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Topology of Global Value Chains: Focus on the Manufacturing Industry, 2000–2015

Hao XIAO, Jiemin GUO, Bo MENG*, Tianyang SUN

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Abstract
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Keywords: value chains, topology, networks, international trade, trade in value-added
JEL classification: F6, F13, F15, D57

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Topology of Global Value Chains:
Focus on the Manufacturing Industry, 2000–2015

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The increasing presence of global value chains (GVCs) has been considered one of the most important phenomena of 21st century international trade. A better understanding of GVCs is crucial for both trade policy making and business practices. Given the increasing complexity and sophistication of GVCs, conventional gross-term-based international trade statistics faces great challenges in accurately depicting trade flows by origin of value-added since products have higher volumes of intermediate components and services produced or processed in various stages across different countries before being exported to final consumers. This study applies various network analysis tools to the new GVC accounting system in which gross exports are decomposed into value-added terms through various GVC routes based on the ADB Multi-Regional Input–Output Tables (2000–2015). Using the proposed decomposition framework, the study helps divide manufacturing-related GVCs into sub-networks with clear visualization of countries' participation patterns. The empirical results show that GVCs are not always like "chains", but complex networks of hubs and spokes; GVCs are not very "global", but still remain to be "regional". These findings can significantly improve our understanding of the interdependency of countries in GVCs, which are normally invisible in traditional trade statistics.

Keywords: global value chains, topology, networks, international trade, trade in value added

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1. Introduction

The concept of global value chains (GVCs) was initially proposed by Krugman (1995), indicating that in international production networks, different countries gain value added by participating in certain production phases of a product. GVCs break up the production process or stages so that different tasks can be carried out in different countries. For example, iPhones are designed in California, United States; have sophisticated inputs such as semiconductors, hard drives, and cameras produced in countries such as Japan, South Korea, or Germany; are assembled in China; and are delivered all over the world mainly using Apple's marketing and after-sales servicing. The expansion of GVCs means that official trade statistics based on gross value reveal only part of the trade story. In other words, given the increasing complexity and sophistication of GVCs, traditional approaches to explain global trade face many new challenges; as mentioned by Maurer and Degain (2010), "what you see is not what you get."

Many efforts have been made to meet the above challenges. Hummels et al. (2001; HIY) defined vertical specialization (VS) and proposed the measurement of "import contents of export" in the context of GVCs. Following that, Daudinet et al. (2011) proposed the DRS method, which was later applied and extended to empirical studies on main OECD countries (Miroudot et al., 2009), the United States (NRC, 2006), and China (Dean et al., 2011; Chen et al., 2008; Koopman et al., 2008). It is worth mentioning that Koopman et al. (KWW, 2014) relaxed the key assumption of the HIY method, thus providing a unified mathematical framework for completely decomposing gross exports into value-added trade according to origin and destinations based on an inter-country input–output (ICIO) model. Wang et al. (WWZ, 2013) further improved the global value-added decomposition method at bilateral sector levels, which constitutes the theoretical framework for quantifying global value-added trade. This method provides a more objective evaluation of the value added gained by exports and the embedded value-added flows in gross trade, which better clarifies the fragmentation of global production and distribution of trade gains. It has been applied by the OECD–WTO, which has set up the so-called TiVA (Trade in Value Added) indicating system (OECD–WTO, 2013).

On the other hand, international trade networks, as vivid demonstrations of economic interactions and linkages among countries and regions, are one the leading application area of network analysis. Network analysis has been extensively adopted in international trade studies (Serrano and Boguna, 2003; Hidalgo et al., 2007; De Benedictis et al., 2013; Fagiolo, 2010; Ferrantino and Taglioni, 2014). Different from the conventional consideration of traditional trade analyses, international trade under the GVC framework involves not only final-goods trade but also complex production networks in terms of trade in intermediates, embodied factors in trade by various routes, etc. This brings many new challenges embodied in answering questions such as (1) what do GVC networks looks like? (2) how do GVC networks differ from traditional trade networks? and (3) what are the special features and evolutionary trends of GVC networks? As far as we know, only limited researches have been undertaken that illustrate global trade networks using a combination of GVC accounting and network analysis. Ferrarini (2013) calculated a bilateral vertical trade index based on the BACI database, which includes trade data on 75 countries at detailed product levels, and accordingly constructed a vertical trade map for 2006 and 2007. Zhu (2015) drew on data from the World Input–Output Database (WIOD, Timmer et al., 2014b) to (1) present global value networks (GVN) where the nodes are individual industries in different countries and the edges are value-added contribution relationships and (2) compute global value trees (GVTs) by a breadth-first search algorithm. However, the above researches did not fully apply the latest outcomes of the GVC accounting framework (e.g., KWW and WWZ) and therefore could not clearly visualize the finer features of global trade in terms of a country's participation pattern and position.

In this study, based on the value-added decomposition of bilateral exports proposed by KWW and WWZ, which we combine with network analysis, we interpret the main features of manufacturing-industry-related GVC networks by subdividing entire GVC networks into some sub-networks using the ADB Multi-Regional Input–Output (MRIO) Tables (extended WIOD database by the Asian Development Bank) for 2000 through 2015. Then, we analyze the additivity, correlation, topology, and modularity features of these networks. The empirical results, including visualization of various GVC networks, can significantly enrich our understanding of the topology of manufacturing-industry-related GVCs as well as their evolution over time.

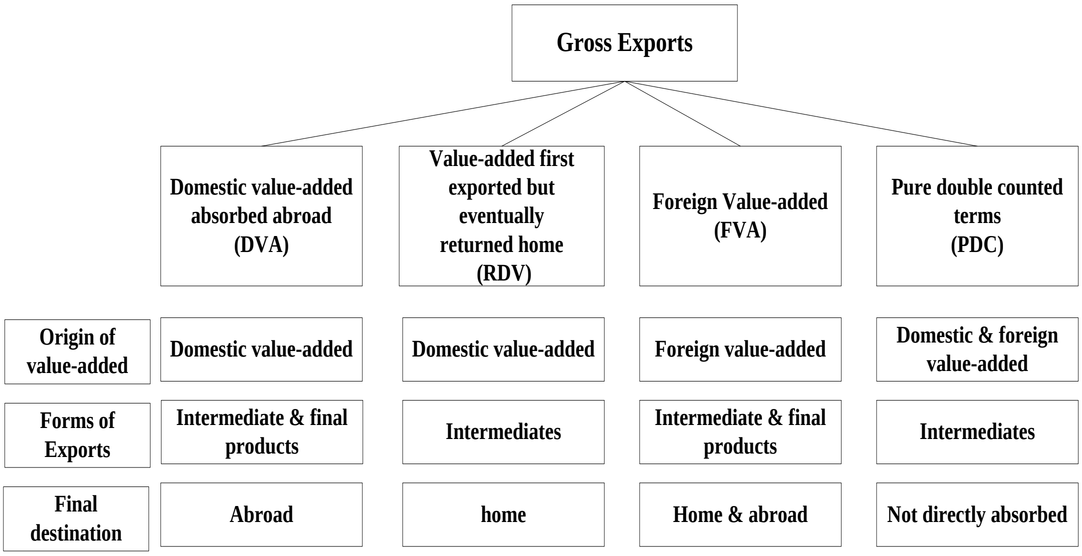


Figure 1. Framework of export decomposition

2. Methodologies

2.1. Definition of GVC Networks

According to the location of final goods and services demanded, WWZ decomposed bilateral trade flows at the sector level into four parts as shown in Figure 1: Domestic Value Added Absorbed Abroad (DVA), Domestic Value Added First Exported then Returned Home (RDV), Foreign Value Added (FVA), and Pure Double Counted Terms (PDC). These in turn can be broken down into 16 sections.

Several conceptual clarifications need to be emphasized in advance. First, exports in gross terms at any level (e.g., country/sector level, overall country level, bilateral/sector level, or overall bilateral level) can simply be separated into two components: domestic value added and foreign value added. Second, due to trade in intermediates, the importing country may not be the destination country consuming the final products. This leads to multiple rounds of value added in exports being absorbed not only in the importing country but elsewhere along the chain as well.

Using networks analysis tools, we can identify the flow of a product from the exporting country (origin node) to the importing country (destination node), with the edges between nodes and weight of edges representing occurrence and magnitude of the corresponding trade flow, respectively. In addition, according to WWZ's decomposition method, gross exports can be aggregated into DVA, RDV, FVA, and PDC in value-added terms; thus, international trade networks can also be decomposed into DVA, RDV, FVA, and PDC sub-networks.

Therefore, although GVC networks maintain the dual form of traditional trade networks, trade flows in value-added form are derived under certain conditions, and the country consuming the final product differs from the importing country, which makes GVC networks unique. There are three main areas of differentiation from other trade network types.

First is the concept of "general equilibrium" (total supply equals total demand in the world market). The derivation in WWZ is based on a closed-world input–output model, which reflects the importance of supply–demand balance in the global market. Also, the model implies that a change in output (endogenous variable) is induced by a change in final demand (exogenous variable) through both domestic and international production networks by way of trade in intermediate products. The aforementioned concept is vital for the GVC framework because it allows us to finally decompose gross exports in value-added terms absorbed by final demand at various destinations. However, this feature hinders the ability to conduct network analysis. Production networks yield a direct or indirect input–output relation among countries and sectors. In other words, borders must exist between countries if interactions are measured in value-added terms. Intensive networks normally weaken the feasibility and reliability of network analysis (Zhou et al., 2016), and therefore, we need to redefine borders when using value-added terms.

The second area of differentiation is superposition and correlation of networks. On one hand, international trade networks can be expressed using four kinds of sub-networks in value-added terms, which have features of networks' superposition. On the other hand, due to the different economic meanings of the above-mentioned four kinds of networks, interactive influences may exist among them. Therefore, when evaluating the "superposition" of a network, interactions among these four networks need to be analyzed, whereas the "correlation" of networks could reveal interdependencies among different networks.

The third area concerns heterogeneity of topology. Although frequently used in traditional international trade studies, topology in GVC networks differs from topology in traditional trade networks because it emphasizes trade relationships in value added across countries. For instance, DVA networks refer to the close relations embodied in domestic value added consumed abroad, whereas RVA networks indicate the close relations of domestic value added first exported (embodied in intermediate exports) then returned home by re-importing. Also, from a dynamic perspective, the evolution of each GVC network varies.

In summary, GVC networks can express international trade networks in terms of value-added flows under the GVC accounting framework, which has the features of "general equilibrium," superposition and correlation of networks, and heterogeneity of topology.

To construct GVC networks, we determine the origin node v_i as the *i*th exporting country and destination node v_j as the *j*th importing country. The edge $a_{i,j}$ is the flow of DVA, RDV, FVA, or PDC from the *i*th exporting country to the *j*th importing country, denoted by the adjacency matrix A = $[a_{i,j}]$. To ensure sparsity of the matrix, only if the DVA (or RDV, FVA, or PDC) is greater than the median of the matrix A, then $a_{i,j}$ = 1; otherwise, $a_{i,j}$ = 0. Moreover, we use the weight matrix W = $[w_{i,j}]$ to denote the magnitude of value-added flows from the *i*th exporting country to the *j*th importing country. Finally, V, A, and W comprise the GVC networks, denoted as G = (V，A，W).

2.2. Indexes of GVC Network Analysis

Based on the features of "general equilibrium," superposition and correlation of networks, and heterogeneity of topology, we select out-strength and in-strength to interpret the superposition of networks, select the correlation to interpret the interdependency of various networks, and determine reciprocity, assortativity, and modularity to interpret the heterogeneity features of topology. The main indexes or methods are as follows:

(1) Out-strength

In GVC networks, out-strength denotes the sum of value-added flows that a certain node sends to others, which reflects the ability of reaching out. We denote this as S_i^{out}, and it is calculated as follows:

$$S_i^{out} = \sum_j W_{i,j} \quad (1)$$

(2) In-strength

In-strength denotes the sum of value-added flows that a certain node receives from others, which reflects its ability of acceptance. We denote this as S_i^{in} , and it is calculated as follows:

$$S_i^{in} = \sum_j W_{j,i} \quad (2)$$

(3) Reciprocity

In GVC networks, three types of connections can exist between two nodes: (1) non-connection, (2) non-reciprocal connection (only one node has an edge linking it to the other), and (3) reciprocal connection (two nodes each have edges linking them to the other). Reciprocity is denoted as the ratio of Type (2) non-reciprocal connections and the sum of Type (2) and Type (3) reciprocal connections, reflecting the extent of reciprocity. With reference to Garlaschelli & Loffredo (2004), the reciprocity index can be obtained by equation (3) as follows:

$$Reciprocity = \frac{\sum_{i \neq j}(a_{i,j} - \bar{a})(a_{j,i} - \bar{a})}{\sum_{i \neq j}(a_{i,j} - \bar{a})^2} \quad （3）$$

where $\bar{a} = \sum a_{i,j} / N(N-1)$.

(4) Assortativity

According to Newman (2002), the assortativity coefficient measures a network's level of homophily, and it is a scalar between −1 and 1. A high coefficient means that one node tends to link to other nodes having the same or similar strength (sum of in-strength and out-strength) and vice versa. It is calculated using equation (4), where H denotes the sum of weights of all edges in the network; w_i denotes the weight of the *i*th edge; and j_i and k_i denote the starting node and the destination node, respectively:

$$Assortativity = \frac{H^{-1}\sum_i w_i j_i k_i - \left(H^{-1}\sum_i \frac{1}{2} w_i (j_i + k_i)\right)^2}{H^{-1}\sum_i \frac{1}{2} w_i (j_i^2 + k_i^2) - \left(H^{-1}\sum_i \frac{1}{2} w_i (j_i + k_i)\right)} \quad （4）$$

(5) Modularity

Modularity is commonly used to evaluate the quality of a community, namely a group of participants in networks with similar features or certain close relationships, and thus, it can indicate divisions within and between networks. We employ the algorithm developed by Blondel (1991) to calculate modularity, which measures the density of links inside the community compared to the links between communities. It is a scalar between −1 and 1 and can be calculated by

$$Q = \frac{1}{2m}\left[w_{i,j} - \frac{A_i A_j}{2m}\right]\delta(c_i, c_j) \quad （5）$$

where $A_i = \sum_j w_{i,j}$ is the sum of weights for edges attached to node *i*. If nodes *i* and *j* are in the same community, $\delta(c_i, c_j)$ is 1; otherwise, it is 0. Also, $m = \sum_{i,j} w_{i,j} / 2$.

To detect a community, two processes are iterated. Initially, each node is assumed to represent a community, which will be confirmed using the following steps.

Using equation (6), we calculate the gain of modularity ΔQ for node *i* when it is placed into its neighboring community of *j*. Considering every neighboring community of node *i*, if the gain is negative, node *i* stays in its original community; however, if the gain is positive, node *i* joins the community having the maximum ΔQ. This process is carried out repeatedly and sequentially for all nodes after which the first stage is completed. ΔQ is calculated as follows:

$$\Delta Q = \left[\frac{\sum C_{in} + A_{i,in}}{2m} - \left(\frac{\sum tot + A_i}{2m} \right)^2 \right] - \left[\frac{\sum in}{2m} - \left(\frac{\sum tot}{2m} \right)^2 - \left(\frac{A_i}{2m} \right)^2 \right] \quad (6)$$

where $\sum C_{in}$ is the sum of weights of all edges inside community C, $\sum tot$ is the sum of all edges connected to the nodes in the community C, A_i is the sum of weights of edges connected to the nodes *i*, $A_{i,in}$ is the sum of weights of edges from node *i* to all nodes in community C, and *m* is the sum of weights of all edges in the network.

The second stage of the algorithm involves constructing a new network where the nodes belong to the communities detected in the first stage. In the new network, the weights of edges between the new nodes are calculated by summing the weights of edges between the corresponding two communities; edges between nodes in the same community are seen as self-loops in the new network. Once the second-stage process is complete, the first-stage process is reapplied to the newly found network. The two processes are reiterated until no more changes are possible (Zhong et al., 2014).

3. Results and Analysis

3.1 Basic Topology of GVC Networks

Using the ADB Multi-Regional Input–Output Tables, we first calculate the reciprocity and assortativity of DVA, RDV, FVA, and PDC networks from 2000 to 2015 according to equations (3) and (4). As shown in Figure 2, reciprocal edges accounted for more than 55% of total edges for DVA, FVA, and PDC, indicating the reciprocity of these networks. The reciprocity of DVA, RDV, FVA, and PDC increased over time until 2008, followed by a significant decline after 2008 for DVA. In contrast, a V-shape recovery was found for FVA and PDC, probably owing to the financial crisis at that time. The assortativities of DVA, RDV, FVA, and PDC networks are all below zero, which means that high-strength countries tend to attach to lower-strength countries. Due to geographical proximity and cultural similarities, smaller countries tend to trade more with hub countries within a region, leading to the emergence of regional value chains featuring powerful countries as cores, such as the EU, NAFTA, APEC, etc. However, under rapid extension due to globalization, no regional value chain can be disconnected from other regions as regional core countries not only serve as hubs within regions but as bridges to other regions as well.

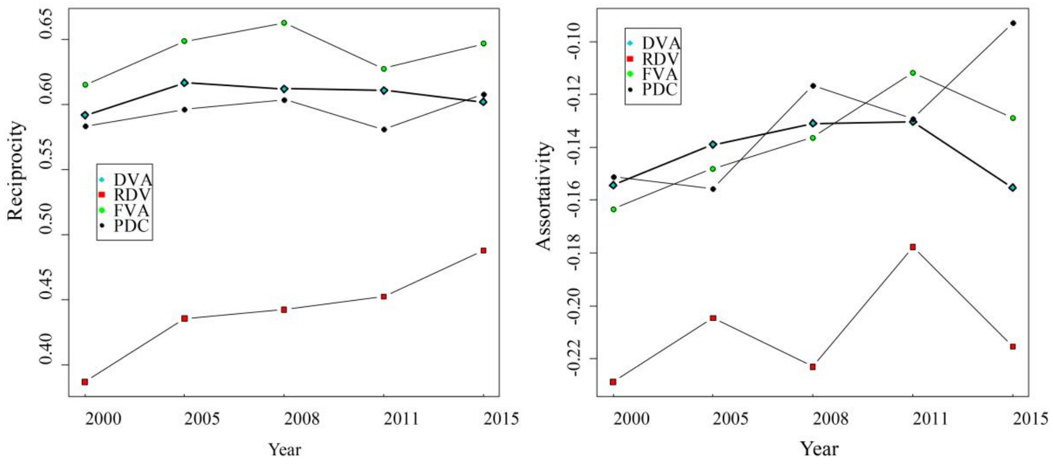


Figure 2. Reciprocity and assortativity of DVA, RDV, FVA, and PDC networks (2000–2015)

3.2 Communities' Evolution

Figure 3 shows the connections of DVA, RDV, FVA, and PDC networks in 2015. It is not difficult to find grids whose color is close to red; these mainly occur within the Asia-Pacific region and among EU countries. This indicate that value-added flows within these regions are denser than flows between other regions.

The results shown in Figure 3 indicate the presence of communities within the manufacturing GVC networks. This finding will be tested in the following analysis.

To verify our hypothesis, we used equations (5) and (6) to calculate the modularity of DVA, RDV, FVA, and PDC networks and analyze the communities within these networks. Although communities are divided differently in some years (caused by certain small countries drifting across communities), they are generally stable in each network, and components of communities remain essentially unchanged. The modularity of the RDV network, as shown in Figure 4, is significantly higher than that of other networks. This occurred because RDV reflects a special trading mode wherein one country exported intermediate products to another country, and the value added in exports returned to the originating country, where the goods were consumed domestically, which led to highly complex trade connections among countries in the same community. The DVA network's modularity, however, is the lowest; the domestic value added embodied in final good trade provides the majority in DVA, which reflects very direct connections between trade partners. Therefore, communities in DVA networks are not so obvious. Generally, the modularity of DVA, RDV, FVA, and PDC networks showed a downward trend from 2000 to 2011, indicating the loosening of clusters in GVC networks in this period. However, this trend reversed after 2011, indicating the growing independency of countries in GVC networks after the global economic crisis.

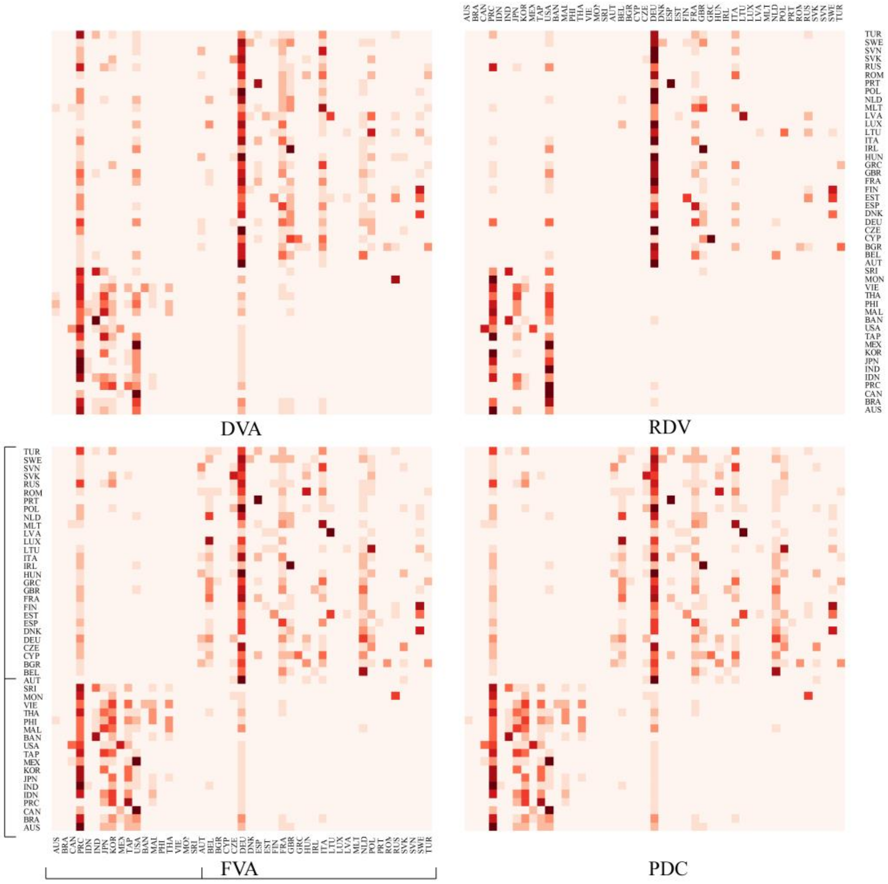


Figure 3. Connections in DVA, RDV, FVA, and PDC networks (2015)

Note: The colors scale (changing from blue to red) represents rising value added of DVA, RDV, FVA, and PDC. The horizontal axis represents the sender of value-added flows, and the vertical axis represents the receiver of value-added flows.

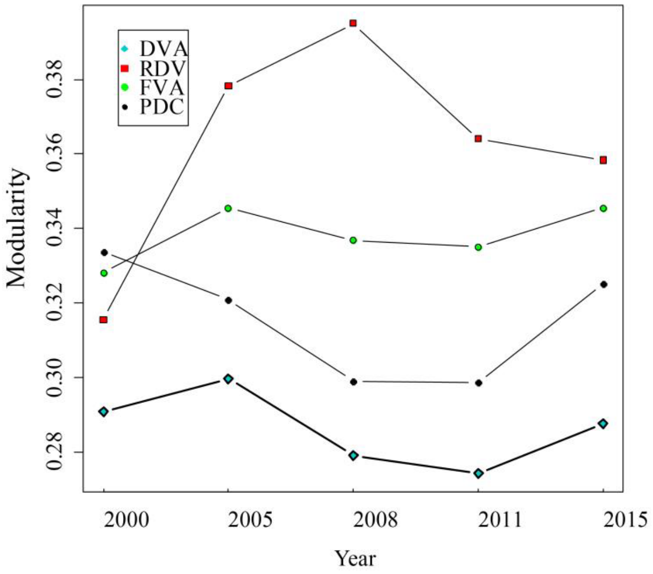
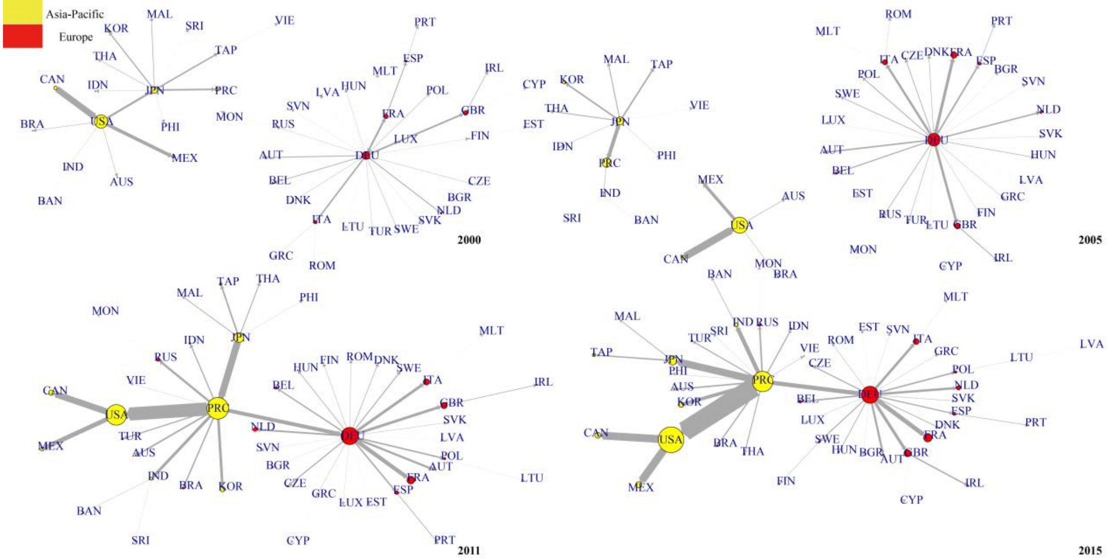


Figure 4. Connections in DVA, RDV, FVA, and PDC networks (2015)

In general, GVC networks can be too dense to permit visualization of some important topological features (such as community, hierarchy, and core–periphery relationships). Zhou (2016) classified the network by import or export ranking of each country, selecting the top-ranking importers or exporters to construct the network in order to preserve only the basic information of the network, which simplified the network for better determination of the characteristics of the network topology. Adapting this approach in this study, we define the "top-1" import network, which is the network retaining the top-1-ranking import relation for a country. Applying this approach produces a very remarkable tree structure. We can analyze the evolution of the GVC network topology through the visualization of the DVA, RDV, FVA, and PDC top-1 networks.



Note: Node size is proportional to the out-strength. Edge width is proportional to strength of value-added flow. Given the large value added of DVA and FVA, in order to facilitate drawing, the nodes in the DVA and FVA networks represent 20 times and 2 times the strength of the nodes of the same size in RDV or PDC networks.

Figure 5. Evolution of DVA network (top-1)

Figure 5 shows the evolution of the top-1 DVA network from 2000 to 2015. We found that in 2000, Japan was one of the most important hubs of the entire DVA network, connecting the Asia-Pacific community (with the United States as the core) as well as the European community (with Germany as the core). Japan was also the core for the East Asia region, coinciding with the so-called "flying geese pattern" (Akamatsu, 1962). In the 2000–2005 period, with the decline of the Japanese economy, this flying geese pattern gradually disintegrated, and the United States became the new hub of the DVA network; nevertheless, Japan still remained the core in East Asia. In 2005, the connection between Japan and the US was much weaker, while China and Japan created a very strong linkage in the East Asia region. In 2011, China not only replaced the United States as the hub of the DVA network but also became a new core in East

Asia. These changes reflect that with China's growth as the "world factory," its position in the DVA network became increasingly important, and the country became one of the cores of the global DVA network. In 2015, China's relations with other hubs (US and Germany) were much stronger, and more Asian countries had built direct DVA linkages around China.

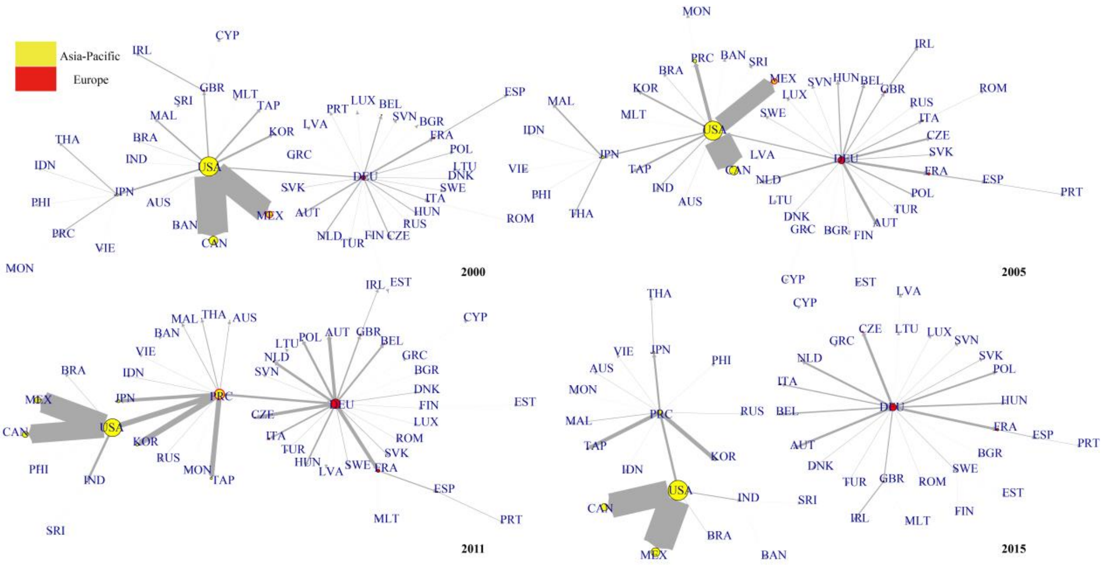


Figure 6. Evolution of RDV network (top-1)

Figure 6 shows the evolution of the top-1 RDV network. Different from the DVA network, from 2000 to 2005, the United States was the core of the Asia-Pacific community as well as connected the Asia-Pacific community to the European community (with Germany as the latter's core). This could reveal that a considerable number of intermediate products, such as semiconductors made in the United States at the high end of the value chain, are exported to other countries, assembled into final products, and then returned to the originating domestic market. These kinds of production routes reflect the dominant role the United States plays in global value chains. As for China, it gradually improved its position in the RDV network over the same period. Over the course of a decade, China, starting from a position on the periphery of the DVA network in 2010, gradually shifted to the middle position and then rose to become the production hub connecting the Asia-Pacific community and European community in 2011. It should be noted that the United States was China's largest RDV exporter (shown in Figure 6 by the arrow pointing from the United States to China), and China's RDV out-strength was significantly below that of the United States, indicating the presence of substantial gaps in terms of position in the RDV network between China and the United States. However, by 2015, China's connections with two other hubs in the RDV networks were weakening, which is consistent with China's stronger presence in the DVA networks. This phenomenon probably reflects several developments that need to be discussed in detail. For example, industry upgrading was occurring within China, which was accompanied by a decline in processing trade. Second, trade protectionism was potentially increasing due to the slow pace of economic recovery after the financial crisis. Furthermore, manufacturing jobs were being re-shored, i.e., returned to source countries due to technological innovation.

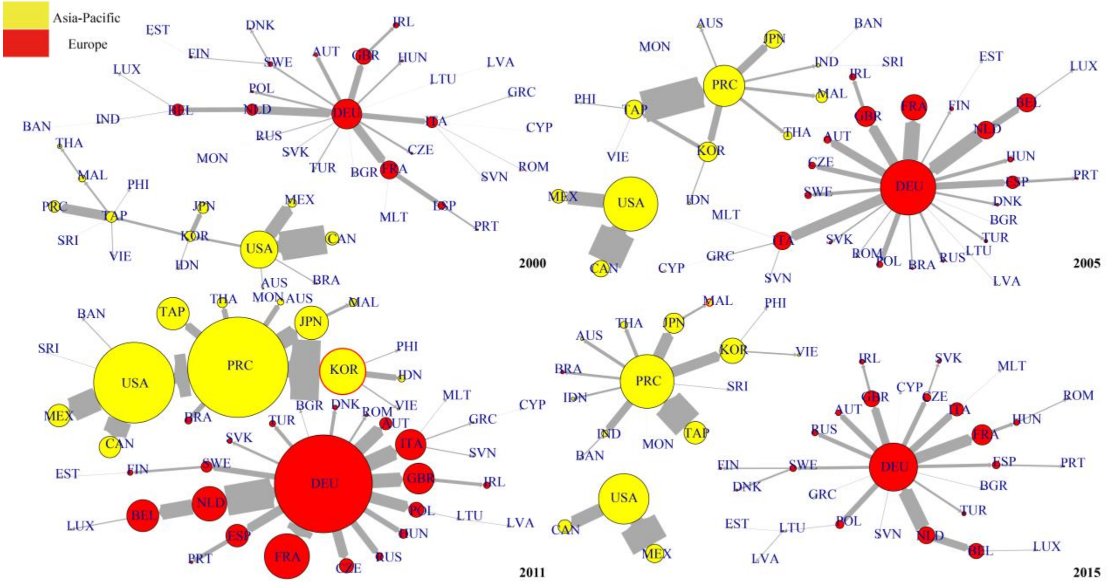


Figure 7. Evolution of FVA network (top-1)

Figure 7 shows the evolution of the top-1 network for FVA. Compared with the DVA and RDV networks, the entire network in 2000 was obviously dispersed, and the European community (with Germany as the core) had few connections with the Asia-Pacific community. The US served as the core of the Asia-Pacific community, with strong connections to Canada, Mexico, Brazil, and Australia. The US also enjoyed a “chain” connection with Japan through Korea and connections with China through Korea and Chinese Taipei. Korea and Chinese Taipei acted as sub-hubs in the Asia-Pacific community and were linked with most ASEAN economies. In 2005, the Asia-Pacific community could be divided into two groups: the US retained connections with Canada and Mexico through NAFTA, while China retained the new core of the East Asia + ASEAN community with strong connections to Japan, Korea, and Chinese Taipei. In 2011, dramatic changes occurred in the entire network with connections strengthening in magnitude. China became the core of the Asia-Pacific community, transferring a large portion of foreign value added to other countries. The relative distance between the European and Asia-Pacific communities shrank, reflecting the fact that complex GVCs developed globally; simultaneously, more countries joined the GVCs through some of the main hubs (US, China, Germany, and

Korea). In 2015, the GVC networks weakened; particularly, the trade groups of NAFTA, East Asia + ASEAN, and Europe were isolated again. This phenomenon is consistent with the finding that complex GVCs have been decreasing in recent years.

Figure 8 shows the evolution of the top-1 PDC networks from 2000 to 2015. One important feature of PDC networks is the obvious "chain" structure among countries, which indicates that the network is hierarchical. In contrast, a star structure indicates that the network is flat (Shi et al, 2014). This chain structure is due to the fact that PDC mainly emerged in the intermediate goods trade, forming stronger chains in globalized production processes. Germany remained the core of the European community, while the United States was the core of the Asia-Pacific community. China was on the periphery in 2000; however, by 2005, it had become the core in East Asia, although connections were still weak between the East Asian and NAFTA countries as well as between East Asia and the European community. In 2011, China was the core of the Asia-Pacific community and became Germany's largest PDC exporter, establishing a bridge between the Asia-Pacific and European communities. Another important feature of the PDC network is that the nodes expanded rapidly, indicating that under global production fragmentation, the development of intermediate goods trade caused a rapid growth in the amount of double counting in trade. In 2015, the Asia-Pacific community's connection with the European community diminished, which also indicates weakening complex GVCs between these regions.

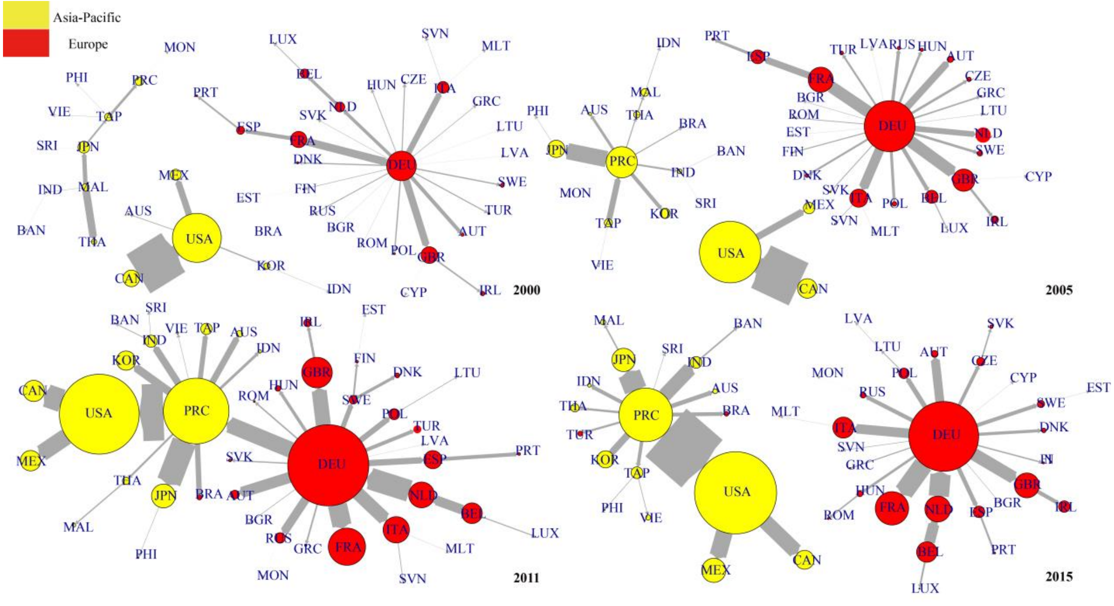


Figure 8. Evolution of PDC network (top-1)

More detailed sectoral level results (Textile, ICT and Auto) can be found Appendix.

4. Conclusion

Based on the decomposition of bilateral gross exports in value-added terms proposed by KWW (2014) and WWZ (2013) and by combining network analysis tools, this study presented a visualized analysis for 2000–2015 manufacturing-related GVC networks in terms of four GVC participation patterns (DVA, RDV, FVA, and PDC). It analyzed the basic topology and community evolution of the corresponding networks. The following conclusions can be drawn from the conceptual framework and application of the empirical results using the WIOD database:

(1) Under the global GVC accounting framework, GVC networks represent the interdependency of countries in terms of their value-added flows. The framework has the "general equilibrium," superposition, and correlation features of networks as well as heterogeneity of topology.

(2) DVA, RDV, FVA, and PDC networks express the reciprocity feature. However, the assortativities of DVA, RDV, FVA, and PDC networks show that countries with great strength tend to attach to weaker countries.

(3) Communities are overall stable in the DVA, RDV, FVA, and PDC networks, with community memberships essentially stable. East Asia, NAFTA, and the EU constitute important communities in GVC networks. This partly implies that geographic distance still matters in GVCs such that more dynamic changes could take part within regional value chains.

(4) Different evolutionary characteristics in the context of top-1 network of DVA, RDV, FVA, and PDC were identified. FVA network shows a more discrete character than other networks, and PDC network presents an obvious complex "chain" structure.

(5) The phenomenon of GVC-related cross-border production sharing during the 2011–2015 period was demonstrated. However, the causes and implications of this trend should be further examined.

(6) GVCs are not always like "chains", but complex networks of hubs and spokes; GVCs are not very "global", but still remain to be "regional". These findings can significantly improve our understanding of the interdependency of countries in GVCs, which are normally invisible in traditional trade statistics.

Appendix Sectoral level results

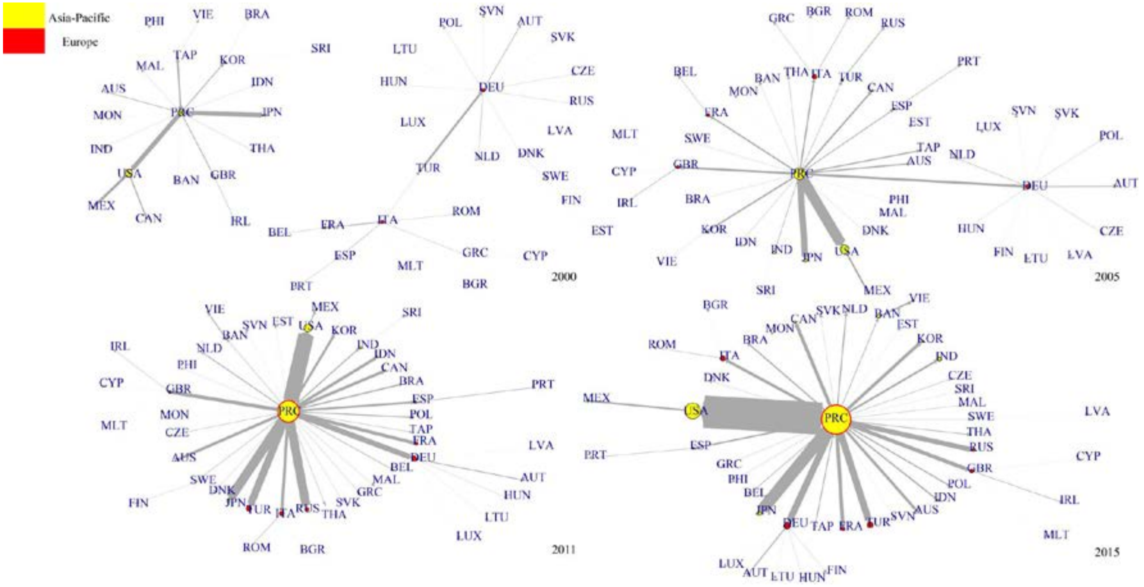


Figure A1-a. Evolution of DVA network (Textile)

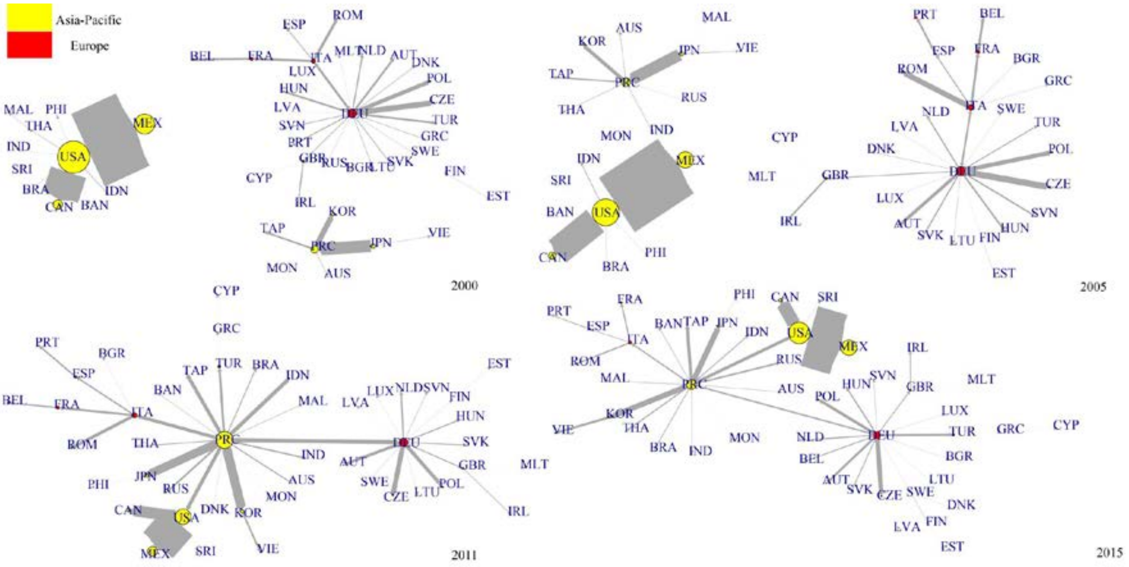


Figure A1-b. Evolution of RDV network (Textile)

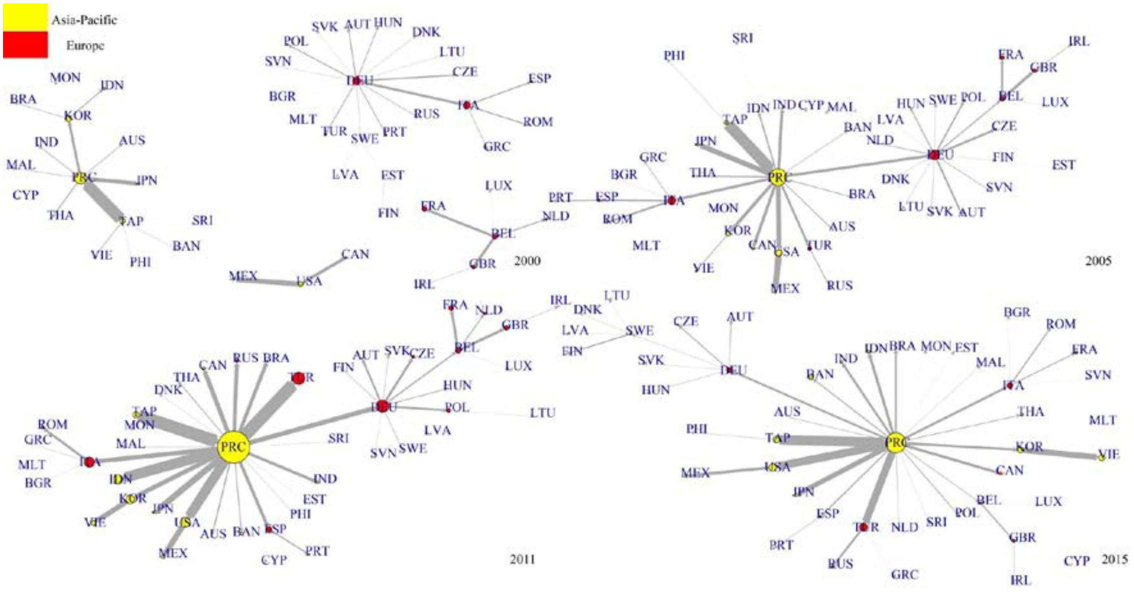


Figure A1-c. Evolution of FVA network (Textile)

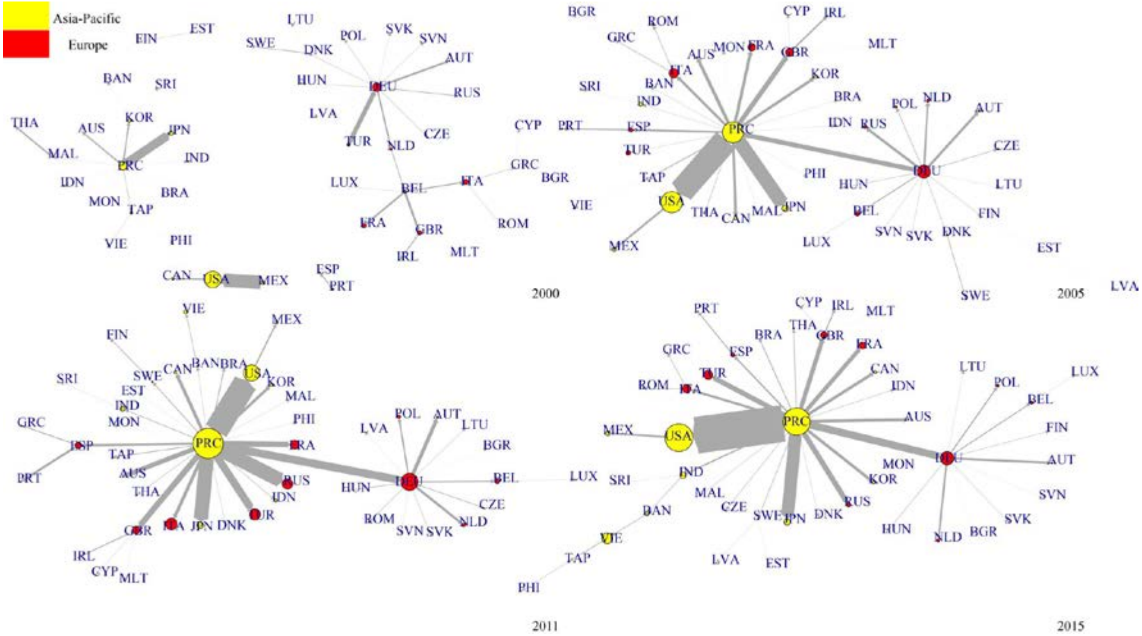


Figure A1-d. Evolution of PDC network (Textile)

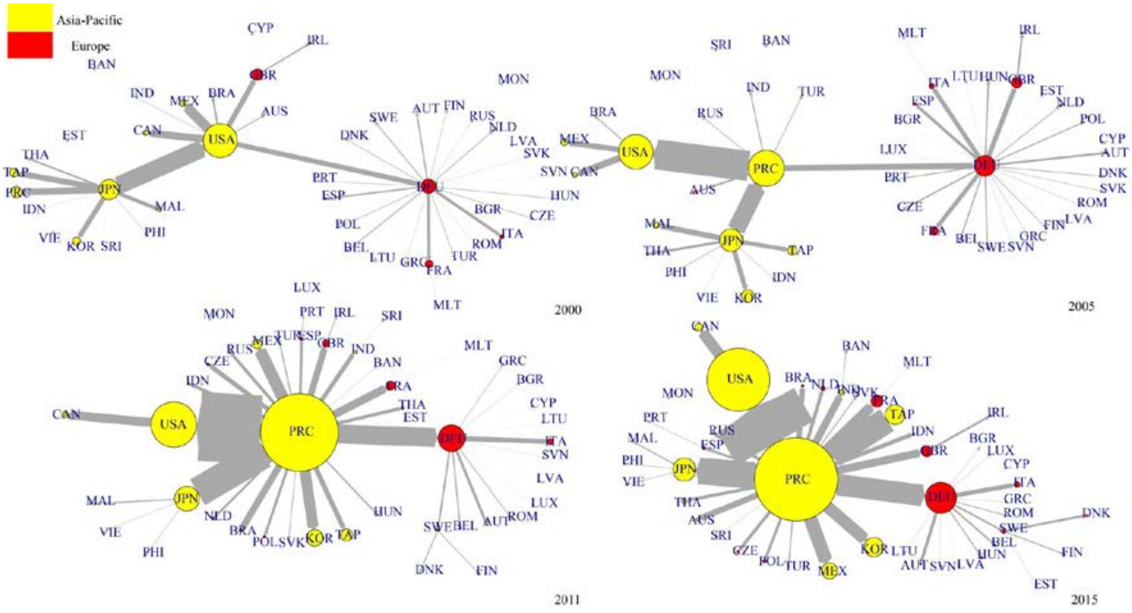


Figure A2-a. Evolution of DVA network (ICT)

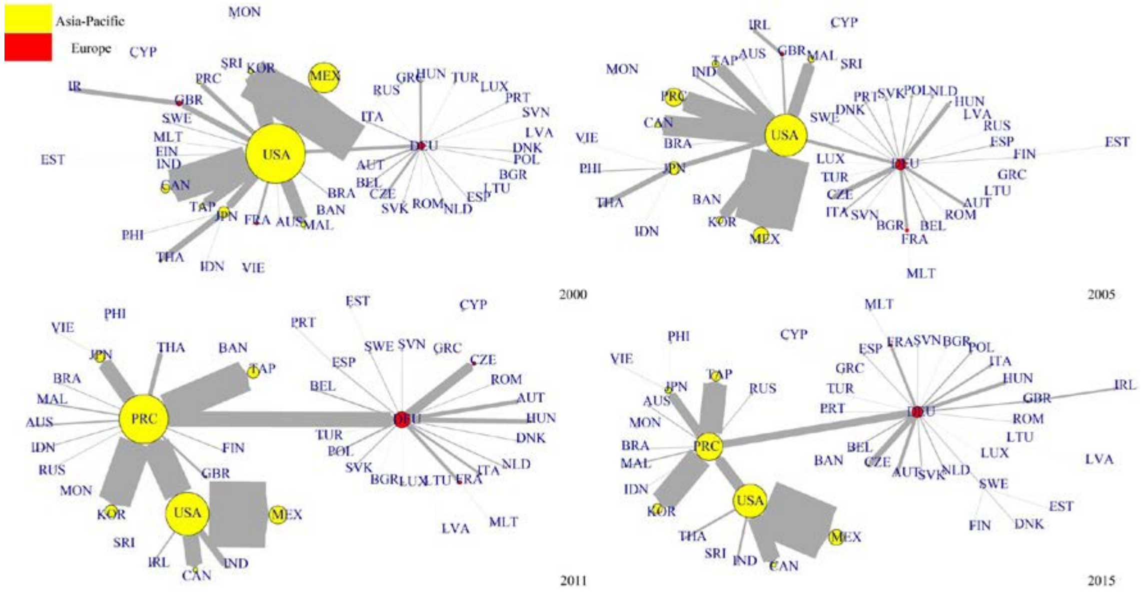


Figure A2-b. Evolution of RDV network (ICT)

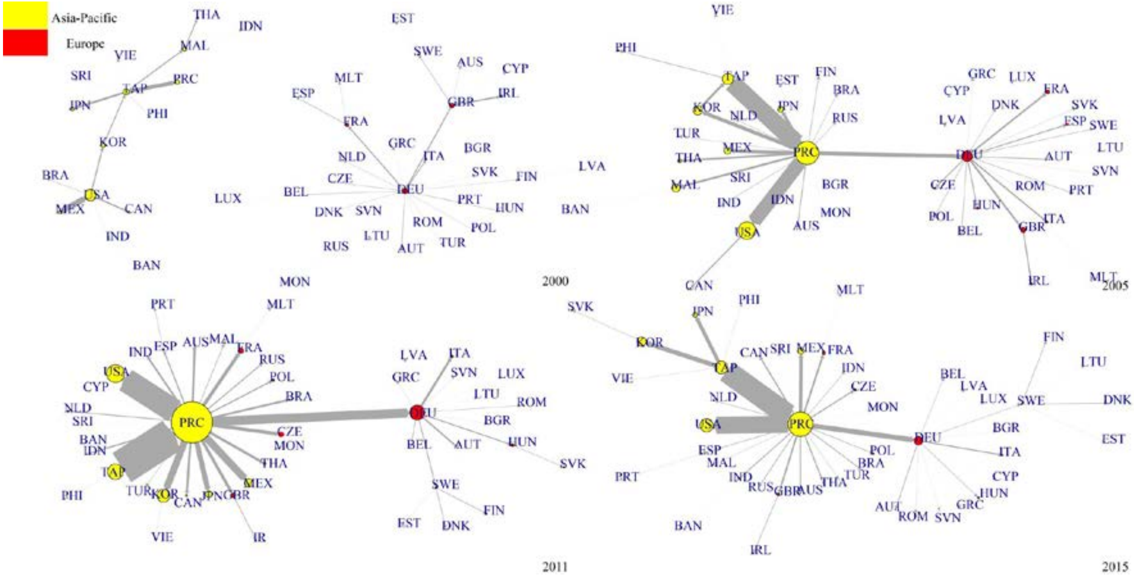


Figure A2-c. Evolution of FVA network (ICT)

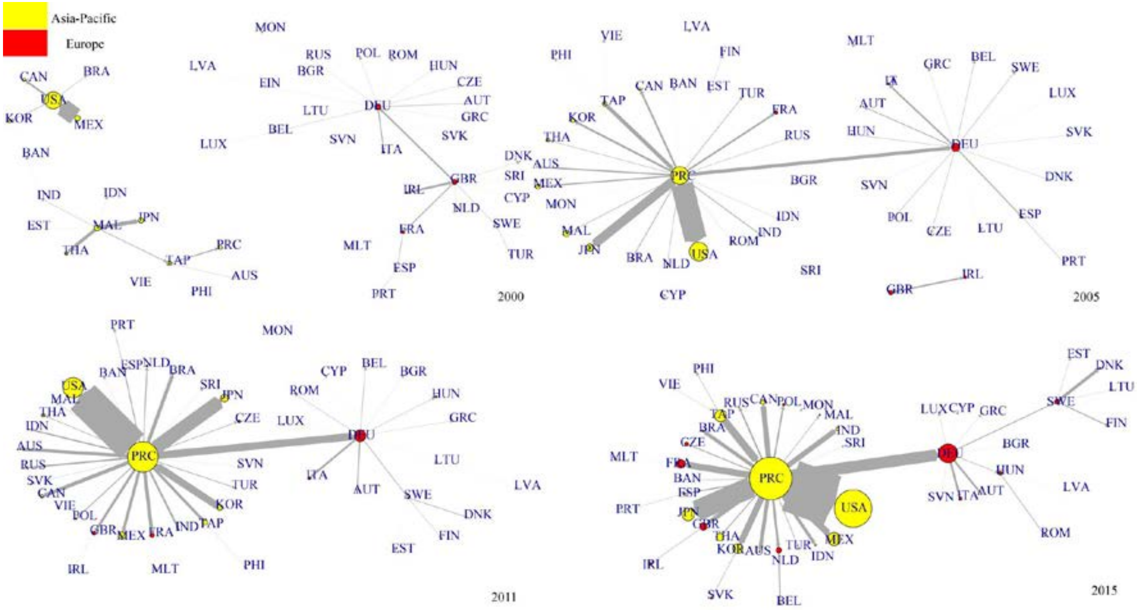


Figure A2-d. Evolution of PDC network (ICT)

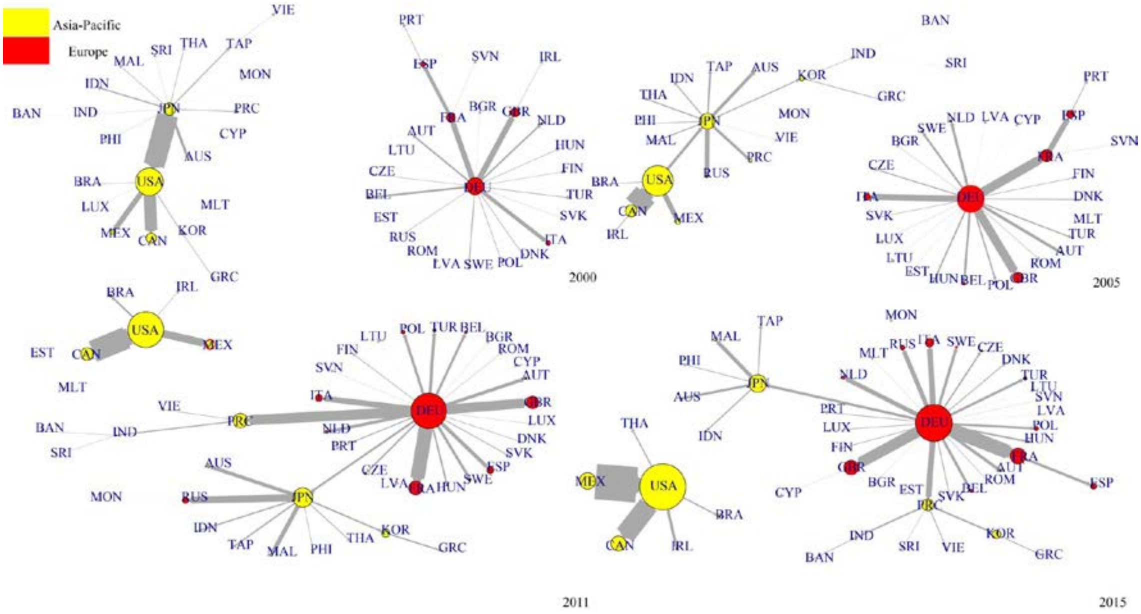


Figure A3-a. Evolution of DVA network (Auto)

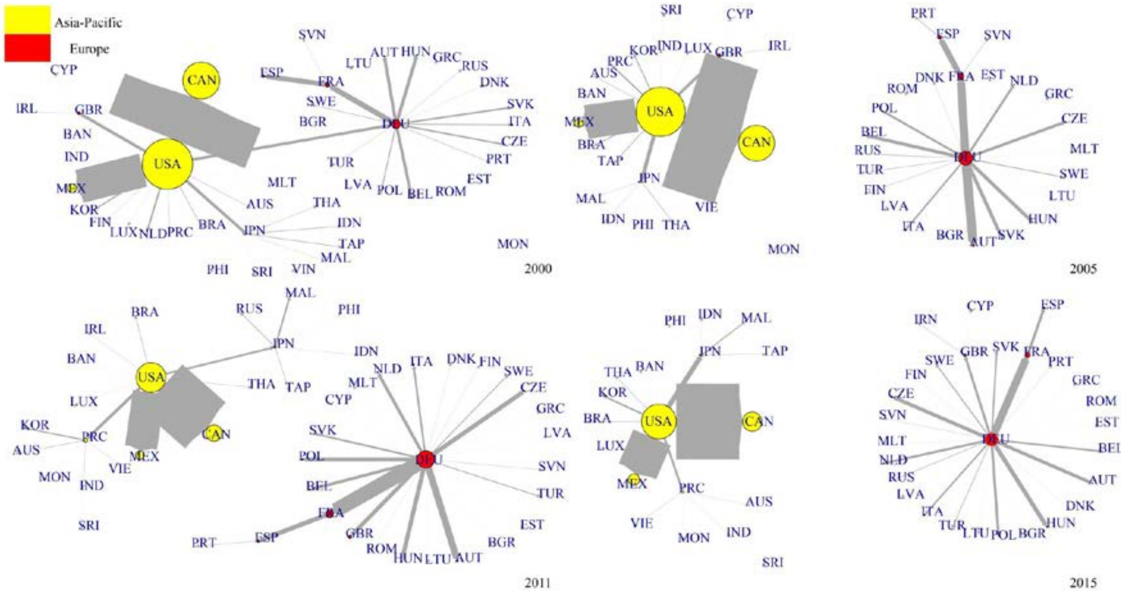


Figure A3-b. Evolution of RDV network (Auto)

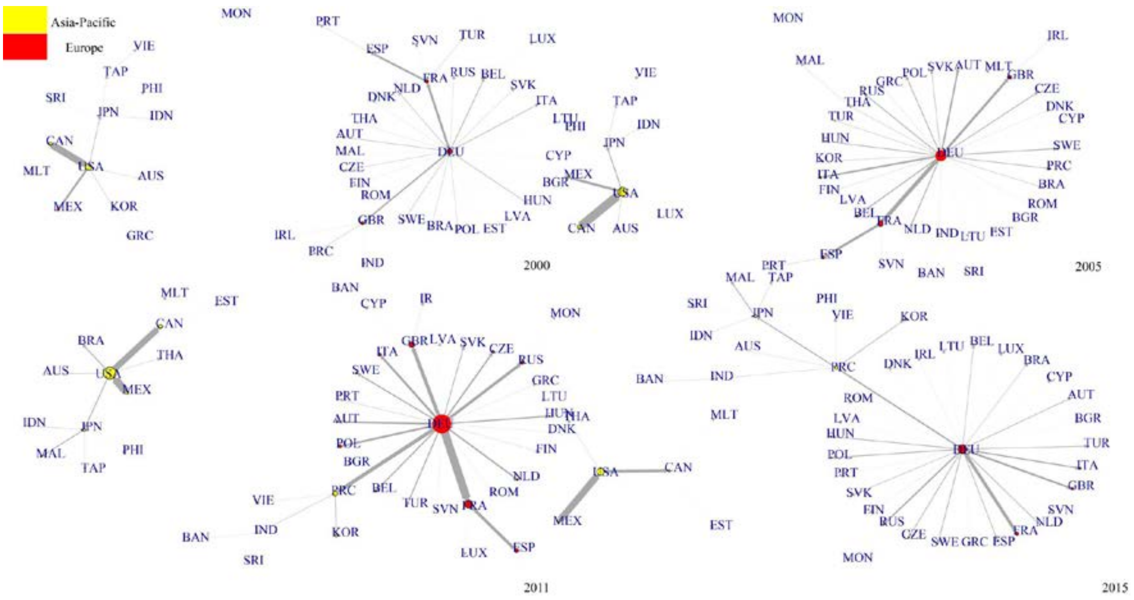


Figure A3-c. Evolution of FVA network (Auto)

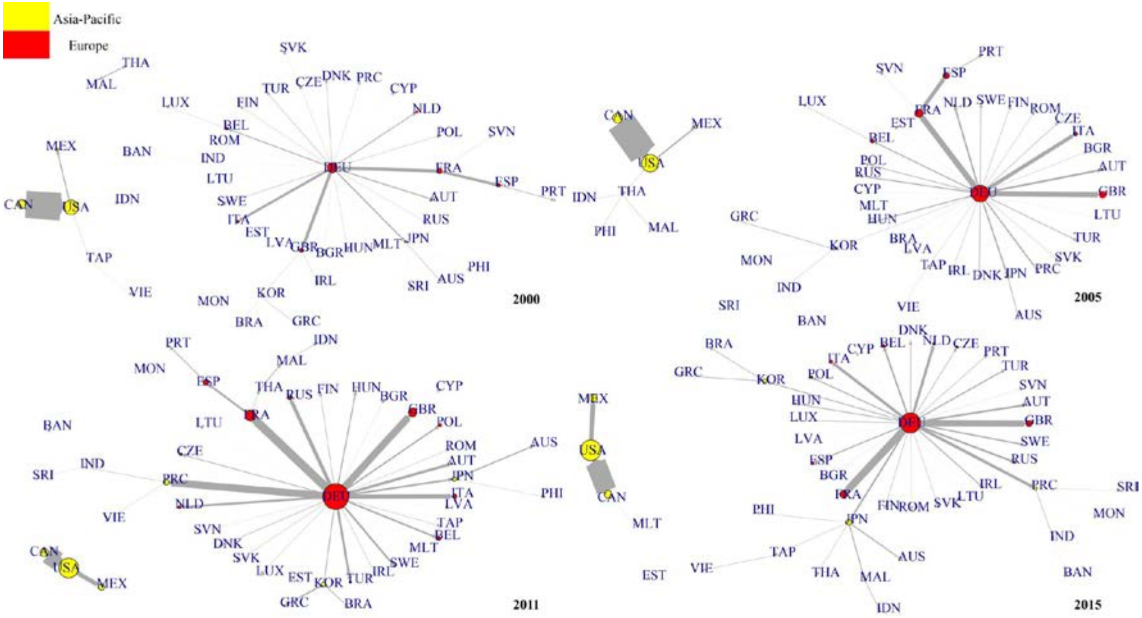


Figure A3-d. Evolution of PDC network (Auto)

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