An Empirical Evaluation of the Shanghai Cooperation Organization from Social Network Perspective

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Abstract
The Shanghai Cooperation Organization (SCO) has played a fundamental role in promoting the regional cooperation among its member states. Recently with the increasing of research for the "One Belt One Road" Initiative, many experts have turned their attention to the SCO. The Social Network Analysis (SNA) is a common paradigm in international relation studies, especially in the quantitative research. We established the Directed-weighted and Undirected-weighted matrix at first. The empirical data are based on the economic and trade exchanges among the SCO member states for two consecutive years. All results, which are calculated by the Organizational Risk Analyzer (ORA) and UCINET, have shown that Russia and China hold central roles in both cases. Because measurements of the SNA are very sensitive, accuracy is fully thought out during the process of data collection. We recommend that China should continue to strengthen cooperation with Central Asian states to balance their ties with Moscow, as they once all belong to the former Soviet Union.
Key words: EMPIRICAL EVALUATION, SHANGHAI COOPERATION ORGANIZATION, SOCIAL NETWORK ANALYSIS

1. Introduction

The Shanghai Cooperation Organization (SCO) was initiated and established by its founders, China, Russia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. The "Shanghai Five", precursor of the SCO, was created with the signing of "Treaty on Deepening Military Trust in Border Regions" by the heads of states of the five founders in Shanghai on April 26, 1996 [1]. And at the recent Ufa summit, held in July 2015, the committee has started the procedure of receiving India and Pakistan to involve this organization as full members, and they are expected to join in 2016 [2]. Meanwhile, there are four Observer States: Afghanistan, Belarus, Iran, and Mongolia. The position of Dialogue Partner was created in 2008, and the present partners are Armenia, Azerbaijan, Cambodia, Turkey, Sri Lanka, and Nepal. Now, the SCO has three Guest Attendances: the Association of South-East Asian Nations (ASEAN), Commonwealth of Independent States (CIS), and Turkmenistan. So far, it is still the only regional organization which established within China and named after a Chinese city [3]. We can see its main organizational structure in Figure 1.

The SCO is the largest regional cooperation organizations in Eurasia, its population is about 1.5 billion, nearly one quarter of the world's population. Its land area is accounts for two-thirds of Eurasia [4]. The primary goal of SCO is creating stability in Central Asia, and some other security-related

concerns, which was once defined in three parts: terrorism, separatism and extremism. Over the past few years, their cooperation fields have expanded to the military cooperation, intelligence sharing, and counterterrorism. Economic and cultural cooperation also occur in the SCO framework. Russia is the biggest partner of China no matter in its current scale or trends, but China has still kept a pivotal position in many cooperation fields. This year, the annual summit was organized together with the first BRIC (Brazil, Russia, India and China) summit, and the China-Russia joint statement said that they want to increase their voice and voting rights in the international community [5].

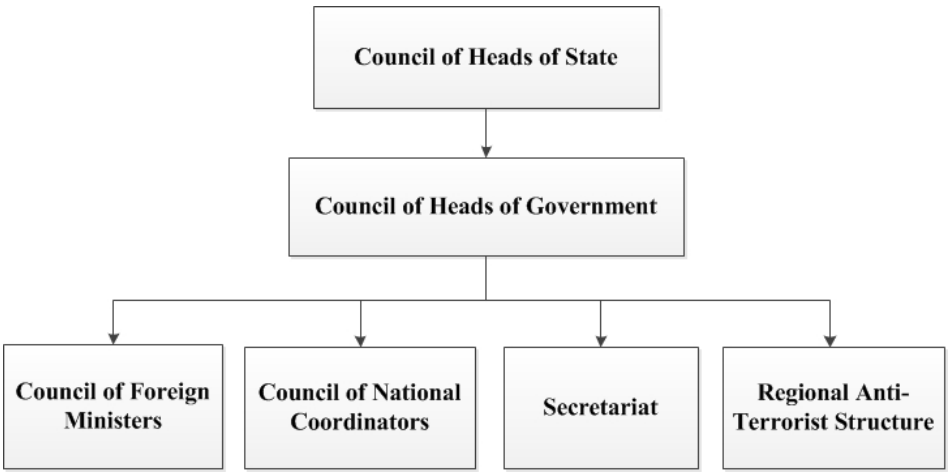

Figure1. Structure of the Shanghai Cooperation Organization

The Shanghai Cooperation Organization has always attached great importance to the external exchanges and cooperation. And it has established close contact with United Nations (UN), as an observer in the General Assembly, European Union (EU), Commonwealth of Independent States (CIS), Association of South-East Asian Nations (ASEAN), Organization of Islamic Cooperation (OIC), and some other international or regional organizations [6]. But, at the same time, we still have seen that the SCO is restricted by its own development, which is not as expected. The SCO is also facing a series of new challenges in mechanism construction, deepen pragmatic cooperation [7]. The SCO is described by some western media observers as a way for Russia and China to challenge the current, western-dominated global order [8].

Most related studying achievements of the Shanghai Cooperation Organization were focused on the economic and political cooperation. However, in previous studies, qualitative researches are more common, quantitative analysis is relatively rare. There also have been many commentaries and discussions about the geopolitical nature of the SCO. Many western analysts believe that one of the initial purposes was becoming a counterbalance to the North Atlantic Treaty Organization (NATO) both Russia and China [9]. It could also play a positive role in avoiding conflicts with the regional organization that already exists. It would also prevent the United States to absolutely intervene the issues of the Central Asia, to some degree [10]. On the other hand, some American scholars believe that the SCO is an important multilateral organization of this region. And it will soon become a potential partner of United States sometime in the future, so the government should give support at present [11]. For Russia, most scholars believe that the SCO is an essential way for consultation and coordination in the regional affairs [12], but it still need to further strengthen some new approaches [13]. Perceptions of the SCO in China are very diverse [14]. There are many domestic academics present some new views to analyze the SCO. We call them the non-traditional security concept or the new security concept [15].

2. Basic methods of the Social Network Analysis

The Social Network Analysis regards relationships as many kinds of networks, which were consisting of nodes. Some of them represent individuals and communications which were common in our daily life, such as friendship, kinships, organizations or sexual relationships. As we known, a unique feature of the SNA is the anti-categorical imperatives [16]. One of the main applications of Graph Theory in Social Network Analysis is to identify the most important role on the network. The thought origin of the Graph Theory can be traced back to the international

mathematician Leonhard Euler and the world famous Seven Bridges of Konigsberg problem [17]. There are a number of different kinds of networks, such as the one-mode network, two-mode network, and affiliation network. And its data sources can also be summed up in three basic types: attribute data, relational data, and ideational data [18]. The Intergovernmental Organizations (IGOs) can also be formed as a network, this will affect behaviors of the member states. In order to study the IGOs systematically, scholars began to apply the SNA to analyze their networks from late 1960s to 70s [19]. Over time, the SNA has been commonly used in the research of international relation, especially after Professor Zeev Maoz's landmark achievement published in 2010 [20].

The edge weight can be conceptualized as the combination of the magnitude and frequency of interactions between two nodes. In some cases, an edge may be formed binary, such as whether two nations recognize each other or not [21]. However, in case of variable strength, just like the amount of phone calls occurred among the terrorists [22]. Networks has many characteristics, such as the Density, Centrality, Clustering, which is in mind of the most widely used. Degree of a node mainly includes Point Centrality, Betweeness Centrality, Closeness centrality, etc. [23].

The two most commonly used software in SNA are the Organizational Risk Analyzer (ORA) and the UCINET. The ORA was developed by Professor Kathleen M. Carley and the Center for Computational Analysis of Social and Organizational Systems (CASOS) [24]. And the UCINET is released by Steve Borgatti, Martin Everett, Lin Freeman, and the Analytic Technologies [25]. At first, we will give some brief introduction about measurements in SNA.

2.1 Network Density

In a network, it was always composed of nodes and ties. That is to say, the nodes are actually exist. When it comes to the edges, just the same as the connections mentioned above, there are two possible situations: potential connection and actual connection. We often used the Density to depict the centralized extent of the entire network. The range of values allowed for the concept is from 0 to 1. And the formula in directed or undirected network is different (1) (2) [26].

$$\Delta_U = \frac{2L}{g(g-1)} \tag{1}$$

$$\Delta_D = \frac{L}{g(g-1)} \tag{2}$$

2.2 Centrality Analysis

The basis of Centrality Analysis refers to the number of node which is able to connect directly, it is mainly used to measure the importance and influence of such node in the whole network. The underlying formula of the Degree is listed at first (3). The Point Centrality also shows that the more connected to the node, the greater importance it will have (4) (5). The Betweeness Centrality often contrast different networks to eliminate the influence of the total number of nodes. And the measure could also present how many connections it control in the whole network (6) (7). The Betweeness Centrality ignored how such nodes can avoid to be controlled by others in most instances. And the Closeness Centrality can just make up the defects (8) (9) [27].

$$C_A = \frac{\sum_{i=1}^{g}[C_A(n^*) - C_A(n_i)]}{\max\sum_{i=1}^{g}[C_A(n^*) - C_A(n_i)]} \tag{3}$$

$$C_D(n_i) = \frac{\sum_j x_{ij}}{g-1} \tag{4}$$

$$C_D = \frac{\sum_{i=1}^{g}[C_D(n^*) - C_D(n_i)]}{[(g-1)(g-2)]} \tag{5}$$

$$C_B(n_i) = \frac{\sum_{j\le k} g_{jk}(n_i)/g_{jk}}{[(g-1)(g-2)]/2} \tag{6}$$

$$C_B = \frac{\sum_{i=1}^{g}[C_B(n^*) - C_B(n_i)]}{[(g-1)^2(g-2)]} \tag{7}$$

$$C_c(n_i) = \frac{g-1}{\sum_{j=1}^{g} d(n_i, n_j)} \tag{8}$$

$$C_C = \frac{\sum_{i=1}^{g}[C_C(n^*) - C_C(n_i)]}{[(g-1)(g-2)]/(2g-3)} \tag{9}$$

2.3 Prestige Analysis

According to the historical experience, Centrality Analysis is used to describe the significance of certain nodes. Prestige Analysis takes greater emphasis on perspective of the whole network. As to the directed relationship, the option to be accepted is usually very interesting. If someone want to calculate the detailed numerical results, Prestige Analysis seems to be more suitable. The formula is as following (10). When network structure change to the most, the divisor will reach the maximum. The formulas in this situation will become more certain, and manifest themselves as the following forms (11) [28].

$$P_D(n_i) = \frac{x_{+i}}{g-1} \tag{10}$$

$$P_p(n_i) = \frac{I_i / (g-1)}{\sum d(n_j, n_i) / I_i} \quad (11)$$

2.4 Clustering Analysis

When the connections between such two countries to some other countries were similar, they would be described as equivalence in the network structure. In fact, exactly equivalent is rare, but some similar ones often appear. The Clustering Analysis mainly includes the hierarchical clustering, convergent correlations and multidimensional scaling [29].

In order to contest the similarity degree of such two nodes, the current measurements mainly include the distance method and correlation coefficient method. Many paper introduces probability to discuss this issue (12) (13). And the distance method is also widely used in analyzing the IGOs' network. Basing on the social relation matrix, the distance method could be changed into a distance matrix. The distance matrix could be calculated by two methods, one is by absolute terms (14), and the other is by the geometric average calculation (15).

$$P(L_s = q) = \frac{\binom{L}{q}\left[\frac{g(g-1)}{2} - L \atop \frac{g_s(g_s-1)}{2} - q\right]}{\left[\frac{g(g-1)}{2} \atop \frac{g_s(g_s-1)}{2}\right]} \quad (12)$$

$$P(L_s \geq q) = \sum_{k=q}^{\min(L, \frac{g_s(g_s-1)}{2})} \frac{\binom{L}{q}\left[\frac{g(g-1)}{2} - L \atop \frac{g_s(g_s-1)}{2}) - k\right]}{\left[\frac{g(g-1)}{2} \atop \frac{g_s(g_s-1)}{2}\right]} \quad (13)$$

$$d_{ij} = \sum_{k \neq i,j} \left| s_{ik} - s_{jk} \right| \quad (14)$$

$$d_{ij} = \sqrt{\sum_{k \neq i,j} \left(s_{ik} - s_{jk} \right)^2} \quad (15)$$

3. Analysis Results of the Shanghai Cooperation Organization

To verify the research methods which mentioned above, we gathered some data from the UN Comtrade Statistics Database as the basis of our calculations. They were mainly about trade volume among members of the Shanghai Cooperation Organization in 2012 and 2013. We could see the raw data intuitively in Figure 2 [30].

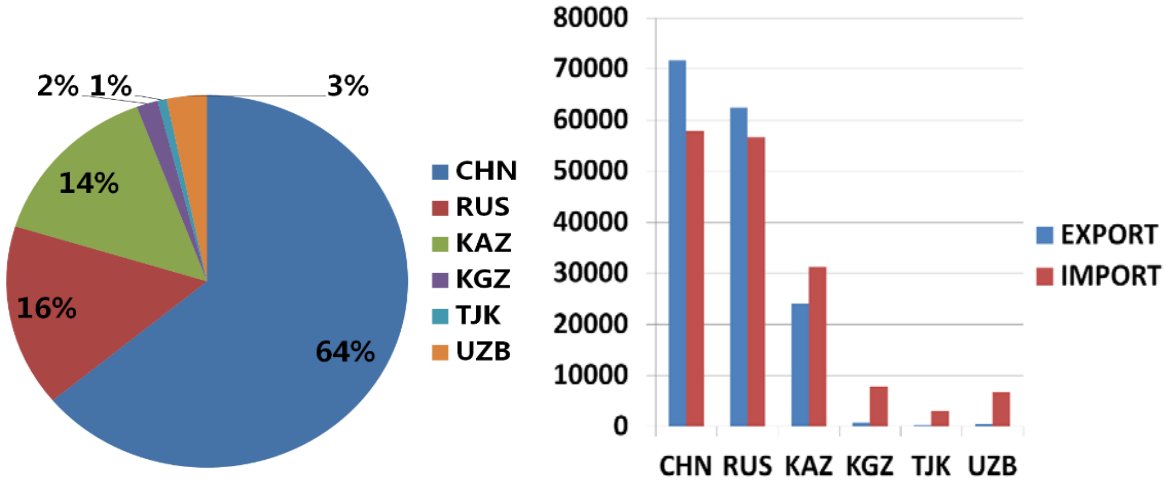

Figure 2. Visualization Results of the Trade Flow in 2012 and 2013

Firstly, we establishes the Directed-weighted and Undirected-weighted matrix based on the volume of the economic and trade exchanges among member states of the Shanghai Cooperation Organization. And then we could finish a comprehensive research mainly includes Network Density, Centrality Analysis, Prestige Analysis, and Clustering Analysis of the network. We can explore the overall situation by studying Network Density. The Centrality Analysis and Prestige Analysis can

both be used to find out the prominent countries with high activities, which have significant impact of the entire network. The Clustering analysis is used to classify similar countries in this network, and reveal influence of the Shanghai Cooperation Organization on relationships national and abroad. According to the theories of Social Network Analysis, it can be concluded that these countries will have similar choices in the international affairs. In this respect, closer the cooperation among the member states is very important and necessary. Clustering Analysis is also based on trade flow ties. Some calculations were shown from Table1 to Table 8, which were finished by the Organizational Risk Analyzer:

Table1. The Undirected-weighted Matrix of Trade Flow in 2012 （Million USD）

Member	CHN	RUS	KAZ	KGZ	TJK	UZB
CHN	-	88195	25677	5163	1857	2875
RUS	88195	-	24302	1830	747	3716
KAZ	25677	24302	-	1057	604	2161
KGZ	5163	1830	1057	-	48	404
TJK	1857	747	604	48	-	0
UZB	2875	3716	2161	404	0	-

Table 2. The Directed-weighted Matrix of Trade Flow in 2013（Million USD）

Member	CHN	RUS	KAZ	KGZ	TJK	UZB
CHN	-	49591	12545	5075	1869	2613
RUS	39668	-	17218	2029	724	2804
KAZ	16051	5665	-	671	493	1127
KGZ	62	110	329	-	51	159
TJK	89	38	72	4	-	0
UZB	1938	1257	963	98	0	-

Table 3. Network-Level Measure of The Undirected -weighted Matrix

Measure	Value	Measure	Value
Density	0.933	Interdependence	0.071
Density(Weighted)	0.120	Efficiency (Global)	0.116
Transitivity	0.923	Efficiency (Local)	0.280
Efficiency	0.100	Column Degree	0.120
Diffusion	0.987	Shared Situation	0.167

Table 4. Network-Level Measure of The Directed-weighted Matrix

Measure	Value	Measure	Value
Density	0.933	Interdependence	0.071
Density(Weighted)	0.110	Efficiency (Global)	0.057
Transitivity	0.923	Efficiency (Local)	0.119
Efficiency	0.100	Column Degree	0.110
Diffusion	0.987	Shared Situation	0.167

The results in the tables above shows that the economic exchanges among the members of the Shanghai Cooperation Organization has been much deepened and expanded in these two years. And differences between the Directed-weighted and Undirected-weighted matrix are so little that should basically be minimal. The following tables are mainly focus on values of each member in the SCO.

Table 5. Results of the Undirected -weighted Matrix of Trade Flow in 2012
Based on Social Network Analysis (a)

Member	Measure				
	Authority	Eigenvector	Inverse	Information	Hub
CHN	0.716	0.943	0.022	0.228	0.716
KAZ	0.921	0.467	0.051	0.212	0.921
KGZ	0.185	0.070	0.256	0.129	0.185
RUS	0.753	0.939	0.044	0.225	0.753
TJK	0.071	0.027	0.255	0.073	0.071
UZB	0.184	0.072	0.066	0.133	0.184

Table 6. Results of the Undirected -weighted Matrix of Trade Flow in 2012
Based on Social Network Analysis (b)

Member	Measure				
	Betweenness	Closeness	Column Degree	Total Degree	Bonacich Power
CHN	0.000	0.022	0.281	0.281	123767
KAZ	0.000	0.039	0.122	0.122	53801
KGZ	0.400	0.063	0.019	0.019	8502
RUS	0.000	0.036	0.269	0.269	118790
TJK	0.900	0.065	0.007	0.007	3256
UZB	0.000	0.044	0.021	0.021	9156

Table 7. Results of the Directed-weighted Matrix of Trade Flow in 2013 Based on Social Network Analysis (a)

Member	Measure				
	Authority	Eigenvector	Inverse	Information	Hub
CHN	0.703	0.993	0.002	0.309	0.587
KAZ	0.910	0.415	0.007	0.348	0.906
KGZ	0.317	0.006	0.049	-0.259	0.019
RUS	0.707	0.915	0.005	0.310	0.892
TJK	0.122	0.003	0.249	-0.112	0.009
UZB	0.249	0.068	0.026	0.404	0.196

Table 8. Results of the Directed-weighted Matrix of Trade Flow in 2013 Based on Social Network Analysis (b)

Member	Measure				
	Betweenness	Closeness	Column Degree	Total Degree	Bonacich Power
CHN	0.000	0.002	0.289	0.289	71693
KAZ	0.000	0.007	0.097	0.097	24007
KGZ	0.550	0.041	0.003	0.003	711
RUS	0.000	0.005	0.252	0.252	62443
TJK	0.800	0.058	0.001	0.001	203
UZB	0.000	0.025	0.017	0.017	4256

The results in the tables has explicitly shown that China and Russia are located in the center position of the SCO. The other countries seems to be at the affiliate location. Compared with China, Russia is closer with the other countries. We surmise it somehow related to that Central Asian and Russia are once all belong to the former Soviet Union.

As we were based on the trade data, China plays a relatively central role in the SCO. Russia's leading position may be more prominent if our supporting data is on the basis of political or military cooperation. In the recent years, many issues proposed by Chinese government wish to change that. As part of this ongoing effort, China takes an active participator in annual joint military exercises in the organizational framework.

Hierarchical Clustering is used to classify different of the members. Firstly, each country was separated in one class, and there were five classes. The size of distance is classified as a reference, until getting the expected results. After we gradually reduce the numbers of classification, we could get Table 9 and Table 10, the results were automatically finished by the UCINET.

Table 9. Hierarchical Clustering Result of the Trade Flow in 2012

Level	Countries
1	China, Russia

2	China, Russia, Kazakhstan
3	China, Russia, Kazakhstan, Uzbekistan
4	China, Russia, Kazakhstan, Uzbekistan, Kyrgyzstan
5	China, Russia, Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan

Table 10. Hierarchical Clustering Result of the Trade Flow in 2013

Level	Countries
1	Kazakhstan, Tajikistan
2	Kazakhstan, Tajikistan; Kyrgyzstan, Uzbekistan
3	Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan
4	Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan, Russia,
5	Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan, Russia, China

From the results, we can find there are some differences in Clustering Analysis between the Directed-weighted and Undirected-weighted matrix, but they are essentially the same. They have just been reversed. China and Russia are both in the same level and has closer contact. Kazakhstan has played a greater role than the other members, because its large number of energy export. China is stronger on economic ties to the Central-Asian countries. The role of Russia would also be more significant if we compared with the political influence. However, we could speculate that China was not so important in international affairs at present, and the Central Asian countries were also lack of influence in the organization.

4. Conclusions

The Social Network Analysis is consider to be one of the most convenient paradigm in the researches of relationship. As to the international organizations, it also becomes very popular in the recent years. There are widespread concern to the "One Belt One Road" Initiative, which is actively sponsored by the new Chinese government. And India and Pakistan will officially join the Shanghai Cooperation Organization in 2016. Which is a pity, there is still few application about quantification study of the SCO. One of the most difficult part is many variables are hard to quantify. In this paper, we try to use the Social Network Analysis, which was very popular in social science, to analyze the cooperation among the members in the SCO based on the economic and trade exchanges, we finds:

Firstly, the importance of both China and Russia in the Shanghai Cooperation Organization is overwhelming, especially in the Network Density, Centrality Analysis, and Prestige Analysis of the network. And the empirical conclusions are consistent with common sense. In some case, Russia is closer with the other countries. This situation reminds us that the Chinese government should play a more important role in international affairs, in order to take a charter and location in center of this regional organization.

Secondly, most metrics of the Social Network Analysis are extremely sensitive to missing or erroneous in the experiment if the source data not accurate. And one clear finding is that the same measurements, such as the Betweenness Centrality and Eigenvector Centrality, are quite different in the Directed-weighted matrix and the Undirected-weighted matrix. In some case, as the Clustering Analysis, the results are not too distinctive. Even so, it is still very important for us to ensure data authentication in our future research.

Thirdly, as we used data originated from the economic and trade without considering political impact, the importance of Russia in the SCO did not fully reflected. We also have not located each country in some other international organizations. The political influence is always quite obvious in geopolitics studies. We would like to do some more researches to validate whether the relationships between the national political influences would play a more important role in the results. And then, the inadequacy of this paper will

be confirmed in the further works.

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