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Volume 26

ASIA-PACIFIC CONTEMPORARY FINANCE AND DEVELOPMENT

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Chapter 1

Asia Pacific, Trans-Pacific Partnership, and the United States: The Network Perspective

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Abstract

The trade agreements among major trading countries can open new prospects of development and growth for global economy. The policy changes by a major trading country can alter the global trade and connection patterns. The trade agreement known as Trans-Pacific Partnership (TPP) was between 12 "Pacific-rim" countries signed earlier in 2016 indicates an upcoming and major policy change for global economy (presidential memorandum to withdraw the United States from TPP was signed in January 2017). The agreement would influence the issues related to "economic growth, employment, innovation, productivity, and competitiveness" of every partner and linked economy. This study illustrates how Asia Pacific's major countries are interlinked with each other, the important sectors and the strength of connections. The level of interconnectedness might have been transformed within regional trade network because of varying global economic patterns and demand trends. The study focuses on the aspects related to agreement and reduction in tariffs that may change the global trading scenarios and appropriate position for region's prominent and developing economies after implementation of the agreement.

Keywords: Trans-Pacific partnership, Asia Pacific region, network analysis, trade network, global trade patterns, regional trade agreements

JEL Classifications: F13 – Trade policy – International Trade Organizations, F17 – Trade forecasting and simulation

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1. Introduction

A network, in its simplest form, is a combination of nodes with edges as connections. Many objects of interest in the physical, biological, and social sciences can be thought of as network. Networks can be simple or complex; they can have few nodes with limited connectivity or many with complex connectivity patterns.

Network evolution is a continuous process, in other words, networks change and overlap with the passage of time. Transformation process is influenced by multiple network characteristics, such as network size, structure, flow patterns, connectivity, degree distributions, clustering, homophily, and diffusion. The process of network transformation is complex, dynamic, and multidimensional, as it involves simultaneously changing factors.

This study is devoted to understand the evolutionary patterns of Asia Pacific trade networks over the years. Aggregate centrality measures and visualization techniques were used to track the changes over time using time series trade data for countries within Asia Pacific region. The resultant statistics helped us to identify the changes within trade networks since the 1980s. Evolution of trade pattern among different countries is also dependent on trade agreements. Previous trade agreements such as North American Free Trade Agreement (NAFTA) increased total trade volume among its member countries and transformed connectivity patterns among member nations. Although various studies disputed claims related to increase in productivity, employment, welfare, and overall economic growth in all member countries due to trade agreements, it is beyond our scope to validate such claims, so we would keep our focus on aggregate changes in trade network with the passage of time.

The Asia Pacific region is expecting major changes in existing trade pattern due to the upcoming trade agreement known as Trans-Pacific Partnership (TPP). The trade agreement known as "TPP" is between 12 "Pacific-rim" countries. Signed in 2016 (presidential memorandum to withdraw the United States from TPP was signed in January 2017), the agreement indicates an upcoming and major policy change not for Asia Pacific only but for global economy. The agreement can influence the issues related to "economic growth, employment, innovation, productivity, and competitiveness" of partner and linked economies. Among other things, the agreement includes measures to decrease the trade barriers such as tariffs and duties placed by member countries to protect their domestic sectors. The resultant market would be more open, accessible, and beneficial for member countries.

We used extended Asia Pacific (Asia Pacific, East Asia, South Asia, and other Pacific-rim countries) trade network to understand the historical trade relations among these nations and evolution of those relations with the passage of time. The trade network data were obtained from the Direction of Trade Statistics (DOTS) published by International Monetary Fund (IMF). The number of total nodes stands at 30 from which different countries belong to different geographical locations such as Asia Pacific, North America, South America, East Asia, and South Asia. Trade networks were generated for different time periods starting from 1986 till 2015 to understand the transformation process and consequential changes in detail.

2. Relation to Literature

The benefit of representing trade, investment, and bilateral banking obligations in the form of connected network is to highlight the relationship between two entities, institutions, or countries. The network representation can enhance our understanding about structure or systemic features of particular graphs. The graph theory and network analysis are concerned about the relationship among nodes and edges, which explains the structure of complete system.

The prominence of network-related studies can be rightly attributed to the rise of social networks and increase in connectivity pattern concerning our lives. Besides the advancements on technological front and social connectivity, the network analysis was commonly used in sciences and other fields. Social network analysis and inclusion of centrality measures can be attributed to Freeman (1979) for his theoretical grounding in social network analysis. Leonhard Euler's (1741) solution of problem concerning bridges of Königsberg is considered the foundation for an area of mathematics that we call graph/network theory.

Modern theory of networks and relevant application in different areas of research are part of Newman (2010), while Jackson (2008) focused on social and economic dimensions of networks. The recent advancement in statistical analysis also changed the dimensions of networks analysis. Barabasi (2002) and Bollobás (1998) discuss the developments in statistical analysis related to networks and mathematical foundations of modern graph theory. Kolaczyk and Csárdi's (2014) work is related to advanced concepts of analysis and visualization of networks.

The application of network analysis related to world trade, connectivity patterns, structural changes, and mapping process can be found in several studies including Bhattacharya, Mukherjee, Saramäki, Kaski, and Manna (2008), Bernard, Jensen, Redding, and Schott (2007), De Benedictis and Tajoli (2010), and De Benedictis and Tajoli (2011).

The studies on banking and investment network are related to changes in network due to external or internal events. The focus remains on certain characteristics of network, such as fragility, possibility of contagion, flow of liquidity, and default probabilities for weaker nodes. We in our earlier work focused on bilateral aggregate banking network to find the possibility of contagion within Eurozone banking networks in Hakeem and Suzuki (2016a). Kalyagin, Koldanov, and Zamaraev (2014) discussed network structure uncertainty for different markets with respect to centrality measures. They used different types of network structures to understand the resultant changes in centralities in case of crisis situation. Bilateral and cross-border flow in terms of liquidity is explained with European Unions' cross-border investment patterns in Hakeem and Suzuki (2016b).

Different types of economic and financial networks include mainly trade, investment, banking, and capital market networks besides many others. These networks are different with respect to basic structure and connectivity patterns. Hakeem and Suzuki (2015) focused on dissimilarity between trade and investment networks to adopt the appropriate measures for better analysis.

Tracking the changes within network especially trade network over certain time span is relatively a new concept. We used the method based on modern graph theory to statistically analyze the networks and inner changes for certain time period. The similar measures or analytics if used at aggregate level and country level can enhance our understanding related to aggregate transformation process for specific time period. Besides the abundance of network-related research, there is scarcity of studies on this particular aspect of financial and trade networks.

3. Theoretical Background

The distinct characteristics of aggregate networks are explored using multiple centrality and statistical measures at macro- and micro-levels. Degree and weights, closeness centrality, clustering coefficient, modularity, path length, and average weights for every country are examined for trade networks. The final network analysis reveals the insights to track the changes related to nodes and edges during particular time period. The steps of our analytical process are as follows:

- analysis of Asia Pacific aggregate trade networks using centrality and other network measures, such as, clustering, modularity, and so on;
- comparative analysis by graphical representation of cumulative analytical measures to understand the transition process; and
- visualization of aggregate graphs for different time periods to understand the comprehensive transformation process.

The distinct characteristics of nodes are also explored using the similar centrality and relevant measures at micro-level. Following network measures are used for trade network analysis.

3.1. Degree Centrality

The simplest and earliest centrality measure in a network is the degree of a node, the number of edges connected to it. In directed networks, nodes have both an in-degree and an out-degree, and both may be effective if used in the appropriate circumstances. Although degree centrality is a simple centrality measure, it can be very insightful. In a financial network, for instance, the financial institution or a node connected to all other nodes can have much more influence on other nodes as well as the resilience of the whole network. The standardized degree centrality of a node is its degree divided by the maximum possible degree.

$$c_i^d = \frac{d}{n-1} \tag{1}$$

Degree centrality is calculated using the Freeman's (1979) general formula for centralization. Aggregate degree centrality for the whole network is:

$$C^d = \frac{\sum_{i=1}^{n} |c_i^d - c_i^d*|}{(n-2)(n-1)} \tag{2}$$

where degree centrality "C^d" is calculated using the maximum value, while n represents the number of nodes within that particular network. The higher the number of nodes, the higher the degree centrality it can have. The degree centralization of any regular node is 0, while star has degree centralization of 1.

For a node, the number of edges ending with it is known as in-degree, and the number of edges originating from it is known as out-degree. The node with no in-degree but all out-degrees is known as "source" and the one with all in-degrees but no out-degree is called "sink." A balanced directed graph has equal number of in- and out-degrees.

3.2. Path Length and Strength

The path length of a network can be defined as the average shortest path length between two nodes.

$$\mathrm{PL} = \frac{2}{N(N-1)} \sum_{i,j} d_{ij} \tag{3}$$

And d_{ij} represents the shortest path between the nodes i and j.

The weights of connection or edges between nodes are represented by matrix, $M = \{w_{ij}\}$. The weight is zero if there is no edge between two nodes, and there is no loop within network which can be defined as $\{w_{ii} = 0\}$.

To compare different kinds of weights for different nodes and edges, we need normalization of weights which can be done as follows:

$$\frac{w_{ij}}{\max(w_{ij})} \tag{4}$$

A node degree for weighted node would be k_i :

$$k_i = \sum_{i,j \in M} w_{ij} \tag{5}$$

The number of edges connected directly to a particular node can be extended directly to strength of a node, which is the sum of the weights of all links attached to that node.

$$s_i = \sum_{i,j \in M} w_{ij} \tag{6}$$

3.3. Betweenness Centrality

Betweenness Centrality is another different centrality concept; it measures the extent to which a node lies on path between other nodes. It quantifies the number of times a node acts as a bridge along the geodesic path between two other nodes. To understand the concept, we need to look at the financial or trade network. In financial network, there is a flow of money or liquidity; and in trade network, there is a flow of goods between two or more nodes. If the flow of goods or money needs to pass through specific node to reach their destination, then that particular node has enormous power to influence the counter parties. There can be several ways to reach destination but geodesic paths are designed to be efficient and cost-effective. So nodes lying on that path have higher betweenness centrality and influence on the whole network. A bank or investment firm with higher betweenness centrality must be stable and strong for the network's resilience.

The idea of betweenness is presented by Freeman (1977), although he mentioned some unpublished works by other authors on this particular issue. Mathematically, we can express the betweenness for a general network by $g_{jk}(i)$ to be the number of geodesic paths from j to k that pass through i. And we define g_{jk} to be the total number of geodesic paths from j to k. Then, the betweenness centrality of node i is:

$$C_i^b = \sum_{j \neq k} \frac{\delta_{jk}^i}{\delta_{jk}} \tag{7}$$

Aggregate betweenness centrality can be calculated using the following equation:

$$C^b = \sum_{i=1}^{n} |C_i^b - C_i^b *| \tag{8}$$

Usually normalized by:

$$C_i^{b\prime} = \frac{C_i^b}{[(n-1)(n-2)/2]} \tag{9}$$

where n is the total number of nodes within network.

3.4. Clustering Coefficient

The clustering coefficient is the degree by which nodes tend to make groups or clusters together. The clustering of nodes having similar connectivity patterns or others characteristics is evident in network analysis. There are two ways to measure the clustering of nodes in particular networks.

(1) global clustering coefficient; and
(2) local clustering coefficient.

This first type "global clustering coefficient" is based on trio of nodes. The trio is combination of three nodes connected to each other. The clustering coefficient measures the density of triangles in the network.

$$C^{Cl} = \frac{1}{n} \frac{[(k^2) - (k)]^2}{k^3} \tag{10}$$

In a random network of connections between nodes and edges, k^2 and k have fixed or finite values; the quantity becomes small as $n \to \infty$, so the clustering coefficient can be small as size of network grows. But in reality, it can be very different depending on network type and size.

The aggregate clustering coefficient is proposed by Watts and Strogatz (1998) and can be calculated by taking the mean of local clustering coefficient of each node.

$$C^{Cl} = \frac{1}{n}\sum\nolimits_{i=1}^{n} C_i^{cl} \tag{11}$$

Whereas the local clustering coefficient of a node can be defined as follows:

$$C_i^{cl} = \frac{e_{jk}}{k_i(k_i - 1)} \tag{12}$$

where e_{jk} is the path from i to j, and k_i is the number of neighbors of a node. We can also represent it in the following way:

$$C_i^{cl} = \frac{n_i}{k_i(k_i - 1)} = \frac{\sum_{jk} e_{ij}e_{jk}e_{ki}}{k_i(k_i - 1)} \tag{13}$$

3.5. Density

The density of a graph represents the proportion of edges compared to the number of nodes. A dense graph would have number of edges close to maximum while less dense graph is not connected completely.

$$D = \frac{|E|}{|V|(|V| - 1)} \tag{14}$$

where E corresponds to number of edges and V shows the number of nodes within single particular network.

3.6. Modularity

Network modularity is about the connectivity within clusters or groups of a network. High modularity explains the stronger connectivity within groups which can also be referred as modules. The connectivity of nodes with modules with other and outer nodes is not strong rather sparse. It is often used to find the community structures or large clusters within network. Modularity can be calculated using the following equation:

$$Q = \frac{1}{(2m)}\sum_{ij}\left[M_{ij} - \frac{k_i k_j}{2m}\right]\delta(c_i, c_j) \tag{15}$$

where M_{ij} represents the adjacency and weighted matrix, m contains all edges such that the network is divided into two communities known as