considered as relatively peripheral countries (e.g., Cambodia, Lao PDR, and Myanmar) with such a small eigenvector centrality index. Singapore is the more connected when taking into account country size.

Eigenvector centrality is also decomposed into hub and authority scores. This decomposition allows determination of a country's supplying or receiving role in the FDI network. Unsurprisingly, China is ranked first in terms of authority, implying that China is the most important FDI destination in ASEAN+3. As suggested in a survey work released by OECD (2000), the main factors that make China an attractive destination for foreign investors can be classified into six sub-categories: (i) China's market size and economic growth performance, (ii) natural and human resource endowments, (iii) the infrastructure quality, (iv) the degree of trade openness and access to international markets, (v) institutional quality, and (vi) investment policies. In terms of being a hub, China's position is mediocre, ranked seventh in absolute value and eleventh in relative value. After China, ASEAN emerging countries, notably Singapore, Thailand and Indonesia, have occupied the 2nd, 3rd and 4th positions respectively in terms of FDI recipients. Looking at the values of hub scores, Japan was the first hub in the ASEAN+3 FDI network, followed by South Korea and Singapore. Taking GDP into account, Singapore moved to the first position. In general, China and Japan play a central role in ASEAN+3's FDI network: China is a leading authority, whereas Japan is by far the most important supplier.

Figure 4. Evolution of FDI and share of FDI to GDP







(Source) Authors' creation by using Gephi software.

Eigenvector centrality indices also allow mapping of FDI distribution in ASEAN+3. The width of the link between two countries is proportional to their value of bilateral FDI. As displayed in Figure 4, ASEAN+3's FDI looks geographically segmented, with the central role played by three newcomer countries (Japan, South Korea, and China) on one side, and ASEAN founding member countries (Indonesia, Thailand, Malaysia, and Singapore) on the other. In other words, ASEAN+3's FDI activities are largely dominated by large and/or advanced economies, whereas developing member countries appear to stand outside the crowd. Overall, the asymmetry of the FDI map results in an open question about the role of ASEAN+3 in coordinating regional FDI flows to reduce the inequality of FDI distribution among member nations. Figure 4 also displays a high level of FDI integration degree (the share of FDI to GDP) in the case of emerging countries, notably, China, Singapore, Indonesia, Malaysia, Thailand, and South Korea. This means that FDI flux considerably contributes to economic growth in these countries.

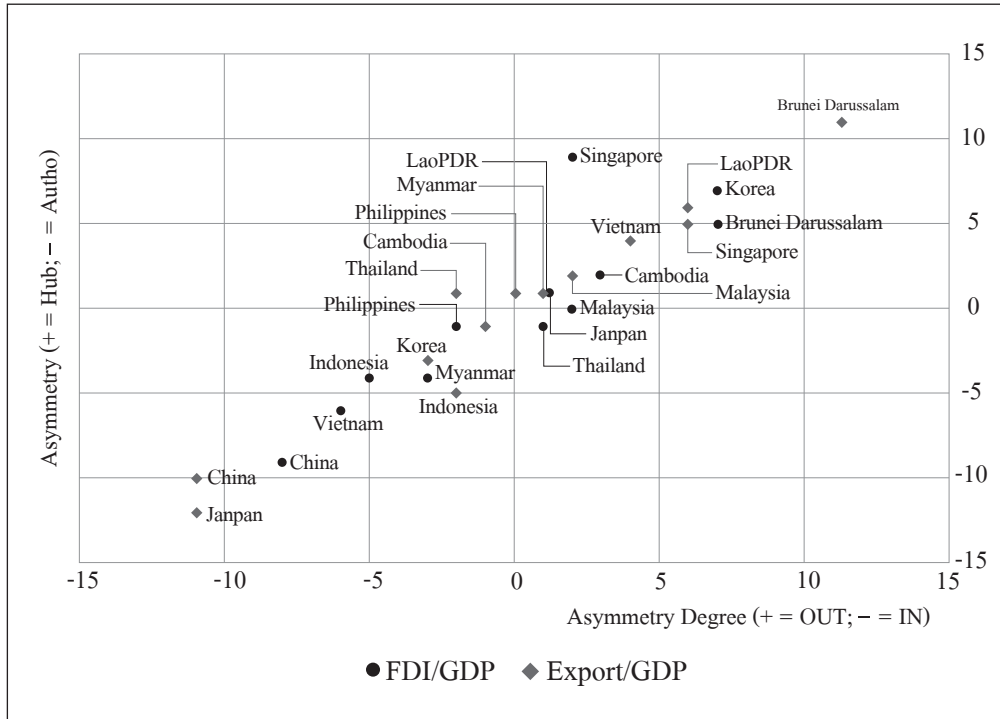
Finally, when comparing the results of the exports and FDI networks, the following facts can be highlighted. First, as shown in Appendix 8.B, the correlations between the out measures (out-degree and hub) and the in measures (in-degree and authority) are strongly negative within the trade network and between trade and financial networks. Within the financial network, out-degree and in-degree are not negatively correlated, meaning that ASEAN+3 countries have a more symmetric position in the financial network. Such a strong specialization does not appear in the network weighted by the absolute values (see Appendix 8.A). Figure 5 highlights that no country is a hub (inversely, authority) for exports and an authority (inversely, hub) for FDI. The asymmetry in the network is measured first by the difference between the ranks in out-degree and in-degree. A positive (inversely, negative) value means that the country is mainly an exporter (inversely, importer) in the ASEAN+3 area. The second measure is the difference between the rankings as a hub or an authority. A positive value means that the country is mainly a hub (inversely, authority). As shown in Figure 5 and reported in Appendix 8, no country, except Thailand, appears in the top left or bottom right spaces. This implies that no country is, simultaneously, a hub and an importer or an authority and an exporter. Regarding trade and financial network specialization, China's position, which is clearly in the bottom left space in both networks, means that China is importing both goods and capital from the ASEAN+3 countries while also exporting outside the region. By contrast, Japan's position is not identical in goods and capital networks. Although Japan, like China, imports goods from ASEAN+3 countries to export outside the region (e.g., as an intra-regional *export hub*), its relationship with the other

ASEAN+3 countries in terms of capital flows is more symmetric. To a lesser extent, South Korea is opposite to Japan, being positioned more neutrally in the trade network and as a provider of financial capital to the region. In contrast, Vietnam is mainly an exporter of goods to the region but a receiver of capital.

Figure 5. Specialization as measured by asymmetry

(In network rankings)

(In the year 2012)



(Source) Authors' creation.

VI. Conclusion

The present paper has investigated the properties of ASEAN+3's economic integration by using both weighted and unweighted network analysis. To the best of our knowledge, this paper is also the first to employ the network approach to study FDI

integration issues in a specific economic region. In this regard, our empirical research provides a number of important findings.

First, the level of trade and FDI integration varies among ASEAN+3 member countries over the observation period. Second, ASEAN+3's intra-regional trade network is more densely connected than its intra-regional FDI network. Third, compared with standard statistics, network analysis allows exploration of not only the first-order but also the second- and higher-order trade and FDI relationships of any given country in the world or in a specific region. Therefore, conducting network analysis, our paper's results provide evidence that larger and richer countries are central players in ASEAN+3's trade and FDI network as defined in absolute values. Such evidence is weakened when looking at networks in terms of relative values (X/GDP or FDI/GDP). Finally, ASEAN+3 has experienced a widening gap in the trend and patterns of intra-regional trade and FDI among member countries. We also find that the expansion of ASEAN to ASEAN+3 can be regarded as a main factor altering the structure of economic integration in East Asia. However, this expansion seems to have strengthened trade and FDI connections only among large and/or advanced economies. This result suggests that ASEAN+3 does not complement ASEAN; rather, the former is replacing the latter in terms of economic integration in favor of only the founding ASEAN countries (Singapore, Thailand, Indonesia, and Malaysia) and the three newcomer countries (China, South Korea, and Japan). A set of policy implications can be derived from our empirical findings. First, ASEAN+3 policy makers should revisit the existing intra-regional trade and investment agreements to restructure trade and FDI connections among member countries. Second, poorly connected nodes (developing countries) should be facilitated to connect to central ones (central countries in regional trade and FDI map) that can be used as hubs to link with the rest of the ASEAN+3 network.

To conclude, our present research, based on the network approach, improves on the literature by supplementing an understanding of the properties of ASEAN+3's economic integration, but it does not link the empirical results with trade and FDI theory. In other words, this work does not attempt to test a theoretical model empirically or to address specific trade and FDI issues. Therefore, an investigation on the properties of ASEAN+3's economic integration *via* a theoretical model will be conducted in our future research.

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Appendix 1.A:

Intra – ASEAN+3 export by GDP

| Exports by GDP (%) | | | | |
|---------------------------|-----------|-----------|-----------|-----------|
| Country | 1990~1997 | 1998~2005 | 2006~2010 | 2011~2013 |
| Brunei Darussalam | 71.54 | 44.96 | 49.90 | 52.82 |
| Cambodia | 6.50 | 11.75 | 15.58 | 21.67 |
| Indonesia | 13.09 | 17.38 | 13.90 | 12.89 |
| Lao PDR | 8.49 | 10.83 | 19.54 | 26.23 |
| Malaysia | 39.44 | 49.57 | 46.70 | 44.56 |
| Myanmar | 6.25 | 13.92 | 14.24 | 10.89 |
| Philippines | 8.23 | 19.62 | 16.51 | 13.01 |
| Singapore | 62.44 | 81.67 | 97.51 | 88.75 |
| Thailand | 14.00 | 26.39 | 31.27 | 33.48 |
| Vietnam | 17.17 | 21.22 | 24.79 | 32.54 |
| Plus 3 | | | | |
| China | 11.04 | 10.83 | 10.46 | 9.30 |
| Japan | 2.75 | 3.79 | 6.27 | 6.58 |
| Korea | 9.12 | 12.89 | 17.42 | 22.84 |

(Source) Author's calculation from Asian Development Bank Data.

Appendix 1.B:

Intra – ASEAN+3 inward FDI by GDP

| In-ward FDI stock by GDP (%) | | |
|-------------------------------------|------------------|------------------|
| Country | 2001~2006 | 2007~2012 |
| Brunei Darussalam | 0.56 | 1.17 |
| Cambodia | 17.81 | 32.09 |
| Indonesia | 0.00 | 6.83 |
| Lao PDR | 4.12 | 24.96 |
| Malaysia | 0.00 | 12.82 |
| Myanmar | 10.86 | 12.14 |
| Philippines | 6.07 | 4.00 |
| Singapore | 26.31 | 29.48 |
| Thailand | 14.50 | 22.72 |
| Vietnam | 5.00 | 11.60 |
| Plus 3 | | |
| China | 5.09 | 3.09 |
| Japan | 0.06 | 0.27 |
| Korea | 1.95 | 3.17 |

(Source) Author’s calculation from Asian Development Bank Data.

Appendix 2: Trade intensity indices

| Country | 1990 ~ 1997 | | | | 1998 ~ 2005 | | | | 2006 ~ 2010 | | | | 2011 ~ 2013 | | | |
|-------------------|-------------|-------|-------|--------|-------------|-------|-------|--------|-------------|-------|-------|-------|-------------|-------|-------|-------|
| | RIP | REP | RTL | TB | RIP | REP | RTL | TB | RIP | REP | RTL | TB | RIP | REP | RTL | TB |
| ASEAN | | | | | | | | | | | | | | | | |
| Brunei Darussalam | -0.10 | -0.22 | -0.06 | 8.57 | 0.64 | 0.42 | -0.11 | 25.13 | 0.89 | 0.57 | -0.16 | 44.54 | 0.88 | 0.47 | -0.21 | 48.32 |
| Cambodia | - | - | - | -15.01 | 0.81 | -0.15 | -0.48 | -10.21 | 0.81 | 0.17 | -0.32 | -5.88 | 0.67 | 0.35 | -0.16 | -6.39 |
| Indonesia | 0.25 | 0.46 | 0.11 | 1.02 | 0.67 | 0.54 | -0.07 | 7.39 | 0.77 | 0.58 | -0.09 | 0.34 | 0.71 | 0.61 | -0.05 | -0.72 |
| Lao PDR | - | - | - | -13.74 | -0.06 | -0.15 | -0.05 | -10.84 | 0.95 | 0.85 | -0.05 | -8.55 | 0.93 | 0.83 | -0.05 | -2.98 |
| Malaysia | 0.61 | 0.75 | 0.07 | -0.45 | 0.71 | 0.68 | -0.02 | 20.37 | 0.71 | 0.68 | -0.01 | 3.39 | 0.70 | 0.67 | -0.01 | 12.42 |
| Myanmar | - | - | - | -0.96 | 0.90 | 0.86 | -0.02 | -0.15 | 0.89 | 0.89 | 0.00 | 0.00 | 0.86 | 0.86 | 0.00 | 0.00 |
| Philippines | 0.35 | 0.42 | 0.04 | -6.92 | 0.57 | 0.48 | -0.04 | -6.19 | 0.69 | 0.50 | -0.09 | -1.46 | 0.62 | 0.49 | -0.07 | -3.60 |
| Singapore | 0.64 | 0.74 | 0.05 | 13.59 | 0.75 | 0.73 | -0.01 | 21.00 | 0.72 | 0.77 | 0.02 | 26.30 | 0.62 | 0.73 | 0.06 | 23.95 |
| Thailand | 0.43 | 0.61 | 0.09 | -4.84 | 0.59 | 0.57 | -0.01 | 7.60 | 0.61 | 0.63 | 0.01 | 6.48 | 0.52 | 0.65 | 0.07 | 2.99 |
| Vietnam | - | - | - | -8.11 | 0.73 | 0.50 | -0.12 | -5.97 | 0.67 | 0.47 | -0.10 | -9.74 | 0.52 | 0.40 | -0.06 | 1.15 |
| ASEAN+3 | | | | | | | | | | | | | | | | |
| Brunei Darussalam | -0.17 | -0.03 | 0.07 | 8.57 | 0.54 | 0.65 | 0.05 | 25.13 | 0.80 | 0.84 | 0.02 | 44.54 | 0.79 | 0.83 | 0.02 | 48.32 |
| Cambodia | - | - | - | -15.01 | 0.70 | -0.57 | -0.64 | -10.21 | 0.74 | -0.43 | -0.59 | -5.88 | 0.60 | -0.17 | -0.38 | -6.39 |
| Indonesia | 0.52 | 0.67 | 0.07 | 1.02 | 0.64 | 0.61 | -0.02 | 7.39 | 0.69 | 0.60 | -0.05 | 0.34 | 0.68 | 0.61 | -0.03 | -0.72 |
| Lao PDR | - | - | - | -13.74 | -0.10 | -0.41 | -0.16 | -10.84 | 0.90 | 0.56 | -0.17 | -8.55 | 0.90 | 0.50 | -0.20 | -2.98 |
| Malaysia | 0.68 | 0.61 | -0.04 | -0.45 | 0.70 | 0.50 | -0.10 | 20.37 | 0.67 | 0.53 | -0.07 | 3.39 | 0.62 | 0.57 | -0.02 | 12.42 |
| Myanmar | - | - | - | -0.96 | 0.92 | 0.68 | -0.12 | -0.15 | 0.90 | 0.73 | -0.08 | 0.00 | 0.90 | 0.79 | -0.05 | 0.00 |
| Philippines | 0.53 | 0.38 | -0.08 | -6.92 | 0.62 | 0.43 | -0.10 | -6.19 | 0.61 | 0.50 | -0.06 | -1.46 | 0.55 | 0.56 | 0.00 | -3.60 |
| Singapore | 0.65 | 0.48 | -0.08 | 13.59 | 0.67 | 0.52 | -0.07 | 21.00 | 0.60 | 0.58 | -0.01 | 26.30 | 0.45 | 0.51 | 0.03 | 23.95 |
| Thailand | 0.66 | 0.49 | -0.09 | -4.84 | 0.68 | 0.47 | -0.11 | 7.60 | 0.64 | 0.49 | -0.08 | 6.48 | 0.57 | 0.50 | -0.04 | 2.99 |
| Vietnam | - | - | - | -8.11 | 0.77 | 0.50 | -0.13 | -5.97 | 0.76 | 0.37 | -0.20 | -9.74 | 0.73 | 0.36 | -0.19 | 1.15 |
| China | 0.09 | -0.06 | -0.07 | 1.77 | 0.53 | 0.19 | -0.17 | 3.07 | 0.36 | -0.03 | -0.19 | 6.48 | 0.15 | -0.08 | -0.11 | 2.62 |
| Japan | 0.34 | 0.20 | -0.07 | 1.46 | 0.51 | 0.25 | -0.13 | 1.49 | 0.46 | 0.35 | -0.05 | 0.94 | 0.39 | 0.39 | 0.00 | -1.91 |
| Korea | 0.50 | 0.38 | -0.06 | -1.20 | 0.56 | 0.38 | -0.09 | 6.27 | 0.50 | 0.40 | -0.05 | 1.95 | 0.35 | 0.44 | 0.04 | 3.12 |

(Note) RIP: Revealed import preference; REP: Revealed export preference; RTL: Revealed trade leadership; TB: Trade balance (% of GDP).
 (Source) Authors' creation.

Appendix 3.A: Trade weighted degree centrality indices

(Export values)

| Country | 1990 ~ 1997 | | | | 1998 ~ 2005 | | | |
|-------------------|-------------|------|------------|------|-------------|------|------------|------|
| | n-Outdegree | Rank | n-Indegree | Rank | n-Outdegree | Rank | n-Indegree | Rank |
| Brunei Darussalam | 179.75 | 10 | 131.04 | 10 | 225.77 | 10 | 103.76 | 12 |
| Cambodia | 12.23 | 12 | 57.38 | 12 | 12.62 | 12 | 142.70 | 11 |
| Indonesia | 1,759.33 | 6 | 1,201.02 | 7 | 2,658.31 | 6 | 2,316.98 | 7 |
| Lao PDR | 6.82 | 13 | 25.54 | 13 | 10.95 | 13 | 85.80 | 13 |
| Malaysia | 2,181.13 | 5 | 2,679.15 | 4 | 3,603.64 | 5 | 4,136.91 | 5 |
| Myanmar | 44.87 | 11 | 116.82 | 11 | 110.12 | 11 | 196.23 | 10 |
| Philippines | 426.23 | 8 | 855.67 | 8 | 1,179.28 | 8 | 1,811.18 | 8 |
| Singapore | 3,158.96 | 2 | 3,849.24 | 2 | 5,596.99 | 3 | 5,021.33 | 4 |
| Thailand | 1,412.85 | 7 | 2,107.35 | 6 | 2,592.02 | 7 | 2,920.31 | 6 |
| Vietnam | 187.67 | 9 | 305.49 | 9 | 631.78 | 9 | 1,010.23 | 9 |
| China | 2,767.77 | 4 | 2,413.49 | 5 | 7,960.26 | 2 | 8,156.67 | 2 |
| Japan | 7,915.29 | 1 | 6,111.64 | 1 | 11,390.39 | 1 | 10,014.26 | 1 |
| Korea | 2,815.25 | 3 | 3,014.34 | 3 | 5,581.44 | 4 | 5,637.21 | 3 |
| Country | 2006 ~ 2010 | | | | 2011 ~ 2013 | | | |
| | n-Outdegree | Rank | n-Indegree | Rank | n-Outdegree | Rank | n-Indegree | Rank |
| Brunei Darussalam | 541.52 | 10 | 277.59 | 12 | 802.83 | 12 | 553.74 | 12 |
| Cambodia | 43.35 | 13 | 466.62 | 10 | 129.38 | 10 | 961.27 | 11 |
| Indonesia | 5,655.49 | 7 | 6,473.36 | 6 | 9,207.84 | 6 | 10,865.27 | 6 |
| Lao PDR | 56.83 | 12 | 172.42 | 13 | 191.26 | 13 | 424.94 | 13 |
| Malaysia | 7,284.98 | 5 | 8,174.90 | 5 | 10,391.51 | 5 | 11,490.16 | 5 |
| Myanmar | 329.12 | 11 | 460.41 | 11 | 588.65 | 11 | 1,158.32 | 10 |
| Philippines | 1,864.76 | 8 | 3,206.95 | 9 | 2,340.38 | 9 | 4,690.03 | 9 |
| Singapore | 13,431.71 | 3 | 9,941.89 | 4 | 17,065.32 | 4 | 12,806.40 | 4 |
| Thailand | 6,148.57 | 6 | 6,421.43 | 7 | 9,323.44 | 7 | 10,186.52 | 7 |
| Vietnam | 1,811.87 | 9 | 3,691.17 | 8 | 3,911.22 | 8 | 7,493.02 | 8 |
| China | 22,642.83 | 1 | 24,385.59 | 1 | 37,135.44 | 1 | 35,790.92 | 1 |
| Japan | 21,999.93 | 2 | 18,783.33 | 2 | 27,315.86 | 2 | 26,170.32 | 2 |
| Korea | 13,194.96 | 4 | 12,550.25 | 3 | 21,120.07 | 3 | 16,932.27 | 3 |

(Source) Authors' creation.

Appendix 3.B: Trade weighted degree centrality indices

(Exports/GDP values)

| Country | 1990 ~ 1997 | | | | 1998 ~ 2005 | | | |
|-------------------|-------------|------|------------|------|-------------|------|------------|------|
| | n-Outdegree | Rank | n-Indegree | Rank | n-Outdegree | Rank | n-Indegree | Rank |
| Brunei Darussalam | 2.43 | 9 | 0.14 | 10 | 3.56 | 2 | 0.07 | 12 |
| Cambodia | 0.45 | 12 | 0.05 | 12 | 0.30 | 13 | 0.12 | 10 |
| Indonesia | 4.09 | 7 | 0.54 | 7 | 1.45 | 8 | 1.47 | 7 |
| Lao PDR | 0.27 | 13 | 0.02 | 13 | 0.59 | 10 | 0.04 | 13 |
| Malaysia | 15.64 | 4 | 2.13 | 4 | 3.50 | 3 | 2.78 | 3 |
| Myanmar | 0.81 | 11 | 0.09 | 11 | 1.18 | 7 | 0.11 | 11 |
| Philippines | 2.86 | 8 | 0.39 | 8 | 1.39 | 6 | 0.70 | 9 |
| Singapore | 22.07 | 2 | 2.80 | 2 | 5.73 | 1 | 2.95 | 5 |
| Thailand | 17.51 | 3 | 2.24 | 3 | 1.88 | 4 | 2.60 | 4 |
| Vietnam | 1.27 | 10 | 0.16 | 9 | 1.57 | 5 | 0.64 | 8 |
| China | 5.72 | 6 | 0.91 | 6 | 0.51 | 11 | 2.73 | 2 |
| Japan | 54.21 | 1 | 7.06 | 1 | 0.31 | 12 | 6.69 | 1 |
| Korea | 10.62 | 5 | 1.52 | 5 | 0.89 | 9 | 1.94 | 6 |
| Country | 2006 ~ 2010 | | | | 2011 ~ 2013 | | | |
| | n-Outdegree | Rank | n-Indegree | Rank | n-Outdegree | Rank | n-Indegree | Rank |
| Brunei Darussalam | 4.40 | 2 | 0.06 | 13 | 4.84 | 2 | 0.08 | 13 |
| Cambodia | 0.44 | 13 | 0.21 | 10 | 0.91 | 11 | 0.28 | 10 |
| Indonesia | 1.12 | 9 | 2.92 | 4 | 1.07 | 8 | 2.35 | 6 |
| Lao PDR | 1.01 | 10 | 0.06 | 12 | 1.93 | 6 | 0.10 | 12 |
| Malaysia | 3.52 | 3 | 2.60 | 6 | 3.43 | 3 | 2.37 | 5 |
| Myanmar | 1.36 | 6 | 0.11 | 11 | 0.96 | 9 | 0.16 | 11 |
| Philippines | 1.17 | 8 | 0.74 | 9 | 0.94 | 10 | 0.64 | 9 |
| Singapore | 7.06 | 1 | 2.62 | 5 | 5.97 | 1 | 2.34 | 7 |
| Thailand | 2.33 | 4 | 3.07 | 3 | 2.55 | 4 | 2.94 | 3 |
| Vietnam | 1.95 | 5 | 0.97 | 8 | 2.53 | 5 | 1.46 | 8 |
| China | 0.54 | 11 | 4.72 | 2 | 0.45 | 13 | 6.04 | 2 |
| Japan | 0.46 | 12 | 6.19 | 1 | 0.49 | 12 | 6.40 | 1 |
| Korea | 1.29 | 7 | 2.37 | 7 | 1.70 | 7 | 2.61 | 4 |

(Source) Authors' creation.

Appendix 4.A: Trade eigenvector centrality indices

| Country | 1990 ~ 1997 | | | | | | | | | | 1998 ~ 2005 | | | | | | | | | | (X Network) | | | | | | | | | |
|-------------|-------------|-------|--------------|------|------|------|------|-----------|------|-------------|--------------|------|------|------|------|-----------|------|-------------|--------------|----|-------------|-----|------|-----------|------|----|--|--|--|--|
| | Eigenvector | | nEigenvector | | Rank | Hub | Rank | Authority | Rank | Eigenvector | nEigenvector | | Rank | Hub | Rank | Authority | Rank | Eigenvector | nEigenvector | | Rank | Hub | Rank | Authority | Rank | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Brunei | 0.03 | 4.32 | 10 | 0.02 | 9 | 0.01 | 10 | 0.02 | 10 | 0.01 | 10 | 0.01 | 10 | 0.01 | 10 | 0.01 | 10 | 0.02 | 2.28 | 10 | 0.01 | 12 | 0.01 | 12 | 0.01 | 13 | | | | |
| Cambodia | 0.00 | 0.63 | 12 | 0.00 | 12 | 0.00 | 12 | 0.00 | 12 | 0.00 | 12 | 0.00 | 12 | 0.00 | 12 | 0.00 | 12 | 0.01 | 0.71 | 12 | 0.00 | 13 | 0.01 | 13 | 0.01 | 12 | | | | |
| Indonesia | 0.21 | 29.92 | 7 | 0.20 | 6 | 0.18 | 7 | 0.20 | 7 | 0.18 | 7 | 0.18 | 7 | 0.18 | 7 | 0.18 | 7 | 0.17 | 24.29 | 6 | 0.21 | 6 | 0.17 | 6 | 0.17 | 7 | | | | |
| Laos PDR | 0.00 | 0.23 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 0.43 | 13 | 0.03 | 11 | 0.02 | 11 | 0.02 | 11 | | | | |
| Malaysia | 0.28 | 39.45 | 5 | 0.24 | 5 | 0.32 | 5 | 0.24 | 5 | 0.32 | 5 | 0.32 | 5 | 0.32 | 5 | 0.32 | 5 | 0.22 | 30.79 | 5 | 0.26 | 4 | 0.27 | 4 | 0.27 | 5 | | | | |
| Myanmar | 0.01 | 1.31 | 11 | 0.00 | 11 | 0.01 | 11 | 0.00 | 11 | 0.01 | 11 | 0.01 | 11 | 0.01 | 11 | 0.01 | 11 | 0.01 | 1.44 | 11 | 0.05 | 9 | 0.06 | 9 | 0.06 | 10 | | | | |
| Philippines | 0.09 | 12.96 | 8 | 0.04 | 8 | 0.12 | 8 | 0.04 | 8 | 0.12 | 8 | 0.12 | 8 | 0.12 | 8 | 0.12 | 8 | 0.11 | 15.72 | 8 | 0.06 | 8 | 0.11 | 8 | 0.11 | 8 | | | | |
| Singapore | 0.38 | 53.99 | 3 | 0.26 | 4 | 0.46 | 2 | 0.26 | 4 | 0.46 | 2 | 0.46 | 2 | 0.46 | 2 | 0.46 | 2 | 0.28 | 40.20 | 4 | 0.24 | 5 | 0.29 | 5 | 0.29 | 4 | | | | |
| Thailand | 0.24 | 34.41 | 6 | 0.14 | 7 | 0.31 | 6 | 0.14 | 7 | 0.31 | 6 | 0.31 | 6 | 0.31 | 6 | 0.31 | 6 | 0.17 | 23.63 | 7 | 0.13 | 7 | 0.17 | 7 | 0.17 | 6 | | | | |
| Vietnam | 0.03 | 4.59 | 9 | 0.02 | 10 | 0.03 | 9 | 0.02 | 10 | 0.03 | 9 | 0.03 | 9 | 0.03 | 9 | 0.03 | 9 | 0.05 | 7.75 | 9 | 0.04 | 10 | 0.07 | 10 | 0.07 | 9 | | | | |
| China | 0.33 | 47.06 | 4 | 0.28 | 2 | 0.35 | 4 | 0.28 | 2 | 0.35 | 4 | 0.35 | 4 | 0.35 | 4 | 0.35 | 4 | 0.52 | 72.96 | 2 | 0.49 | 2 | 0.52 | 2 | 0.52 | 1 | | | | |
| Japan | 0.63 | 88.44 | 1 | 0.81 | 1 | 0.39 | 3 | 0.81 | 1 | 0.39 | 3 | 0.39 | 3 | 0.39 | 3 | 0.39 | 3 | 0.59 | 82.76 | 1 | 0.59 | 1 | 0.46 | 1 | 0.46 | 2 | | | | |
| Korea | 0.39 | 55.53 | 2 | 0.27 | 3 | 0.50 | 1 | 0.27 | 3 | 0.50 | 1 | 0.50 | 1 | 0.50 | 1 | 0.50 | 1 | 0.43 | 60.47 | 3 | 0.33 | 3 | 0.40 | 3 | 0.40 | 3 | | | | |
| Country | 1990 ~ 1997 | | | | | | | | | | 1998 ~ 2005 | | | | | | | | | | 2010 ~ 2013 | | | | | | | | | |
| Brunei | 0.02 | 2.61 | 10 | 0.01 | 10 | 0.01 | 12 | 0.01 | 10 | 0.01 | 12 | 0.01 | 12 | 0.01 | 12 | 0.01 | 12 | 0.02 | 3.10 | 10 | 0.01 | 10 | 0.01 | 10 | 0.01 | 12 | | | | |
| Cambodia | 0.01 | 0.99 | 12 | 0.00 | 13 | 0.01 | 11 | 0.00 | 13 | 0.01 | 11 | 0.01 | 11 | 0.01 | 11 | 0.01 | 11 | 0.01 | 1.67 | 12 | 0.00 | 13 | 0.01 | 13 | 0.01 | 11 | | | | |
| Indonesia | 0.17 | 24.36 | 6 | 0.14 | 6 | 0.15 | 7 | 0.14 | 6 | 0.15 | 7 | 0.15 | 7 | 0.15 | 7 | 0.15 | 7 | 0.19 | 27.48 | 5 | 0.17 | 6 | 0.19 | 6 | 0.19 | 7 | | | | |
| Laos PDR | 0.00 | 0.32 | 13 | 0.00 | 12 | 0.00 | 13 | 0.00 | 12 | 0.00 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 13 | 0.00 | 0.69 | 13 | 0.00 | 12 | 0.00 | 12 | 0.00 | 13 | | | | |
| Malaysia | 0.18 | 25.39 | 5 | 0.17 | 5 | 0.19 | 5 | 0.17 | 5 | 0.19 | 5 | 0.19 | 5 | 0.19 | 5 | 0.19 | 5 | 0.19 | 27.19 | 6 | 0.18 | 5 | 0.19 | 5 | 0.19 | 6 | | | | |
| Myanmar | 0.01 | 1.51 | 11 | 0.01 | 11 | 0.01 | 10 | 0.01 | 11 | 0.01 | 10 | 0.01 | 10 | 0.01 | 10 | 0.01 | 10 | 0.02 | 2.76 | 11 | 0.01 | 11 | 0.02 | 11 | 0.02 | 10 | | | | |
| Philippines | 0.07 | 10.56 | 9 | 0.05 | 8 | 0.08 | 9 | 0.05 | 8 | 0.08 | 9 | 0.08 | 9 | 0.08 | 9 | 0.08 | 9 | 0.08 | 11.43 | 9 | 0.05 | 9 | 0.09 | 9 | 0.09 | 9 | | | | |
| Singapore | 0.26 | 36.68 | 4 | 0.27 | 4 | 0.23 | 4 | 0.27 | 4 | 0.23 | 4 | 0.23 | 4 | 0.23 | 4 | 0.23 | 4 | 0.24 | 34.26 | 4 | 0.26 | 4 | 0.22 | 4 | 0.22 | 4 | | | | |
| Thailand | 0.16 | 22.16 | 7 | 0.14 | 7 | 0.17 | 6 | 0.14 | 7 | 0.17 | 6 | 0.17 | 6 | 0.17 | 6 | 0.17 | 6 | 0.18 | 24.84 | 7 | 0.15 | 7 | 0.19 | 7 | 0.19 | 5 | | | | |
| Vietnam | 0.09 | 12.70 | 8 | 0.04 | 9 | 0.09 | 8 | 0.04 | 9 | 0.09 | 8 | 0.09 | 8 | 0.09 | 8 | 0.09 | 8 | 0.14 | 20.04 | 8 | 0.07 | 8 | 0.15 | 8 | 0.15 | 8 | | | | |
| China | 0.59 | 83.19 | 1 | 0.45 | 2 | 0.73 | 1 | 0.45 | 2 | 0.73 | 1 | 0.73 | 1 | 0.73 | 1 | 0.73 | 1 | 0.60 | 85.05 | 1 | 0.53 | 2 | 0.69 | 2 | 0.69 | 1 | | | | |
| Japan | 0.54 | 76.59 | 2 | 0.67 | 1 | 0.40 | 2 | 0.67 | 1 | 0.40 | 2 | 0.40 | 2 | 0.40 | 2 | 0.40 | 2 | 0.50 | 70.95 | 2 | 0.56 | 1 | 0.46 | 1 | 0.46 | 2 | | | | |
| Korea | 0.44 | 62.21 | 3 | 0.45 | 3 | 0.38 | 3 | 0.45 | 3 | 0.38 | 3 | 0.38 | 3 | 0.38 | 3 | 0.38 | 3 | 0.44 | 62.21 | 3 | 0.49 | 3 | 0.35 | 3 | 0.35 | 3 | | | | |

(Source) Authors' creation.

Appendix 4.B: Trade eigenvector centrality indices

(X/GDP Network)

| Country | 1990 ~ 1997 | | | | | | 1998 ~ 2005 | | | | | | |
|-------------|-------------|--------------|------|------|------|-----------|-------------|--------------|------|------|------|-----------|------|
| | Eigenvector | nEigenvector | Rank | Hub | Rank | Authority | Eigenvector | nEigenvector | Rank | Hub | Rank | Authority | Rank |
| Brunei | 0.34 | 47.82 | 4 | 0.53 | 2 | 0.01 | 0.34 | 47.82 | 4 | 0.53 | 2 | 0.01 | 12 |
| Cambodia | 0.03 | 3.64 | 13 | 0.03 | 12 | 0.01 | 0.03 | 3.64 | 13 | 0.03 | 12 | 0.01 | 11 |
| Indonesia | 0.22 | 30.83 | 7 | 0.19 | 5 | 0.20 | 0.22 | 30.83 | 7 | 0.19 | 5 | 0.20 | 7 |
| Lao PDR | 0.04 | 5.15 | 12 | 0.04 | 11 | 0.00 | 0.04 | 5.15 | 12 | 0.04 | 11 | 0.00 | 13 |
| Malaysia | 0.40 | 57.06 | 3 | 0.36 | 3 | 0.40 | 0.40 | 57.06 | 3 | 0.36 | 3 | 0.40 | 2 |
| Myanmar | 0.09 | 12.48 | 11 | 0.11 | 8 | 0.01 | 0.09 | 12.48 | 11 | 0.11 | 8 | 0.01 | 10 |
| Philippines | 0.14 | 19.88 | 9 | 0.18 | 7 | 0.08 | 0.14 | 19.88 | 9 | 0.18 | 7 | 0.08 | 8 |
| Singapore | 0.47 | 66.16 | 2 | 0.60 | 1 | 0.25 | 0.47 | 66.16 | 2 | 0.60 | 1 | 0.25 | 4 |
| Thailand | 0.26 | 36.28 | 5 | 0.22 | 4 | 0.24 | 0.26 | 36.28 | 5 | 0.22 | 4 | 0.24 | 5 |
| Vietnam | 0.14 | 19.41 | 10 | 0.19 | 6 | 0.05 | 0.14 | 19.41 | 10 | 0.19 | 6 | 0.05 | 9 |
| China | 0.22 | 31.13 | 6 | 0.07 | 10 | 0.25 | 0.22 | 31.13 | 6 | 0.07 | 10 | 0.25 | 3 |
| Japan | 0.48 | 68.01 | 1 | 0.02 | 13 | 0.70 | 0.48 | 68.01 | 1 | 0.02 | 13 | 0.70 | 1 |
| Korea | 0.20 | 27.94 | 8 | 0.10 | 9 | 0.23 | 0.20 | 27.94 | 8 | 0.10 | 9 | 0.23 | 6 |
| Country | 2006 ~ 2010 | | | | | | 2010 ~ 2013 | | | | | | |
| | Eigenvector | nEigenvector | Rank | Hub | Rank | Authority | Eigenvector | nEigenvector | Rank | Hub | Rank | Authority | Rank |
| Brunei | 0.34 | 48.23 | 4 | 0.57 | 2 | 0.0078 | 0.38 | 54.17 | 3 | 0.64 | 1 | 0.01 | 12 |
| Cambodia | 0.04 | 5.13 | 13 | 0.02 | 13 | 0.0162 | 0.08 | 10.58 | 12 | 0.07 | 11 | 0.02 | 10 |
| Indonesia | 0.30 | 41.71 | 6 | 0.11 | 8 | 0.4076 | 0.22 | 31.61 | 9 | 0.11 | 8 | 0.27 | 4 |
| Lao PDR | 0.05 | 7.09 | 12 | 0.05 | 11 | 0.0038 | 0.12 | 16.76 | 10 | 0.14 | 7 | 0.01 | 13 |
| Malaysia | 0.36 | 50.34 | 3 | 0.30 | 3 | 0.3458 | 0.32 | 45.66 | 5 | 0.32 | 3 | 0.25 | 5 |
| Myanmar | 0.08 | 11.90 | 11 | 0.09 | 9 | 0.0108 | 0.07 | 9.17 | 13 | 0.08 | 10 | 0.01 | 11 |
| Philippines | 0.11 | 15.60 | 10 | 0.12 | 7 | 0.0748 | 0.09 | 12.95 | 11 | 0.11 | 9 | 0.06 | 9 |
| Singapore | 0.48 | 67.28 | 1 | 0.65 | 1 | 0.1496 | 0.40 | 56.64 | 2 | 0.51 | 2 | 0.15 | 7 |
| Thailand | 0.23 | 33.06 | 7 | 0.22 | 4 | 0.1824 | 0.24 | 33.84 | 7 | 0.24 | 5 | 0.19 | 6 |
| Vietnam | 0.16 | 22.09 | 9 | 0.19 | 5 | 0.078 | 0.23 | 31.93 | 8 | 0.27 | 4 | 0.12 | 8 |
| China | 0.33 | 46.66 | 5 | 0.05 | 10 | 0.4168 | 0.36 | 51.44 | 4 | 0.04 | 12 | 0.46 | 2 |
| Japan | 0.41 | 58.53 | 2 | 0.04 | 12 | 0.6232 | 0.44 | 61.59 | 1 | 0.04 | 13 | 0.70 | 1 |
| Korea | 0.23 | 32.64 | 8 | 0.13 | 6 | 0.2564 | 0.27 | 37.99 | 6 | 0.18 | 6 | 0.29 | 3 |

(Source) Authors' creation.

Appendix 5: FDI intensity indices

| Country | Revealed inward stock preference | | Revealed outward stock preference | | Revealed FDI leadership | |
|-------------------|----------------------------------|-----------|-----------------------------------|-----------|-------------------------|-----------|
| | 2001~2006 | 2007~2012 | 2001~2006 | 2007~2012 | 2001~2006 | 2007~2012 |
| ASEAN | | | | | | |
| Brunei Darussalam | -0.74 | -0.65 | 0.94 | 0.93 | 0.84 | 0.79 |
| Cambodia | 0.90 | 0.81 | -0.75 | 0.37 | -0.82 | -0.22 |
| Indonesia | -1.00 | 0.17 | 0.16 | 0.89 | 0.58 | 0.36 |
| Lao PDR | 0.14 | 0.83 | -0.14 | 0.79 | -0.14 | -0.02 |
| Malaysia | -1.00 | 0.36 | -1.00 | 0.61 | 0.00 | 0.15 |
| Myanmar | 0.79 | 0.78 | 0.00 | 0.00 | -0.40 | -0.39 |
| Philippines | 0.43 | 0.04 | -1.00 | -0.17 | -0.72 | -0.11 |
| Singapore | -0.13 | -0.28 | 0.88 | 0.31 | 0.51 | 0.55 |
| Thailand | 0.52 | 0.59 | 0.92 | 0.92 | 0.20 | 0.16 |
| Vietnam | 0.23 | 0.26 | 0.00 | 0.00 | -0.11 | -0.13 |
| ASEAN+3 | | | | | | |
| Brunei Darussalam | -0.75 | -0.52 | 0.73 | 0.69 | 0.74 | 0.60 |
| Cambodia | 0.93 | 0.95 | -0.93 | -0.35 | -0.93 | -0.65 |
| Indonesia | -1.00 | 0.25 | 0.18 | 0.88 | 0.59 | 0.32 |
| Lao PDR | 0.49 | 0.98 | -0.36 | 0.65 | -0.42 | -0.20 |
| Malaysia | -1.00 | 0.32 | -1.00 | 0.35 | 0.00 | 0.01 |
| Myanmar | 0.50 | 0.72 | 0.00 | 0.00 | -0.25 | -0.36 |
| Philippines | 0.96 | 0.93 | -1.00 | -0.30 | -0.98 | -0.62 |
| Singapore | 0.71 | 0.59 | 0.70 | 0.69 | -0.01 | 0.05 |
| Thailand | 0.95 | 0.97 | 0.73 | 0.80 | -0.11 | -0.09 |
| Vietnam | 0.78 | 0.91 | 0.00 | 0.00 | -0.39 | -0.45 |
| China | 0.75 | 0.54 | -0.62 | -0.70 | -0.69 | -0.62 |
| Japan | -0.23 | 0.16 | 0.06 | 0.09 | 0.15 | -0.03 |
| Korea | 0.92 | 0.93 | 0.69 | 0.46 | -0.12 | -0.23 |

(Source) Authors' creation.

Appendix 6: FDI degree centrality indices

| Country | Unweighted degree centrality | | | | | | | |
|-------------|---|------|------------|------|-------------|------|------------|------|
| | 2001~2006 | | | | 2007~2012 | | | |
| | n-Outdegree | Rank | n-Indegree | Rank | n-Outdegree | Rank | n-Indegree | Rank |
| Brunei | 0.17 | 10 | 0.18 | 13 | 0.24 | 11 | 0.25 | 13 |
| Cambodia | 0.08 | 13 | 0.57 | 4 | 0.24 | 10 | 0.58 | 6 |
| Indonesia | 0.51 | 6 | 0.39 | 9 | 0.53 | 8 | 0.54 | 7 |
| Lao PDR | 0.17 | 11 | 0.22 | 12 | 0.17 | 13 | 0.33 | 11 |
| Malaysia | 0.47 | 7 | 0.42 | 8 | 0.72 | 6 | 0.50 | 10 |
| Myanmar | 0.14 | 12 | 0.31 | 11 | 0.19 | 12 | 0.33 | 12 |
| Philippines | 0.43 | 8 | 0.56 | 5 | 0.56 | 7 | 0.63 | 4 |
| Singapore | 0.99 | 2 | 0.83 | 1 | 1.00 | 1 | 1.00 | 1 |
| Thailand | 0.83 | 3 | 0.46 | 7 | 0.87 | 4 | 0.97 | 2 |
| Vietnam | 0.22 | 9 | 0.36 | 10 | 0.28 | 9 | 0.51 | 9 |
| China | 0.71 | 4 | 0.61 | 3 | 1.00 | 2 | 0.65 | 3 |
| Japan | 0.61 | 5 | 0.56 | 6 | 0.74 | 5 | 0.61 | 5 |
| Korea | 1.00 | 1 | 0.75 | 2 | 0.96 | 3 | 0.53 | 8 |
| Country | Weighted degree centrality (Stock of FDI) | | | | | | | |
| | 2001~2006 | | | | 2007~2012 | | | |
| | n-Outdegree | Rank | n-Indegree | Rank | n-Outdegree | Rank | n-Indegree | Rank |
| Brunei | 17.39 | 7 | 3.68 | 13 | 19.52 | 9 | 13.54 | 13 |
| Cambodia | 0.15 | 11 | 23.27 | 11 | 2.01 | 12 | 261.55 | 11 |
| Indonesia | 181.19 | 4 | 1266.64 | 2 | 328.76 | 7 | 4116.99 | 3 |
| Lao PDR | 0.36 | 10 | 8.07 | 12 | 1.00 | 13 | 143.39 | 12 |
| Malaysia | 0.00 | 12 | 1191.95 | 3 | 3126.89 | 4 | 2892.48 | 5 |
| Myanmar | 0.53 | 9 | 96.50 | 10 | 4.45 | 10 | 433.70 | 10 |
| Philippines | 0.00 | 13 | 481.83 | 7 | 98.87 | 8 | 1196.41 | 8 |
| Singapore | 3337.14 | 2 | 1141.83 | 5 | 10495.34 | 2 | 4693.19 | 2 |
| Thailand | 175.42 | 5 | 1186.56 | 4 | 1053.78 | 6 | 3852.11 | 4 |
| Vietnam | 1.14 | 8 | 205.56 | 8 | 3.41 | 11 | 1299.64 | 7 |
| China | 162.38 | 6 | 3613.58 | 1 | 1368.02 | 5 | 12675.47 | 1 |
| Japan | 5068.11 | 1 | 178.50 | 9 | 13955.27 | 1 | 1001.82 | 9 |
| Korea | 1265.52 | 3 | 756.95 | 6 | 4315.83 | 3 | 1638.77 | 6 |

| Country | Weighted degree centrality (Stock of FDI / GDP) | | | | | | | |
|-------------|---|------|------------|------|-------------|------|------------|------|
| | 2001~2006 | | | | 2007~2012 | | | |
| | n-Outdegree | Rank | n-Indegree | Rank | n-Outdegree | Rank | n-Indegree | Rank |
| Brunei | 0.0285 | 2 | 0.0002 | 12 | 0.0170 | 6 | 0.0007 | 13 |
| Cambodia | 0.0002 | 10 | 0.0017 | 11 | 0.0020 | 10 | 0.0043 | 11 |
| Indonesia | 0.0093 | 6 | 0.0628 | 3 | 0.0063 | 7 | 0.1425 | 2 |
| Lao PDR | 0.0010 | 7 | 0.0002 | 13 | 0.0018 | 11 | 0.0027 | 12 |
| Malaysia | 0.0000 | 11 | 0.0810 | 2 | 0.1218 | 2 | 0.1000 | 4 |
| Myanmar | 0.0003 | 9 | 0.0088 | 10 | 0.0018 | 12 | 0.0132 | 10 |
| Philippines | 0.0000 | 12 | 0.0190 | 6 | 0.0037 | 8 | 0.0215 | 8 |
| Singapore | 0.3530 | 1 | 0.0393 | 5 | 0.5492 | 1 | 0.1025 | 3 |
| Thailand | 0.0128 | 5 | 0.0397 | 4 | 0.0395 | 4 | 0.0850 | 5 |
| Vietnam | 0.0000 | 13 | 0.0125 | 8 | 0.0000 | 13 | 0.0248 | 7 |
| China | 0.0007 | 8 | 0.1447 | 1 | 0.0027 | 9 | 0.2765 | 1 |
| Japan | 0.0140 | 4 | 0.0123 | 9 | 0.0310 | 5 | 0.0373 | 6 |
| Korea | 0.0198 | 3 | 0.0175 | 7 | 0.0467 | 3 | 0.0135 | 9 |

(Source) Authors' creation.

Appendix 7.A: FDI eigenvector centrality indices in the weighted networks

(FDI)

| Country | 2001~2006 | | | | | 2007~2012 | | | | | | |
|-------------------|--------------|------|-------|------|-----------|-----------|--------------|------|-------|------|-----------|------|
| | nEigenvector | Rank | Hub | Rank | Authority | Rank | nEigenvector | Rank | Hub | Rank | Authority | Rank |
| Brunei Darussalam | 0.400 | 11 | 0.002 | 7 | 0.001 | 13 | 0.164 | 13 | 0.001 | 9 | 0.001 | 13 |
| Cambodia | 0.411 | 12 | 0.000 | 10 | 0.003 | 11 | 1.225 | 11 | 0.000 | 13 | 0.005 | 11 |
| Indonesia | 30.024 | 5 | 0.042 | 5 | 0.295 | 4 | 24.738 | 6 | 0.022 | 6 | 0.236 | 3 |
| Lao PDR | 0.134 | 13 | 0.000 | 10 | 0.001 | 12 | 0.792 | 12 | 0.000 | 12 | 0.002 | 12 |
| Malaysia | 26.871 | 7 | 0.000 | 10 | 0.277 | 5 | 23.027 | 7 | 0.058 | 4 | 0.210 | 5 |
| Myanmar | 1.603 | 10 | 0.000 | 9 | 0.012 | 10 | 2.552 | 10 | 0.000 | 10 | 0.016 | 10 |
| Philippines | 10.958 | 8 | 0.000 | 10 | 0.120 | 7 | 8.473 | 8 | 0.002 | 8 | 0.091 | 7 |
| Singapore | 67.351 | 3 | 0.524 | 2 | 0.310 | 2 | 65.905 | 3 | 0.577 | 2 | 0.220 | 4 |
| Thailand | 27.830 | 6 | 0.017 | 4 | 0.306 | 3 | 29.541 | 5 | 0.032 | 5 | 0.304 | 2 |
| Vietnam | 3.150 | 9 | 0.000 | 8 | 0.024 | 9 | 6.521 | 9 | 0.000 | 11 | 0.059 | 8 |
| China | 72.186 | 2 | 0.006 | 6 | 0.760 | 1 | 80.112 | 1 | 0.022 | 7 | 0.849 | 1 |
| Japan | 79.308 | 1 | 0.812 | 1 | 0.027 | 8 | 76.075 | 2 | 0.758 | 1 | 0.047 | 9 |
| Korea | 37.144 | 4 | 0.250 | 3 | 0.207 | 6 | 35.700 | 4 | 0.289 | 3 | 0.140 | 6 |

(Source) Authors' creation.

Appendix 7.B: FDI eigenvector centrality indices in the weighted networks

(FDI/GDP)

| Country | 2001–2006 | | | | | | 2007–2012 | | | | | |
|-------------|-------------------|---------|--------|--------|-----------|--------|--------------|--------|--------|--------|-----------|--------|
| | nEigenvector | Rank | Hub | Rank | Authority | Rank | nEigenvector | Rank | Hub | Rank | Authority | Rank |
| | Brunei Darussalam | 17.1327 | 6 | 0.0003 | 8 | 0.0023 | 11 | 5.9227 | 9 | 0.0015 | 9 | 0.0022 |
| Cambodia | 0.7010 | 12 | 0.0002 | 9 | 0.0072 | 10 | 0.7415 | 12 | 0.0010 | 11 | 0.0040 | 11 |
| Indonesia | 36.5607 | 4 | 0.0253 | 4 | 0.3545 | 3 | 39.2337 | 4 | 0.0103 | 6 | 0.3623 | 2 |
| Lao PDR | 0.2617 | 13 | 0.0005 | 6 | 0.0022 | 12 | 0.6235 | 13 | 0.0020 | 7 | 0.0028 | 12 |
| Malaysia | 46.6070 | 3 | 0.0000 | 10 | 0.4867 | 2 | 40.0742 | 3 | 0.0832 | 3 | 0.3408 | 3 |
| Myanmar | 3.8705 | 11 | 0.0000 | 12 | 0.0368 | 9 | 3.6512 | 11 | 0.0003 | 12 | 0.0363 | 9 |
| Philippines | 10.0818 | 8 | 0.0000 | 11 | 0.1035 | 5 | 6.1740 | 8 | 0.0015 | 8 | 0.0610 | 6 |
| Singapore | 98.7752 | 1 | 0.9972 | 1 | 0.0020 | 13 | 96.9638 | 1 | 0.9893 | 1 | 0.0232 | 10 |
| Thailand | 22.7742 | 5 | 0.0162 | 5 | 0.2210 | 4 | 26.7727 | 5 | 0.0332 | 5 | 0.2447 | 4 |
| Vietnam | 5.1215 | 10 | 0.0000 | 13 | 0.0495 | 8 | 4.6872 | 10 | 0.0000 | 13 | 0.0393 | 7 |
| China | 73.2335 | 2 | 0.0005 | 7 | 0.7437 | 1 | 78.7878 | 2 | 0.0010 | 10 | 0.8152 | 1 |
| Japan | 9.4148 | 9 | 0.0298 | 3 | 0.0685 | 7 | 15.0883 | 6 | 0.0472 | 4 | 0.1140 | 5 |
| Korea | 15.3870 | 7 | 0.0635 | 2 | 0.0977 | 6 | 12.3627 | 7 | 0.0930 | 2 | 0.0387 | 8 |

(Source) Authors' creation.

Appendix 8.A: Pearson correlation matrix of the measures

(weighted network in 2012)

(Flows of Export or stock of FDI)

| | | Export | | | | | FDI | | | | |
|--------|--------|--------|-------|-------|-------|-------|--------|--------|-------|-------|------|
| | | OutDeg | InDeg | Eig. | Hub | Auth. | OutDeg | InDeg | Eig | Hub | Auth |
| Export | OutDeg | 1 | | | | | | | | | |
| | InDeg | 0.987 | 1 | | | | | | | | |
| | Eig. | 0.984 | 0.97 | 1 | | | | | | | |
| | Hub | 0.948 | 0.907 | 0.978 | 1 | | | | | | |
| | Auth. | 0.982 | 0.994 | 0.979 | 0.917 | 1 | | | | | |
| FDI | OutDeg | 0.779 | 0.798 | 0.681 | 0.554 | 0.775 | 1 | | | | |
| | InDeg | 0.504 | 0.428 | 0.571 | 0.709 | 0.421 | -0.051 | 1 | | | |
| | Eig. | 0.96 | 0.931 | 0.93 | 0.914 | 0.912 | 0.763 | 0.604 | 1 | | |
| | Hub | 0.783 | 0.802 | 0.688 | 0.56 | 0.782 | 1 | -0.053 | 0.762 | 1 | |
| | Auth. | 0.501 | 0.43 | 0.561 | 0.685 | 0.423 | -0.008 | 0.985 | 0.627 | -0.01 | 1 |

(Note) OutDeg-Outdegree; InDeg-Indegree; Eig.-Eigenvector; Auth-Authority.

(Source) Authors' creation.

Appendix 8.B: Pearson correlation matrix of the measures

(weighted network in 2012)

(Flows of Export to GDP, or stock of FDI to GDP)

| | | Export/GDP | | | | | FDI/GDP | | | | |
|------------|--------|------------|--------|-------|--------|--------|---------|-------|-------|--------|------|
| | | OutDeg | InDeg | Eig. | Hub | Auth. | OutDeg | InDeg | Eig | Hub | Auth |
| Export/GDP | OutDeg | 1 | | | | | | | | | |
| | InDeg | -0.29 | 1 | | | | | | | | |
| | Eig. | 0.434 | 0.663 | 1 | | | | | | | |
| | Hub | 0.934 | -0.326 | 0.463 | 1 | | | | | | |
| | Auth. | -0.353 | 0.952 | 0.642 | -0.361 | 1 | | | | | |
| FDI/GDP | OutDeg | 0.716 | 0.085 | 0.416 | 0.474 | -0.003 | 1 | | | | |
| | InDeg | -0.118 | 0.614 | 0.358 | -0.175 | 0.408 | 0.167 | 1 | | | |
| | Eig. | 0.325 | 0.496 | 0.514 | 0.156 | 0.298 | 0.695 | 0.82 | 1 | | |
| | Hub | 0.671 | 0.071 | 0.377 | 0.432 | -0.015 | 0.984 | 0.151 | 0.685 | 1 | |
| | Auth. | -0.314 | 0.613 | 0.272 | -0.296 | 0.437 | -0.123 | 0.944 | 0.61 | -0.158 | 1 |

(Note) OutDeg-Outdegree; InDeg-Indegree; Eig.-Eigenvector; Auth-Authority.

(Source) Authors' creation.