The **structure and evolution of the trade networks of the Belt and Road countries: Identification and implication**

Zhigao Liu[a,b], Tao Wang[c], Jung Won Sonn[c], Weidong Liu[a,b] and Wei Chen[a,b*],

[a]*Key Laboratory of Regional Sustainable Development Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China*

[b]*School of Resources and Environment, University of Chinese Academy of Sciences, Beijing 100049, China*

[c] *Bartlett School of Planning, University College London, London. WC1N 3PR, United Kingdom*

Abstract:

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Introduction

The Belt and Road Initiative ('BRI', hereafter) that was proposed by Chinese President Xi Jinping in 2013 found its way into the new revised Charter of the Chinese Communist Party in October 2017. This gives BRI a constitutional status as part of "Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era" (Xinhua, 2017a)[i]. The BRI refers to the land-based Silk Road Economic Belt (One Belt) and the oceangoing 21st-century Maritime Silk Road (One Road) that were announced in September and October 2013 respectively. Since then, particularly after March 2015 when the "Vision and Actions on Jointly Building the Silk Road Economic Belt and the 21st Century Maritime Silk Road (NDRC, MFA and MC, 2015, '("Vision and Actions" hereafter) [ii]were announced, BRI has received widespread international attention (Toops, 2016; Bennett, 2016; Vinokurov and Tsukarev , 2017)[iii]. Not only journalists but also academics are quick to partake in the debate. Academic journals published special issues, as well as individual papers on BRI, covering it from various perspectives. (E.g., East Asia, 2015; China & World Economy, 2017; China Report, 2017; Baltic Journal of European Studies, 2017; Geopolitics, 2017).

To promote this, the most ambitious economic and diplomatic program since the founding of the People's Republic of China, China hosted the Belt and Road Forum for International Cooperation in May 2017. It was attended by twenty-nine heads of state and government leaders, over 80 leaders of international organizations, and more than 1500 representatives from over 130 countries, making it the highest-level forum since the Belt and Road initiative was proposed in 2013. During this forum, President Xi pledged at least $113 billion extra funding for the BRI and the Chinese government signed economic and trade cooperation agreements with the governments of 30 countries along the Belt and Road and beyond (Xinhua, 2017b)[iv]. As of September 25 2017, 74 countries and international organizations have signed the cooperation agreements on BRI with China (Xinhua, 2017c)[v]. Considering the increasing influence of China as a global power in the turbulent world and the positive and widespread responses worldwide, China's BRI is believed to have the potential to be the world's largest platform for regional collaboration, refashioning global economic and even political order.

According to the Vision and Actions document and President Xi's speeches on the Belt and Road Forum for International Cooperation, the intention of this initiative was not to re-establish an ancient network of silk trade routes between Asia and Europe, but to use the metaphor of the ancient Silk Roads as a soft basis to create a promising platform for international cooperation. It is also to form what President Xi calls a "community of common destiny" of mutual benefit and a "community of interests" of shared development and prosperity (Xi, 2017)[vi]. (CITATION needed here) The Silk Road concept was coined in 1877 by the German geographer, Ferdinand von Richthofen (von Richthofen 1877)[vii], who described the historic overland routes of economic and

cultural exchange across Eurasia as “Seidenstrasse” (silk roads) or “Seidenstrassen” (silk routes). The Silk Road concept was extended by the French Sinologist Édouard Chavannes (Chavannes 1903)[viii] to include pre-existing maritime trade routes. These two authors and subsequent users of the concept did not mean any specific transportation routes by Silk Road. Rather, Silk Road was a system of trade connections whose physical form included different transportation corridors in different periods of history.

The ancient Silk Road is a transcontinental network, connecting China to other parts of the Eurasian continent and facilitating flows of economic, scientific, technological, religious, and cultural exchanges (Liu, 2010). Consequently, the Silk Road is an important, if not the only, symbol of the common historical and cultural heritage of most countries in Asia, Europe, and Africa. Obviously, China’s BRI used this historical metaphor to denote "peace and cooperation, openness and inclusiveness, mutual learning and mutual benefit," which are referred to as the “Silk Road Spirit” in the Vision and Actions document, as a way to promote global economic growth and inclusive development (Liu and Dunford, 2016). The new initiative focuses not only on the physical and economic connectivity, but also on the spiritual and cultural connection of countries along the ancient Silk Road and beyond. As the Vision and Actions document suggests, policy coordination, infrastructure connectivity, trade facilitation, financial cooperation, and international civilian bonds are the five cooperation priorities of China’s BRI.

Trade facilitation and development is one of the priority area of China’s BRI. President Xi's speech at the opening of Belt and Road forum suggests that the BRI is committed to promoting “the system of fair, equitable and transparent rules for international trade and investment” (Xi, 2017)[ix]. The other four cooperation priorities are also related to trade facilitation and development. Firstly, policy coordination provides institutional foundations for cross-country trade development, simplifying the process in international trade, removing existing trade barriers, and creating new business-friendly regulations. Secondly, infrastructure connectivity will improve the physical infrastructure networks connecting sub-regions of Asia, Europe, and Africa, thereby reducing the time and cost associated with the logistical process of export and import. Thirdly, financial cooperation means establishment of regional development financial institutions and joint monitoring of financial risks, which will expand the scope of local currency settlement and currency exchange, which will in turn facilitate large-scale international trade. Finally, international civilian bonds will increase support from the grassroots level through exchanges and dialogues between different cultures, which in turn will expand the trade market.

Against the background, a research on the structure and evolution of the B&R trade network might have implications for the policy formulation for trade facilitation and the construction of BRI. International trade network has been studied for a long time, by sociologists, economists, mathematicians, and even physicists. However, they have not paid enough attention to the varying importance of a country’s trade relations. Not all bilateral trade relations are of equally importance to a country because, in a country’s trade value, a few top partners occupy dominant share. Those top partners influence the shaping of a country’s involvement in international trade.

To study the trade network with particular attention to each country’ top partners, we build upon Zhou, Wub and Xu (2016)[x], and construct the international trade network of the B&R countries. For the sake of readability, we used the top 2 trade network, rather than the top 1 network which

loses many important trade relations. Here the top 2 trade network refers to the relation network of all countries' top 2 trade partners, in which country i is linked to country j if j is i's one of the top 2 trade partners. Top 2 network should capture most important relations in international trade. Based on the top 2 network, we characterize the structure and evolution of the B&R trade network and quantify the relative positions of countries of different periods. By doing so, we can identify temporal changes in the composition of the communities (e.g., the community leaders), and in the patterns of trade across different communities.

Although the Chinese government announced that the initiative is open to all countries, it has identified 65 countries, including China, along the Belt and Road (hereafter, the B&R countries). These nations account for more than 60% of the world's population and about one-third of the world's GDP. In this paper, we look at the structure and evolution of the B&R trade network. Our analysis starts in the year 2000 because that is when China joined the World Trade Organization, of which membership symbolizes a free trade economy. The last year in our data is 2016 because data for 2017 and later is not available yet. Moreover, considering the influences of the global financial crisis and the Belt and Road Initiative on the trade networks, we also compared the changes in the B&R trade networks before and after 2000 and 2013. This gives us five points of time, namely, the years 2000, 2004, 2008, 2013, and 2016.

Methodology

Data and complete international trade network of the Belt and Road countries

From a social network analysis point of view, the international trade comprises a network in which the nodes are countries and connections between nodes or edges, the trade relations between those countries. We used data from 2000 to 2016 from IMF Direction of Trade Statistics (DOTS). As one of the most frequently used trade databases, it provides data on the international distribution of each country's exports and imports. Because most states report imports in CIF values (i.e. cost, insurance, freight) and exports in FOB values (i.e. free on board), the global total of import values are often larger than that of export values. In this study, we used import data, rather than export data, since states tend to monitor import more closely than export (Barbieri et al., 2009) and thus the former is believed to be more accurate than export figures (Smith and White, 1992; Kim and Shin, 2002)[xi]. We used the Matlab software to create an undirected weight matrix A^t based on bilateral import trade among the Belt and Road countries. In the matrix, node i stands for country i and A_{ij}^t stands for the total trade values between country i and country j at year t.

We used the Ucinet 6 software to describe some basic characteristics and the evolution of the B&R trade network from 2000 to 2010. Table 1 shows the results. First, the B&R trade networks grew rapidly from 2000 to 2008, as the number of ties between countries increased from 1782 to 2168, indicating that on average, the B&R countries together developed 43 new trade partners each year. The growth of trade ties has resulted not only in a constant increase in network density from 0.428 to 0.521, but also in an increase in degree centralization from 0.032 to 0.117 during the same time

period, which suggests that despite the increase in number of ties, the international trade amongst the B&R countries tended to be increasingly concentrated between a few dominant countries.

Despite being affected by the 2008 global economic crisis, the complete trade network of B&R countries from 2009 to 2016 developed very slowly and even became unstable. There was growth of 58 new trade ties in this seven-year period, but there was also a noticeable fluctuation in the number of ties and density and degree centralization during the crisis and post-crisis period. The number of trade ties stayed relatively steady between 2164 and 2188 in the period 2009 to 2012, suddenly went up to 2216 in 2014, decreased to 2192 one year later, and then increased to 2222 in 2016 with an increase of 58 new trade relations. This may indicate that the B&R countries can still develop new trade partners, despite the short stagnation immediately after the 2008 economic crisis. On the whole, the small increase in both the density and the degree centralization of the B&R trade network during the turbulent period implies that the B&R countries might have started to recover from the economic slowdown and some countries continued to strengthen their ties with key trade partners while shedding off nonessential ties. Therefore, further focus on a country's top trade partners might be more useful in understanding the real picture of the international trade network of B&R countries (Zhou et al., 2016).

<Table 1 Descriptive statistics of the complete B&R trade network >

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of countries	64	64	64	64	64	64	65	65	65
Number of ties	1782	1802	1840	1840	1886	1884	2102	2130	2168
Density	0.428	0.433	0.442	0.442	0.453	0.453	0.505	0.512	0.521
Degree Centralization	0.032	0.036	0.045	0.061	0.072	0.082	0.091	0.107	0.117
Year	2009	2010	2011	2012	2013	2014	2015	2016	
Number of countries	65	65	65	65	65	65	65	65	
Number of ties	2164	2168	2188	2184	2216	2192	2216	2222	
Density	0.520	0.521	0.526	0.525	0.533	0.527	0.533	0.534	
Degree Centralization	0.116	0.112	0.117	0.112	0.120	0.125	0.122	0.126	

The top networks of the complete B&R trade network

The B&R trade network in 2016 is used as an illustration of the construction of the top networks. First, we construct the complete B&R trade network using the data from matrix A^t . Then we extract the top networks by keeping each country's top trade relations. The top 1 network consists of each country's topmost trade relationships with each other, while the top 2 network comprises of each country's top two trade relationships with other countries and so on. Figure 1 visualizes the overall and top networks of the B&R trade network. Evidently, the top 1 network contains fewer ties than the top 2 network. In other words, the top trade network includes the major trade ties from the complete network but does not include some other relations, which provides some information on the trade relation structure as well. Hence, higher the standard we choose, greater is the level of importance the resultant trade network possesses.

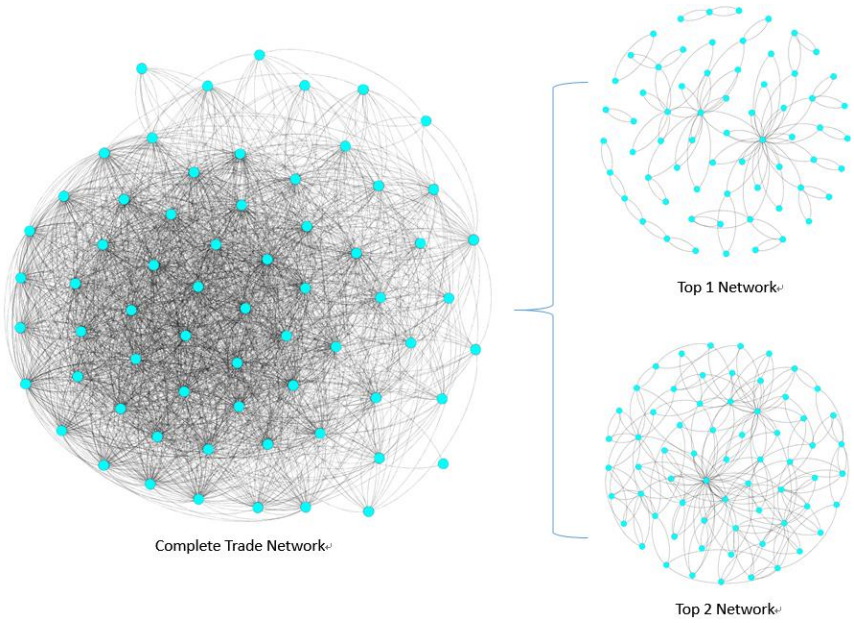
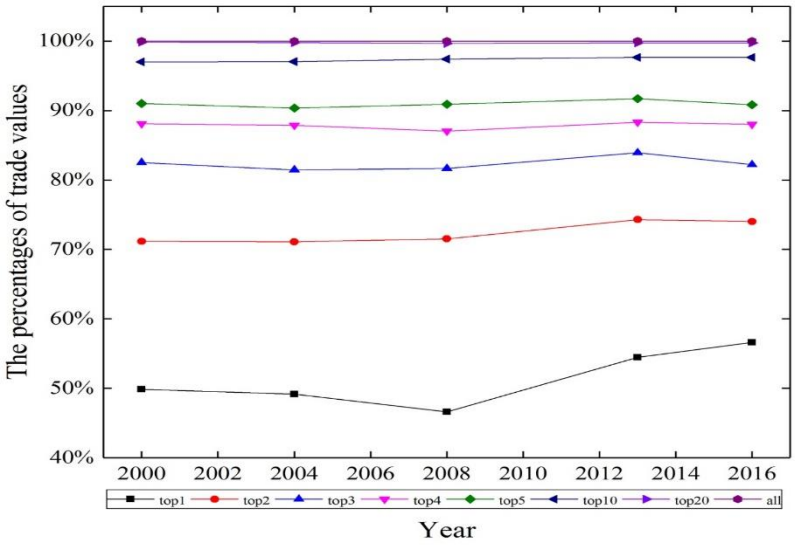


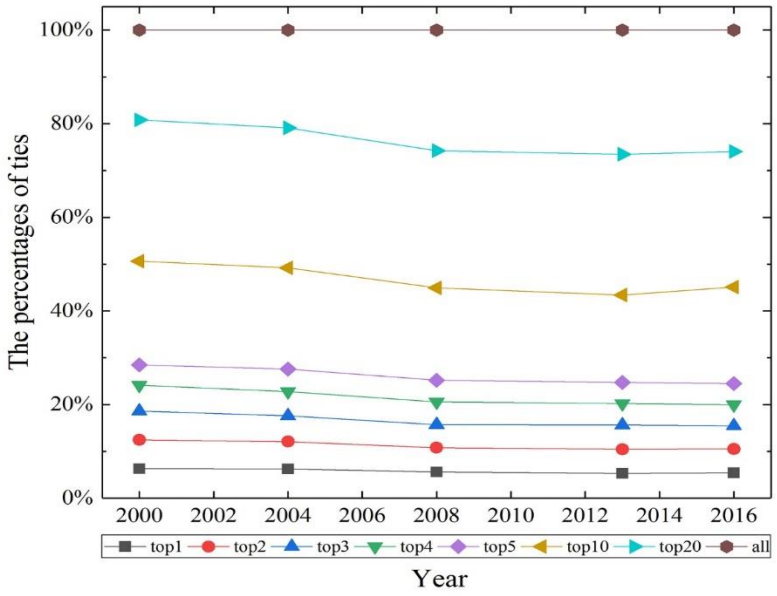
Table 2 The percentages of top networks in the complete B&R trade network in 2016

Networks	top1	top2	top3	top4	top5	top10	top20	all
percentages of edges	5.40%	10.53%	15.48%	19.98%	24.48%	45.09%	74.08%	100.00%
percentages of trade values	56.61%	74.03%	82.20%	88.01%	90.84%	97.64%	99.73%	100.00%

Table 2 shows the percentages of trade ties and trade values of the top networks in those of the overall B&R trade network in 2016. As shown in Table 2, the ties in the top 1 and top 2 networks account for only 5.4% and 10.53% of the total trade ties respectively but the trade values make up 56.61% and 74.03% of the total trade values respectively. As the threshold is lowered, more trade ties and trade values are included in the corresponding networks. The shares of the top 3, top 4, and top 5 networks are approximately 15%, 20%, and 25% of total trade ties, while they account for approximately 82%, 88%, and 90% of total trade values.



(a) The percentages of ties in top trade networks



(b) The percentages of trade values in top networks

Fig 2. The visualization of the percentages of top networks in the B&R trade network in the years 2000, 2004, 2008, 2013 and 2016.

Figure 2 further visualizes the relationship between top trade networks and their percentages in total B&R trade for every two years from 2000 to 2016. On the whole, the top 1 network alone takes up less than 6% of the total ties but above 50% of the trade values with an exception of the year 2008 when trade was hit due to the global economic crisis. The top 2 network alone accounts for approximately 10% trade ties but above 70% in trade values, which indicates that the top networks indeed constitute the backbone of the B&R trade network.

Although the top 1 network is the foundation of all types of top networks, it does not contain a lot of the information about the trade structure. In Fig.1, the top 1 network can mislead us to believe

that there are some communities of countries that actively trade with each other but are relatively disconnected from the rest of the countries. On the other hand, the top 2 network shows a similar structure to that of the whole network. Consequently, in the remainder of this paper, we use the top 2 trade networks in investigating the network structure in the following years: 2000, 2004, 2008, 2013, and 2016.

Although we constructed the top networks, there are still some problems we need to solve. First, it is not the exact values of the top trade relations but, as we mentioned above, the top trade relations themselves are important for each country in our study. Another problem is that the top networks do not indicate the volume of trade if the involved countries are small ones. However, to those small countries, top networks still represent the most important trade links, which make those networks worth studying. Second, it is very difficult to visualize original top networks, partly because there are tremendous differences in the trade values, and partly because these trade values cannot present the real structure. Moreover, since many trade relations are removed, comparing the values of the top relations does not mean much in the visualization of the real trade network. For this reason, we use binary codes for the top networks, i.e., 1 for all top networks and 0 for the rest. In the remainder of this paper, we employ the Community Detection approach to investigate the structure and dynamics of the top trade networks, rather than the trade values of the B&R countries.

Community Detection approach

Besides the descriptive statistics, community detection is another way to illuminate the features of the top networks, especially the structural characteristics. There are a number of publicly available tools for exploring complex networks. Gephi, for example, is an open source platform with analytical and data visualization functions. The software runs on Windows. Gephi provides many common metrics for social network analysis (SNA) and scale-free networks to measure graphs (centrality measures, density, clustering coefficients, path lengths, community detection, etc.). Many social network analysts choose Gephi because it is extremely powerful in visualization and community detection. It allows users to interact with the representation, manipulate the structures, shapes, and colors to reveal hidden patterns. And users can customize the color, the size and the labels for readability and overall aesthetics. Moreover, Gephi uses a modularity optimization method—the fast unfolding algorithm for community detection—to decompose a gigantic network into several relatively independent modules (also called groups, clusters, or communities), which are sets of highly connected nodes (Blondel, V.D. et al., 2008). Therefore, we used Gephi to detect and visualize the community structure in the top trade networks of the B&R countries from 2000 and 2016. This study split the overall top 2 trade network into several relatively independent trade communities. Each country is densely connected internally within the communities, but there are sparser connections between communities.

There are many different methods for community identification. A widely used measure for evaluation of community decomposition is modularity. Modularity is designed to measure the density of links inside communities as compared to links between communities. The value of the modularity lies in the range [−1, 1]. The closer to 1 the value of the modularity is, the better is the quality of the partitions. The modularity is defined as

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

where c_i presents the community which node i belongs to. The δ function equals 1 if $c_i = c_j$ and 0 otherwise. A_{ij} is the edge weight between i and j. $k_i = \sum_j A_{ij}$ presents the sums of the weights of the edges of node i and $m = \frac{1}{2}\sum_{ij} A_{ij}$ is the total edge weight of the network.

In order to maximize the value of modularity efficiently, the fast unfolding algorithm is used. This algorithm, also known as Louvain Method for community detection, is a method to extract communities from large networks and is developed by Vincent Blondel and his colleagues from the University of Louvain. It is a simple, efficient, and easy to implement method for identifying communities in large networks and outperforms many similar greedy modularity optimization methods in both the modularity and the time categories. It is today widely used for detecting communities in large networks (Blondel, V.D. et al., 2008).

This algorithm is performed in two phases, each of which is iterated. First, each node in the network is assigned to a community. So, there is only one node in each community. We put node i into its neighboring community where node j is and a variation of the modularity ΔQ arises. For each node i and the neighboring community C, the variation of the modularity is defined as:

$$\Delta Q = \left[\frac{\sum_{in}+2k_{i,in}}{2m} - \left(\frac{\sum_{tot}+k_i}{2m}\right)^2\right] - \left[\frac{\sum_{in}}{2m} - \left(\frac{\sum_{tot}}{2m}\right)^2 - \left(\frac{k_i}{2m}\right)^2\right], \quad (2)$$

Where $\sum_{in}$ is the sum of the weights of the edges inside the neighboring community C. $\sum_{tot}$ is the sum of the weights of the edges incident to all nodes in C. k_i presents the sums of the weights of the edges of node i, $k_{i,in}$ is the sum of the weights of edges from node i to nodes in community C and m is the total edge weight of the network. If the variation is positive, i joins the neighboring community with maximum ΔQ. Otherwise i stays in its original community. This process is applied repeatedly and sequentially for every node until no further improvement can be achieved.

In the second phase of the algorithm, we build a new network based on the communities (i.e. nodes) during the phase. The weights of the edges between the new nodes are given by the sum of the edges between nodes in the corresponding two communities. Edges between nodes of the same community lead to self-loops in the new network. Then we re-apply the first phase of the algorithm and iterate it. When the number of the communities stop changing, we attain the maximum modularity of the community partition.

Results and Analysis

Countries' positions in the top 2 network

Identifying influential nodes in dynamical processes is crucial to understanding network structure and evolution. Centrality concepts were developed in social network analysis to quantify the importance of nodes in a network. Various centrality measures have been proposed to identify the hierarchical structures of a network. In order to identify countries' positions in the top 2 trade network of the B&R region, we employed three classic quantitative indicators of centralities: degree centrality (DC), closeness centrality (CC), and between centrality (BC). Each centrality measure reflects its own particular structure property.

Degree Centrality (DC) scores the number of connections of a node. In international trade, because degree centrality is the number of countries a particular country exports to or imports from, it can be used as the measure of a country's influence over the whole international trade network. Closeness Centrality (CC) is a measure of the geodesic distance from a node to other nodes (i.e. a measure of how topologically close a node is with respect to others) and it is related to the ability to reach other nodes. In trade network, degree centrality captures how much a country is influenced by and how much it influences other countries. Between Centrality (BC) is a measure of the share of the shortest paths going through a node between other pairs of nodes among all the shortest paths and quantifies the ability to act as a bridge among other nodes (De Benedictis, L. and L. Tajoli, 2011). Between centrality measures how much a country acts as an intermediary or gatekeeper in the trade network. Both degree centrality and closeness centrality (CC) are based on the idea that the centrality of a node in a network is related to its distance to the other nodes, while Between Centrality (BC) is based on the idea that central nodes stand between others. We used Ucinet 6 software again to measure the centralities.

Table 3 top 10 countries by centrality indicators in years (2000, 2004, 2008, 2013 and 2016)

2000					2004						2008			
	Country	CC	Country	BC	Country	DC	Country	CC	Country	BC	Country	DC	Country	CC
5	Russia	0.50	Russia	0.47	Russia	0.35	Russia	0.52	Russia	0.45	Russia	0.38	Russia	0.57
9	China	0.47	China	0.31	China	0.32	China	0.52	China	0.38	China	0.33	China	0.55
9	Singapore	0.41	Singapore	0.12	Serbia	0.14	Turkey	0.45	Turkey	0.09	Serbia	0.16	Turkey	0.47
1	Turkey	0.41	Mongolia	0.08	Singapore	0.13	Greece	0.42	Iran	0.09	Singapore	0.14	Hungary	0.44
0	Mongolia	0.40	Thailand	0.07	Turkey	0.11	Hungary	0.41	Ukraine	0.07	Turkey	0.13	Greece	0.44
0	Kyrgyzstan	0.39	Croatia	0.07	Iran	0.08	Singapore	0.40	Serbia & Montenegro	0.07	Iran	0.09	Syria	0.42
0	Vietnam	0.39	Turkey	0.06	Hungary	0.08	Saudi Arabia	0.39	Hungary	0.07	Hungary	0.09	Serbia	0.41
8	Iran	0.37	Hungary	0.06	Saudi Arabia	0.08	Kyrgyzstan	0.39	Greece	0.07	Saudi Arabia	0.08	Kyrgyzstan	0.41
8	Thail&	0.37	Belarus	0.05	Greece	0.08	Iran	0.39	Saudi Arabia	0.07	Greece	0.08	Vietnam	0.41
8	Croatia	0.37	Iran	0.05	Oman	0.08	Romania	0.39	Qatar	0.06	Oman	0.06	Tajikistan	0.41
2013					2016									
	Country	CC	Country	BC	Country	DC	Country	CC	Country	BC				
4	Russia	0.55	Russia	0.49	China	0.41	China	0.59	China	0.60				
3	China	0.52	China	0.40	Russia	0.25	Russia	0.50	Russia	0.24				
9	Turkey	0.46	Serbia	0.22	Serbia	0.16	Serbia	0.46	Serbia	0.16				
3	Serbia	0.44	Turkey	0.10	Singapore	0.14	Turkey	0.44	Hungary	0.13				
3	Hungary	0.43	Iran	0.08	Turkey	0.13	Singapore	0.42	Poland	0.11				
1	Kyrgyzstan	0.42	Hungary	0.08	Hungary	0.11	Hungary	0.42	Turkey	0.08				
9	Vietnam	0.41	Romania	0.06	Qatar	0.09	Qatar	0.41	Qatar	0.07				
9	Belarus	0.41	Greece	0.05	Poland	0.09	Greece	0.41	Iran	0.07				
8	Greece	0.40	Bhutan	0.04	Iran	0.08	Poland	0.41	Singapore	0.06				
8	Kazakhstan	0.39	Syria	0.03	Saudi Arabia	0.08	Iran	0.41	United Arab Emirates	0.04				

Table 3 shows the top 10 countries in terms of centralities in the years 2000, 2004, 2008, 2013, and 2016. According to the connectivity-based analysis, we can draw the following conclusions. First, China and Russia have been consistently listed as the top 2 countries in terms of all centralities. It suggests that these two large countries are not only the biggest trading countries but also absolutely dominate the trade network of the B&R region. China grew fast and became the center of the B&R trade network in 2016 overtaking Russia. Second, Serbia and Hungary are the two key countries in the B&R trade network. Their centrality indices are high and stable, particularly after 2004. Greece also played an important role in the years 2004, 2008, and 2013, although it experienced a decline after 2013. Third, there are three pivotal countries in the Middle East: Turkey, Iran, and Saudi Arabia. Turkey has been ranked high in all centrality indices in all years. Iran, following Turkey, is the second most important country in the Middle East. The degree centrality of Saudi Arabia is also high but the country's low closeness centrality shows a weak influence on the overall trade network. Last but not least, in Southeast Asia, Singapore has a similar position to Saudi Arabia: high in degree centrality but low in closeness centrality and between centrality.

As shown in Table 3, there are some changes in the positions of some countries in the top 2 trade network across the time periods. The European countries became more important after 2004. Besides Hungary and Serbia, such countries as Romania, Greece, and Poland play increasingly important roles. The Middle Eastern countries always have a strong influence in the B&R trade. Besides Turkey, Iran, and Saudi Arabia, some countries with rich oil and natural gas resources like Qatar and Oman, also rank high in some years. While European countries are gaining importance, Central Asian and Southeast Asian countries might be losing importance. In 2000, some countries in Central Asia and Southeast Asia had high centralities, but their centralities index declined in 2004 and 2016, implying that their positions in the B&R trade remained unstable.

Structural evolution of the top 2 network

We used Gephi to detect the communities and then visualize the structures and the communities of the B&R trade network with the ForceAtlas2 algorithm (Jacomy et al., 2014). In the visualization, the nodes indicate the countries, the links represent the trade relationships between two countries, the countries in the same color belong to the same community, and the area of a node is proportional to the number of trade relations of the country. Table 4 shows the size of identified communities in the top 2 trade network of the B&R countries. While the number of communities remained stable at six or seven, the patterns of trade across different communities and the composition of the communities were not. Firstly, the overall international trade networks of the B&R countries have experienced a leadership change from Russia to China, owing to the economic rise of the latter. Secondly, some communities experienced substantial membership reorganization, and it is particularly true for the Russia and Iran-led communities. Thirdly, a temporary communities emerged and disappeared quickly. For instance, two communities, each led by Kuwait and Thailand appeared in 2000 but did not last long. The Poland-led community disappeared in 2004 but reappeared in 2016. It is worth nothing here that a community may comprises smaller sub-communities of counties. Finally, the number of trade communities have declined from seven in 2000 to five in 2016, which means the level of concentration has increased over time.

Table5: the evolution of the community size in the top 2 trade network

Community No:	Community Leader	2000	2004	2008	2013	2016
1.	Russia	18	14	13	10	11
2.	China	16	13	13	17	17
3.	Serbia	0	0	8	10	13
4.	Hungary	8	5	10	14	6
5.	Kuwait	8	0	0	0	0
6.	Poland	7	0	0	0	9
7.	Thailand	7	0	0	0	0
8.	Serbia and Montenegro	0	11	0	0	0
9.	Iran	0	8	11	9	0
10.	Turkey	0	7	0	0	0
11.	Israel	0	6	0	0	0
12.	Greece	0	0	6	0	0
13.	Kazakhstan	0	0	4	0	0
14.	Czech	0	0	0	5	0
15.	Myanmar	0	0	0	0	9
No. of communities		6	7	7	6	6

As shown in Fig.3 a, seven trade communities are identified in 2000, centered on Russia, China, Kuwait, Hungary, Poland, and Thailand. The Russia-led community was the largest with eighteen member countries, most of which are the former Soviet Union countries (Azerbaijan, Latvia, Tajikistan, Kyrgyzstan Georgia, Armenia, Moldova, and Estonia) and the Balkan states (Greece, Romania, Macedonia, and Albania). The second largest community was the one around China and includes sixteen countries, most of which are the South and Southeast Asian countries (Singapore,

Sri Lanka, Malaysia, Indonesia, Pakistan, Bangladesh, Brunei, and the Philippines), and the Middle East (Turkey, Saudi Arabia, Qatar, Israel, Syria, Jordan, and Egypt). In this community, Singapore is the second largest after China. The Hungary and Kuwait communities both covered eight countries, while the other two communities were oriented towards Poland and Thailand, and were smaller in terms of the number of countries as both consist of only six countries each. The Kuwait, Poland and Thailand-led communities were geographically decentered and have disappeared in 2004, 2008, and 2013.

In 2004, although the two largest communities were still Russia and China, the numbers of their member countries both declined. The Russia-led community was very unstable with new countries from Central Europe (Poland, Czech, Slovakia); Eastern Europe (Belarus, Estonia, Latvia); Central Asia (Kazakhstan, Kyrgyzstan); and other regions (Mongolia, Lebanon, India, Bhutan) joining, while some old members disappeared, including countries from the South Caucasus (Armenia, Azerbaijan, Georgia) and the Balkan Peninsula (Greece, Romania, Macedonia, and Albania). Compared to the Russia-led community, the China-led community remained relatively stable with only five old member countries (Turkey, Israel, Egypt, Pakistan, and Brunei) exiting and two members (Thailand and Oman) being clustered. Four new community leaders (Serbia and Montenegro, Iran, Turkey, and Israel) emerged temporarily in 2004, but they do not appear in the subsequent visualizations, as shown in Table 5.

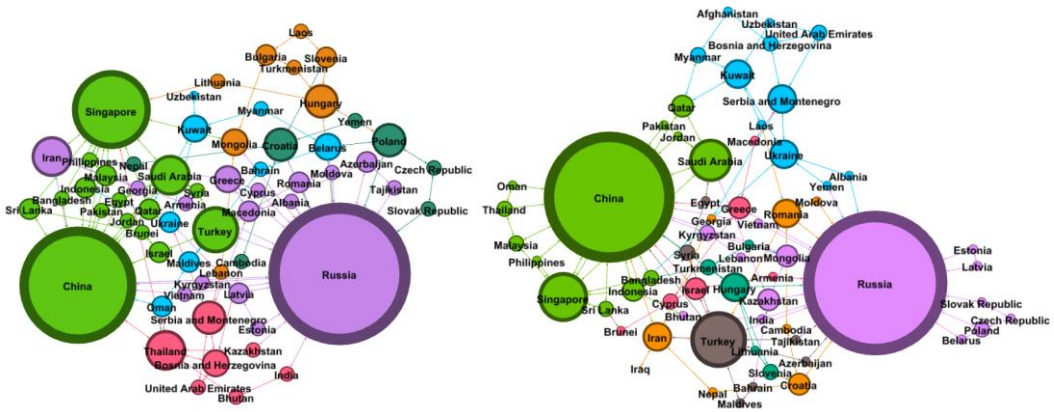
In 2008, the two largest communities were Russia and China-led and each had eleven member countries. Turkey, an independent community leader in 2004, joined the Russia-led community. Poland moved away from the Russia-led community and joined China- centered community. The third and fourth largest communities were led by Iran and Hungary respectively and their members increased to eleven and ten, respectively. Note that Serbia replaced as the community leader Serbia and Montenegro after Serbia and Montenegro was broken into two separate countries in 2006. Given Serbia was around 90% of Serbia and Montenegro both in population and GDP, such replacement is not surprising (United States Statistics Division, 2017). Some old member counties including Ukraine, United Arab Emirates, Bosnia and Herzegovina, Afghanistan still were in this community, while Kuwait, Uzbekistan, Laos, Albania left. Two temporary communities that were led by Greece and Kazakhstan emerged in 2008 but did not last until 2013.

In 2013, the China-led community became the largest one, its membership increased to seventeen. Most of old members remained (with an exception of Bangladesh and Uzbekistan), five new members (United Arab Emirates, Ukraine, Jordan, Philippines, Azerbaijan) joined. In contrast, the number of Russia-led community declined in 2013 to ten, because six members of the year 2008 (Poland, Lebanon, Kyrgyzstan, Azerbaijan, Armenia, and Albania) left while only three new counties (Syria, Mongolia and Yemen) joined. The Hungary community grew to the third largest with fourteen countries. It had seven new member countries, namely, two from Eastern Europe (Romania, Moldova) and five from Asia (Bangladesh, Sri Lanka, Kazakhstan, Turkmenistan, and Brunei) while losing only one old member (Moldova).

Although the fourth largest community was still led by Serbia and its number increased to ten, its members have changed a lot. Compared to the year 2008, this community had merely two old members, Bosnia and Herzegovina, plus Montenegro, by now a separate country, remained. Meanwhile, seven new courtiers (Greece, Israel, Kyrgyzstan, Macedonia, Lebanon, Cyprus, and

Albania) joined. The number of countries in the Iran-led community was nine which is not too different from those of previous years. However, due to the high turnaround of membership, only five of 2008 members (India, Bhutan, Iraq, Myanmar and Georgia) remained. A small community with five members was formed around Czech but did not make it to 2016.

The most noticeable change of 2016 was the emergence of the two new communities (those led by Myanmar and Poland, respectively), each with nine members. The Myanmar-led community was geographically diffused, all in Asia (Kuwait, Bhutan, Mongolia, India, Afghanistan, Nepal, and Uzbekistan) except Ukraine. The Poland-led community was more geographically concentrated with five out of seven members (Czech, Slovak, Romania, Latvia, Estonia and Moldova) within 700 kilometers in terms of border to border distance. Laos and Georgia are the two outliers in this community. The Hungary-led community shrank from fourteen members in 2013 to six in 2016. Only three original members (Turkmenistan, Slovenia, and Croatia) remained until 2013. The Serbia-led community became more visible with the increasing number of the members. Only four old members (Greece, Montenegro, Cyprus, Bosnia and Herzegovina, and Albania) withdrew while eight (Serbia, Qatar, United Arab Emirates, Macedonia, Lebanon, Cambodia, Brunei and Bulgaria) joined. The China-led and Russia-led communities remained dominant over the overall 2016 network.



2000 **2004**

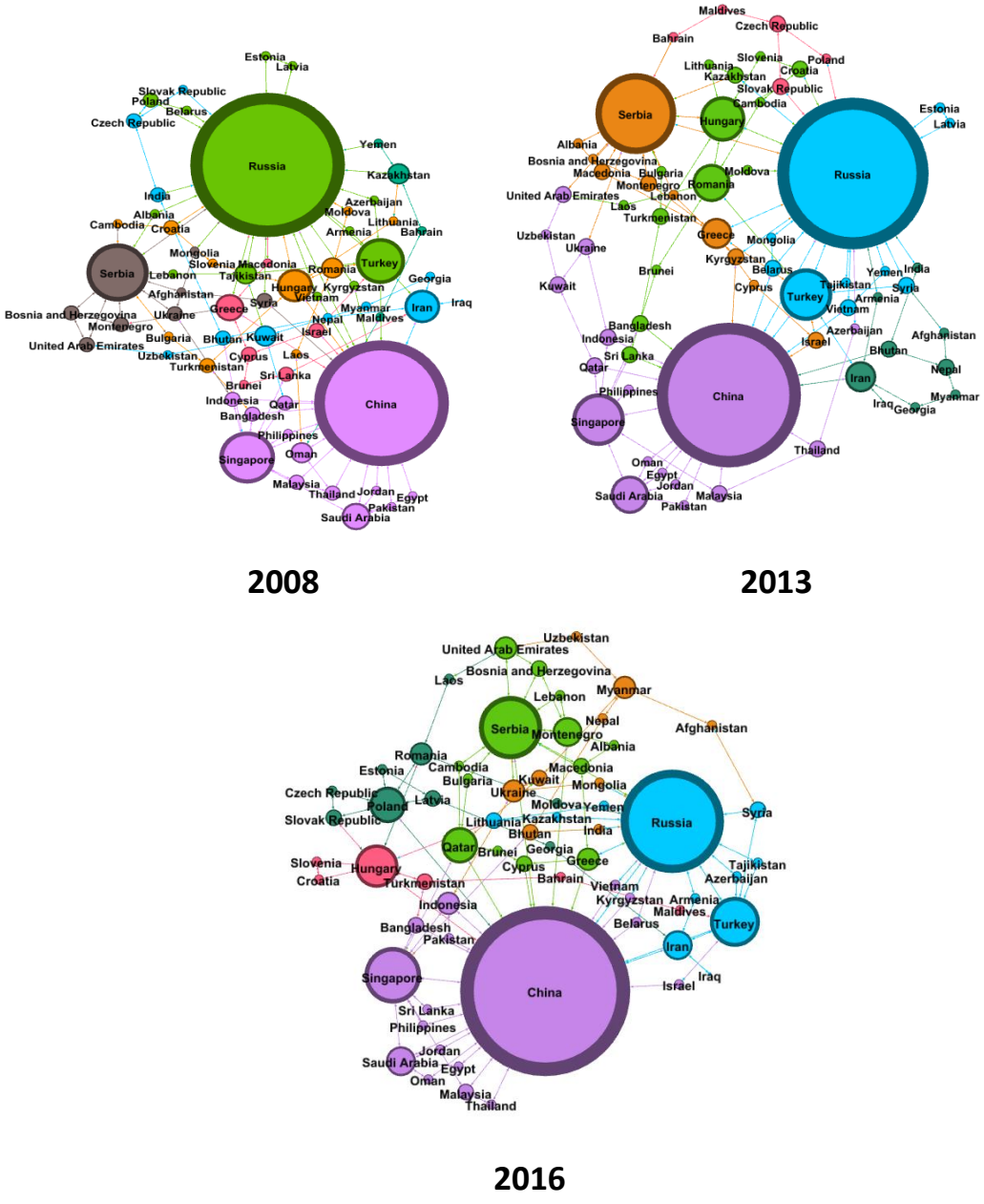


Fig 3. The visualization of the structure of the B&R trade network in Gephi in the years 2000, 2004, 2008, 2013, and 2016.

Conclusions and Policy Implications

Facilitation of international trade is one of the key aims of Belt and Road Initiative. As such, understanding the structure and evolution of the B&R trade network might offer clues for the construction of what President Xi called “the system of fair, equitable and transparent rules for international trade and investment” (Xi, 2017). Network analysis approaches have been widely used to illuminate the complex trade network, but previous studies did not pay enough attention to the different weights of a country’s trade relations. Within our limited knowledge, this study is the first attempt to use top trade networks to understand the structure and evolution of the B&R

trade. More specifically, we used the top 2 trade networks to identify structural changes such as changes in countries' positions, and the overall patterns of trade across communities and the compositions of the communities from 2000 and 2016. Our findings can be summarized as follows, which will provide the basis for policies formulation for trade facilitation and development.

First, not all relations in the trade network are equally important to a country, especially in the time of global economic turbulence. After the 2008 global economic crisis, although the complete trade network of B&R countries developed very slowly, both network density and degree centralization continued increasing. It implies that the trade network became more concentrated on a few dominant countries than before, because some countries further strengthened their ties with key trade partners while shedding off nonessential ties, during the post 2018 economic crisis period. Moreover, in the complete B&R trade network in 2016, the top 2 trade network accounted for less than 11% of the total trade ties, while it makes up nearly 75% of the total trade values. Therefore, the identification and maintenance of the top networks is critical to the overall network development. Top networks provide us with a useful but relatively simple tool to illuminate the network structure of international trade.

Second, the centralities-based studies identified the competitive positions of countries. After 2013, China was higher than Russia in terms of the three centralities, which suggests that China become more dominate over the trade network of the B&R region. The future impacts of China's BRI certainly rely on the degree of integration in the connected regions. Since the top 10 countries measured by centrality indices are either community leaders (e.g. Russia) or regional sub-centers (e.g. Singapore) or "bridges" between two communities (Romania and Hungary in 2016), China should select them as regional strategic partners. Their positions can be used in various ways to realize the potential of the China-proposed BRI. Despite the relative position of Russia declined, China should further strengthen trade relations with it, because it has strong influence in the network. Besides Russia, other countries with stable and high centrality indices would be regional strategic partners as well. They are Singapore, Serbia, Greece, Turkey, Iran, Poland, Hungary and Romania. Obviously factors other than trade network should be taken into consideration. Such factors include geo-political and economic competition and the historical relations with China.

Third, both the trade communities and their compositions of the B&R countries are highly unstable. This suggests the trade communities are completive to each other, in terms of the community leaders and their members. Despite that Russia stayed as a community leader, its community members were changed and were geographically decentralized. The Poland- led community experienced disappearance and re-emergence. Such community leaders as Kuwait, Thailand, Turkey, Israel, Greece, Kazakhstan, Czech, Myanmar gained the leadership in some years while losing in some other years. This fluctuation might imply that they have some but instable influence, and they might be considered for China's regional strategic partners. It is also important to note that most of trade networks consist of geographically separated counties. This reflects the complicated politico-economic systems of the B&R countries and the obstacles that has to be overcome before the construction of a more cohesive trade network. The countries that have strategically important geographical position but that have weak trade links should be prioritized. Myanmar, Pakistan, and Belarus are such countries.

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