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The Competitiveness and Complementarity of Arms Trade of Countries along the "Belt and Road" and its Dynamic Evolution: Based on Complex Network Analysis Method

Abstract: This paper uses network analysis to study the competitiveness and complementarity and its dynamic change of arms trade among countries along the "Belt and Road" during 2004-2016. The research shows that: (1) The arms trade relations of the countries along the "belt and road" are increasingly strengthened, the trade network density is increased, and the trade centralization trend is obvious. Trade competition intensifies and is greater than trade complementarity. (2) In terms of the complementary relationship of arms trade, there are two important national blocks. One is an export-oriented block composed of Russia and some central-eastern European countries. The other is a compatible type block composed of China, India and other countries. (3) In terms of arms trade competitiveness, the countries along "Belt and Road" are divided into three competing groups: the first group is composed of Russia, Israel and some central-eastern European countries; The second group is composed of China, India and other emerging arms producing and selling countries. The third is a wide range of other countries along the "Belt and Road".

Keywords: Belt and Road; Arms Trade; Complex Network; Trade Competitiveness; Trade Complementarity

1. Introduction

International arms trade refers to the purchase and sale of special military supplies in the international market, which is a special form of international trade. According to the content of the transaction, the concept of arms trade can be divided into a broad sense and a narrow sense. In a broad sense, the arms trade includes all goods related to national security, such as weapons and equipment, ammunition, military spare parts, military training and military production technology. In the narrow sense, the arms trade mainly refers to the international trade of large weapon systems such as fighter planes, warships, tanks and self-propelled artillery. The research on arms trade mainly focuses on the latter (Zhu, 2002; Hu, 2005).

The academic circle focuses on the trade between the countries along the "Belt and Road" mostly in the category of general commodities, but does not pay much attention to the issue of arms trade. Some scholars consider the particularity of arms trade. For example, Zhao Ying (2006) points out that "due to the particularity of its trade object, it has gradually risen to a political act". During the Cold War, due to the fierce East-West confrontation, the international arms trade, as a special means of military activities, was based more on political and military considerations than economic interests.

However, since the world entered the "Post-Cold War" era, with the easing of the international situation, regional countries began to take economic interests into account while pursuing political and strategic interests. If Russia exports arms, except to offset foreign debts, the rest are carried out in accordance with commercial principles to create foreign exchange income; While highlighting its political and military interests, the United States exports advanced weapons from an economic perspective to seize the

international arms market. Some countries, such as France and Germany, are developing demand-oriented standard weapons and equipment based on the demand of buyers.

For a long time, international arms trade has enjoyed a special status in the world political and economic fields as a powerful lever to adjust international and regional political relations and promote national strategies. For a country's economic development, arms export helps to relieve the surplus pressure of national defense industry; For national security, arms import is conducive to accelerating the modernization of a country's weapons and equipment and narrowing the gap with other countries (Qiu, et al., 2003). Therefore, it is of great practical significance for China's economic development, the furthering of the "Belt and Road" initiative and the mutual benefit and stable development of countries along the "Belt and Road" to pay enough attention to and study the arms trade issue.

2. The basic pattern and evolution of arms trade among countries along the "Belt and Road" in recent ten years

2.1 Total imports and exports of arms and its change

In the past decade, the arms' imports and exports of countries along the "Belt and Road" has been growing continuously and occupies an important position in the world arms market. According to the data provided by the Stockholm International Peace Research Institute (SIPRI), the arms' exports of countries along the "Belt and Road" reached \$8.01 billion in 2004, accounting for 37.45% of the world's total amount. In 2016, exports increased to \$12.173 billion, accounting for 37.73% of the world's total amount. The average annual export growth of countries along the "Belt and Road" reached 6.80% in the decade, 4.5 times higher than the world's 1.50%. In 2004, the arms imports of countries along the "Belt and Road" reached \$14.189 billion, accounting for 66.35% of the world's total amount. In 2016, imports rose to \$21.884 billion, accounting for 67.86% of the world's total amount. The average annual import growth of countries along the "Belt and Road" reached 2.50% in the decade, 1.7 times higher than the world's 1.5%. In recent 10 years, the arms' imports of the countries along the "Belt and Road" is larger than the exports, showing the state of deficit. During 2004-2016, the average annual arms' imports exceeded export by about 76.33%.

From the perspective of the change, in the past 10 years, the growth of import and export of countries along the "Belt and Road" has experienced a relatively obvious fluctuation process (see *Fig. 1*). Among them, the increase of arms' export fluctuates the most in countries along the "Belt and Road", with a drop of 256.7% in 2005. During 2011-2014, the growth of export experienced its steepest decline in a decade, with an average annual decline of 214%. During the financial crisis in 2008, the growth rate of arms' imports along the "Belt and Road" and the growth rate of arms import and export of the world all declined, while the arms' export of the "Belt and Road" increased slightly. After 2014, arms' imports and exports growth of the "Belt and Road" and world picked up, and the international arms market began to improve.

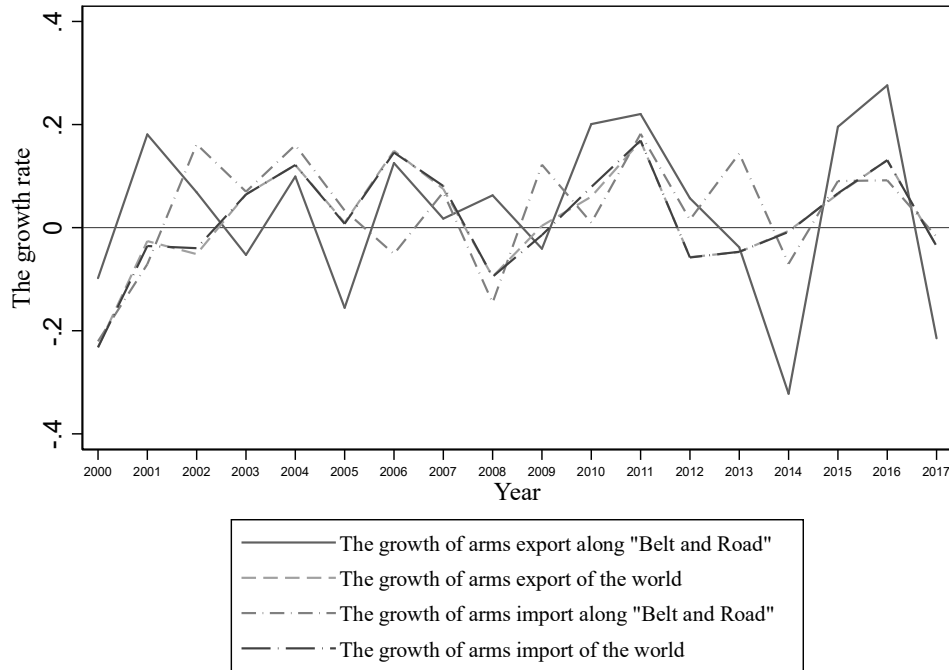


Fig. 1 The growth rate of arms import and export of countries along the "Belt and Road" and the world during 2000-2017

2.2 Characteristics and change of arms import and export economies

This paper gathers the top 5 arms import and export countries along the "Belt and Road" from 2004 to 2016 (see *Table 1*), and finds that the arms' import and export of countries along the "Belt and Road" has the following characteristics: (1) In the proportion of arms' import and export, there is a relatively obvious centralization trend. In 2004, the total exports of the top 5 arms export countries accounted for 95.23% of the total exports of the countries along the "Belt and Road". In 2012, the proportion rose to 97.13%. In 2016, the proportion was still as high as 93% although it declined somewhat. Similarly, the top 5 arms import countries accounted for 63.69% of the total amount of countries along the "Belt and Road" in 2004. The proportion dropped to 52.43% in 2008, recovered to 56.16% in 2014, and dropped to more than 50% in 2016. (2) The arms' exports of Russia, Israel, China, Ukraine, Turkey and other five countries took a relatively stable leading position in the sample period. Similarly, the arms' imports from China, India, the United Arab Emirates (UAE) and Saudi Arabia took a relatively stable leading position in the sample period. (3) In terms of exports, Russia has been firmly positioned as the largest arms exporter in the "Belt and Road" region, occupying more than half of the export share in the region. Arms' exports of China have become increasingly important, with the proportion of its exports jumping from 7.60% in 2004 to 18.00% in 2016. For the imports of arms trade, China was the largest arms imports country in the region for a period in the "Belt and Road" region, up to 23.36%

in 2004. While the first position of arms imports replaced by India in 2014, the proportion is 25.44%, China was reduced to 9.76%. In 2016, China is no longer one of top five arms imports countries along the "Belt and Road". (4) Most of the top five countries, except Russia and China, account for less than 10% of their imports and exports and show a downward trend. For example, Israel, which ranked 2nd in terms of arms exports in 2004, saw its export share fall from 7.60% to 4.24% in 2008 (3rd) and 3.77% in 2012 (3rd). The United Arab Emirates, the third largest arms importer in 2004, saw its import share drop from 8.53% to 5.93% in 2008 (5th), 6.30% in 2012 (4th) and 5.88% in 2016 (5th).

Table 1 Arms imports and exports of top 5 countries along the "Belt and Road"

Year	2004	2008	2012	2016
Arms exports of top 5 countries	Russia (78.41%) Israel (7.60%) China (5.16%) Ukraine (2.48%) Uzbekistan (1.57%)	Russia (75.70%) China (7.88%) Ukraine (4.71%) Israel (4.24%) Belarus (2.72%)	Russia (67.70%) China (12.33%) Ukraine (12.15%) Israel (3.77%) Turkey (1.17%)	Russia (57.00%) China (18.00%) Ukraine (11.77%) Israel (4.40%) Turkey (2.55%)
Arms exports proportion of top 5 countries	95.23%	95.26%	97.13%	93.72%
Arms imports of top 5 countries	China (23.36%) India (15.68%) UAE (8.53%) Saudi Arabia (8.25%) Greece (7.86%)	China (14.77%) India (14.52%) Singapore (8.78%) Pakistan (8.43%) UAE (5.93%)	India (25.44%) China (9.76%) Turkey (8.69%) UAE (6.30%) Saudi Arabia (5.98%)	India (15.06%) Saudi Arabia (13.64%) Iraq (8.35%) Egypt (7.82%) UAE (5.88%)
Arms imports proportion of top 5 countries	63.69%	52.43%	56.16%	50.75%

Note: Calculations are based on data from the Stockholm International Peace Research Institute

3. Competitiveness and complementarity of countries along the "Belt and Road": based on network analysis method

3.1 The construction of competitiveness and complementarity network of countries along the "Belt and Road"

Because of the large number of countries along the "Belt and Road", traditional methods can only analyze bilateral relations between countries. This paper analyzes the arms trade competitiveness and complementarity of the countries along the "Belt and Road" as a whole by means of network analysis method. In complex network analysis, each country is regarded as a "node" in the network, and the relationship between countries is connected in the form of "line" or "arch", thus forming a "network". Depending on the type of relationship concerned, different types of networks can be

formed. According to the competitiveness and complementarity of arms trade between countries, two different types of arms trade relationship networks can be established in countries, so as to reveal the general situation of arms trade of countries along the "Belt and Road" more comprehensively.

Trade complementarity between countries usually occurs when the export structure of one country is exactly matched with the import structure of another country, while trade competition between countries usually occurs when the export structure of two countries is similar (Carbaugh, 2012).

There are many ways to measure trade complementarity. This paper chooses the method proposed by Drysdale (1967), and the formula is as follows:

$$RCA_{xi}^k = \frac{X_i^k}{X_i} \bigg/ \frac{X_w^k}{X_w} \quad (1)$$

$$RCA_{mj}^k = \frac{M_j^k}{M_j} \bigg/ \frac{M_w^k}{M_w} \quad (2)$$

$$TCO_{ij}^k = RCA_{xi}^k \cdot RCA_{mj}^k \quad (3)$$

Where i and j denote export country i and export country j , respectively. X_i^k denotes the export of product k in country i . X_i denotes the total exports of country i , X_w^k denotes the total exports of product k of the world. X_w denotes the total exports of the world. M_j^k denotes the imports of product k in country j . M_j denotes the total imports of the world. M_w^k denotes the total imports of product k of the world. M_w denotes the total imports of the world. RCA_{xi}^k is the revealed comparative advantage index for export products k in country i , RCA_{mj}^k denotes the revealed comparative advantage index for import product k in country j (Balassa, 1965; Balassa, 1989). TCO_{ij}^k is the trade complementarity index of product k in country i and country j . The larger the index, the more complementary the two countries' trade.

There are various methods to measure trade competitiveness. This paper selects the method of Li, et al. (2017) and the formula is as follows:

$$TCI_{ij}^k = 0.5 \left| RCA_{xi}^k - RCA_{xj}^k \right| \quad (4)$$

Where RCA_{xi}^k and RCA_{xj}^k are the revealed comparative advantage index of product k in country i and country j , respectively. TCI_{ij}^k as a measure index of the trade competitiveness of product k in country i and country j , takes the value range of $[0, +\infty)$. The higher the value, the stronger the trade competitiveness between the two countries.

In order to compare the dynamic change of complex networks, this paper constructed two periods of networks in 2004 and 2016. To meet the need of vertical comparison, 66 countries along the "Belt and Road" are selected in this paper to construct the network

of arms trade. According to the division of time dimension and arms trade relationship, four arms trade networks are constructed (see Fig. 2-Fig. 5).

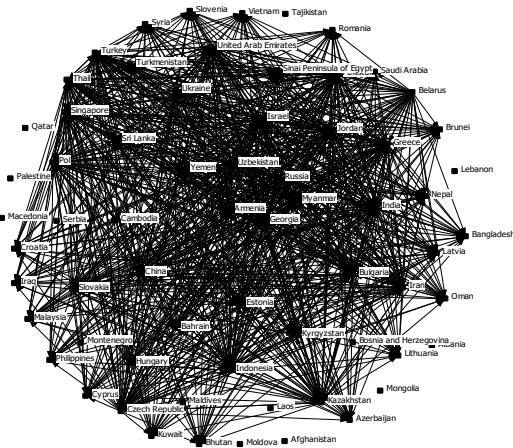


Fig. 2 Network of Complementarity in 2004

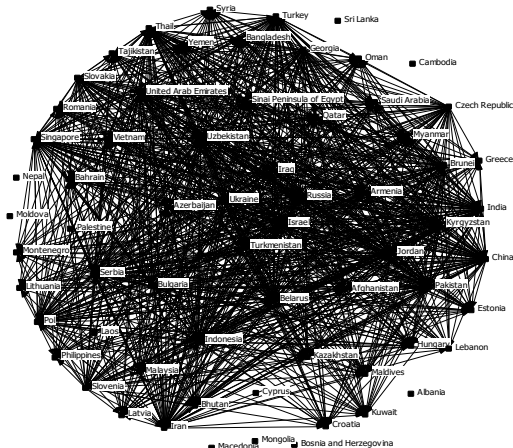


Fig. 3 Network of Complementarity in 2016

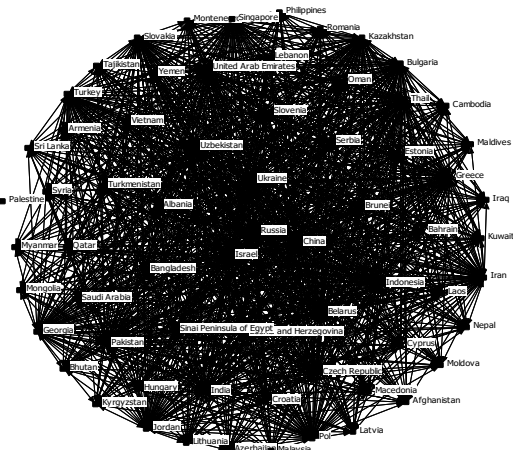


Fig. 4 Network of Competitiveness in 2004

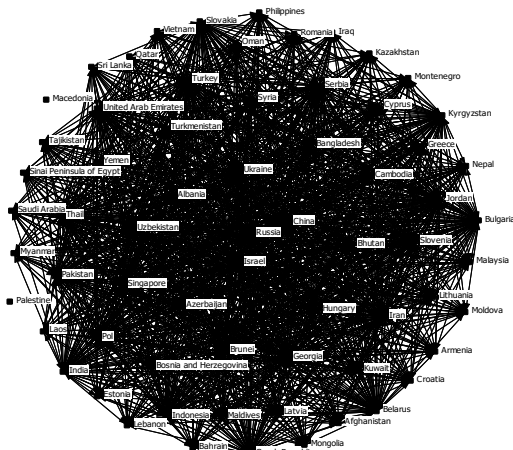


Fig. 5 Network of Competitiveness in 2016

3.2 Density analysis of arms trade networks

Density has been widely used in complex network analysis, and the concept describes the overall degree of correlation between each node in a network. Theoretically, the degree of association of any network is no higher than that of a "complete network" whose nodes are all connected to each other. Therefore, the closer the association between all nodes, the greater the network density (Scott, 2012). Assuming that there are N countries, L actual lines, and the maximum number of lines is $N(N-1)$, the density of this network is:

$$D_N = \frac{L}{N(N-1)}, \quad D_N \in [0,1] \quad (5)$$

According to Eq. (5), the density corresponding to the 8 arms trade networks is calculated (see Table 2). Arms trade complementarity (CTO) network density was 0.232 in 2004, the number of significant trade relations in 995, density rose to 0.265 in 2016,

a significant relationship between the number increased to 1135, during the period increased by 14.2%, the results show that, with the increase of arms trade among countries along the "Belt and Road", the trade structure has also been optimized, and the trade complementarity has been significantly enhanced. In 2004, the density of the arms trade competitiveness (CTI) network was 0.549, and the number of significant trade relationships was 2,354. In 2016, the density rose to 0.576, and the number of significant trade relationships increased to 2,472, an increase of 4.9% during the period, indicating that the arms trade competitiveness among countries along the "Belt and Road" has intensified in the past 10 years. Although from the perspective of network density, the competitiveness is greater than the complementarity, but the latter is more obvious, and the development space of arms cooperation among countries along the "Belt and Road" is still broad.

Table 2 Density of 8 arms trade networks

Arms trade network	Network density	Significant number of trade relationships
Network of Complementarity in 2004	0.232	995
Network of Complementarity in 2016	0.265	1135
Network of Competitiveness in 2004	0.549	2354
Network of Competitiveness in 2016	0.576	2472

3.3 Centrality analysis of arms trade networks

Centrality is an important index to measure the position and function of nodes in network. In the arms trade network, what kind of "power" a country has^①, or what kind of central position it occupies, is the focus of this paper. Based on the fact that the local centrality of nodes in networks of different scales is not comparable, this paper analyzes the centrality of networks according to "relative degree centrality" proposed by Freeman (1979). In a network of N nodes, the maximum possible degree of any nodes must be $(N - 1)$. If the degree is n , then the relative degree centrality is:

$$D_r = \frac{n}{N-1} \quad (6)$$

Where the concepts of density and centralization represent different aspects of the overall compactness of a network. If density is a measure of the overall cohesion level of a network, then the centralization describes the extent to which such cohesion is listed and organized around certain nodes, and the two concepts complement each other (Scott, 2012). In different networks, the centrality distribution of member states may be

^① Different disciplines and scholars give different answers to what "power" is. In the eyes of scholars in the field of social network, "power" symbolizes influence. The reason why a social actor has power is that it is associated with others, in other words, it is dependent on others (Liu, 2014).

different (Li, et al., 2017). Therefore, the analysis method of relative degree centralization index comes into being. The relative degree centralization index is expressed as:

$$C_{RD} = \sum_{i=1}^n \frac{C_{AD_{max}} - C_{RD_i}}{n-2} \quad (7)$$

Where $C_{AD_{max}}$ is the maximum of relative degree centrality, and C_{RD_i} is the relative degree centrality of i node.

The centrality measurement results of each network are shown in *Table 3*. Firstly, from the mean value of relative degree centrality, the mean values of complementarity and competitiveness networks in 2004 were 26.030 and 35.667, respectively, and 30.273 and 37.455 in 2006, increasing by 16.3% and 5.01%, respectively, indicating that the arms trade of countries along the "Belt and Road" has been closer in the past 10 years. Secondly, from the centralization of the network, the relative degree centrality of complementarity and competitiveness network in 2004 were 38.03% and 44.95% respectively, and in 2016 were 37.64% and 40.53%, respectively, fell 1.0% and 9.8%. The results show that since recent 10 years, the arms trade relations between countries are scattered to the multinational trend along the "Belt and Road", with the different visual impression on arms trade proportion to concentrate in a few countries.

Table 3 The centrality analysis of four arms trade networks

Arms trade network	Relative degree centrality D_r and rank of some countries	Relative degree centralization C_{RD}	Mean of relative degree centrality $Mean_D_r$
Network of Complementarity in 2004	Russia (46, 70.8, 18) China (50, 76.9, 5) India (50, 76.9, 5)	38.03%	26.030
Network of Complementarity in 2016	Russia (54, 83.1, 5) India (54, 83.1, 5) China (54, 83.1, 5)	37.64%	30.273
Network of Competitiveness in 2004	Russia (64, 98.5, 1) China (64, 98.5, 1) India (50, 76.9, 5)	44.95%	35.667
Network of Competitiveness in 2016	Russia (63, 96.9, 1) India (63, 96.9, 1) China (63, 96.9, 1)	40.53%	37.455

Finally, the change of some countries in the four networks of trade competitiveness and complementarity are analyzed^①. In the arms trade complementarity network, in

^① The selected countries are the top three countries in terms of arms trade in that year. In 2014 and 2016, the top three countries in arms trade were Russia, China and India.

2014, Russia had 46 countries with significant complementary relationship with other countries along the "Belt and Road", with a relative degree centrality of 70.8, ranking 18th. China and India are among the 50 countries that have complementary relations along the "Belt and Road", and their relative degree centrality are both 76.9, ranking joint fifth. In 2016, the number of countries with complementary relationships with Russia rose to 54, with the relative degree centrality rising to 83.1, which puts Russia in joint fifth place with China and India. Russia and India are playing an increasingly important role in the complementary relationship with countries along the "Belt and Road". In the arms trade competitiveness network in 2004, Russia, similar to China, had 64 competitors with countries along the "Belt and Road", with a relative degree centrality of 98.5, ranking joint first. India has 50 competitors with countries along the "Belt and Road", with a relative degree centrality of 76.9, ranking fifth. In 2016, Russia, China and India all had 63 competitive relationships with countries along the "Belt and Road", with a relative degree of degree centrality of 96.9, ranking joint first. Different from the complementarity aspects, the arms trade competitiveness among Russia, China and India along the "Belt and Road" is becoming increasingly fierce.

3.4 Block model analysis of arms trade network

Block model analysis, as a method to study network location model, mainly conducts descriptive algebraic analysis of social roles. This method was first proposed by White, et al. (1976), and has been further improved and promoted (Wasserman & Faust, 1994; Doreian, et al., 2004). Many scholars also use the "block model" to study some specific issues, such as the study of the world economic system (Snyder & Kick, 1979) and the study of the scientific community (Breiger, 1976). Countries along the "Belt and Road" are divided into several country blocks in using CONCOR arithmetic (convergence of iterated correlations) introduced by Schwaratz (1977), and the role of each economic block and its member countries in arms trade is revealed according to the trade relations between the inside and the outside of the block. Based on the practice of Li, et al. (2014), this paper divides the member countries into four typical country blocks. The first kind of block is called "inward type block", the internal association of the block is stronger than outside. The second kind of block is called "outward type block", the internal association is weaker than outside. The third kind of block is called "dual type block", there are many internal and external associations. The fourth kind of block is called "isolated type block", with little or no internal or external correlation. The block

division of member countries varies according to the different standards of concern^①.

Relevant setting is required before block model analysis. According to the practice of Li, et al. (2017), the maximum segmentation depth is 2 and convergence standard is 0.2. Block model analysis divides each network into four arms trade blocks. The internal and external trade relations of each country block were reflected by the "density matrix" and "image matrix" of the network^②. The value of a block (1-block or 0-block) can be based on a variety of criteria, such as: complete fitting, 0-block standard, 1-block standard, α - density index, maximum standard, and average standard. Without generality, the average density of the whole network is taken as the value standard of 0-1 in the image matrix, as the result presented are reliable and convenient to demonstrate in using the standard of average density. In the block model analysis, in order to make the countries along the "Belt and Road" be clearly classified among each block, it is very necessary to appropriately improve the significance standard of arms trade relationship. In this paper, 0.3 is taken as the critical value as the screening standard of complementarity network and competitiveness network.

3.4.1 Block Model analysis of complementarity network in arms trade

The density matrix and image matrix were calculated based on the arms trade complementarity network (TCO-0.3 standard) in 2004 (see *Tables 4* and *Table 5*). In 2004, the average density of the arms trade complementarity network (TCO-0.3 standard) was 0.1431 and the goodness of fit R^2 was 0.703.

Table 4 Arms trade complementarity network (TCO-0.3 standard) density matrix in 2004

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	0	0	0	0
The 2nd block	0	0	0.903	0.969
The 3rd block	0	0	0.009	0.005
The 4th block	0	0	0.629	0.769

Table 5 Image matrix of arms trade complementarity network (TCO-0.3 standard) in 2004

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	0	0	0	0
The 2nd block	0	0	1	1
The 3rd block	0	0	0	0
The 4th block	0	0	1	1

The first block is an isolated block. The arms trade between the countries in the block and other countries along the "Belt and Road" is less complementary, and TCO is less

^① It should be noted that due to the different characteristics of the network itself, the above four typical types of blocks may not exist simultaneously in a specific network.

^② The density matrix is an extension of the overall network density, and the principle of measurement is the same.

than 0.3 in terms of both intra-block exports and off-block exports. The block consists of 15 countries, including Afghanistan, Albania, Moldova, Maldives and Mongolia. The second block belongs to the outward block. There are many countries with TCO greater than 0.3 calculated based on the exports of the block, and the export momentum towards the third block and the fourth block is strong, with densities of 0.903 and 0.969, respectively. The fourth block has more opportunities to import arms from the second block, and its trade is more complementary. The block is made up of five countries: Belarus, Uzbekistan, Ukraine, Slovakia and Russia. The third block belongs to the outward block. There are few countries whose TCO is greater than 0.3 calculated by the exports of the block, while there are more countries importing arms from the second block and the fourth block, with densities of 0.903 and 0.629, respectively, which are highly complementary to the trade between the two. There are 33 countries in the block, which is the largest number of countries in the block. The countries and regions in the block are widely distributed, including Southeast Asian countries represented by the Philippines and Vietnam, Middle Eastern countries represented by Iran and Iraq, and central and Eastern European countries represented by Hungary and Romania. The fourth block belongs to the dual block. This block has an important position in the network. It is not only closely related to the arms trade within the block (density is 0.769), but also highly complementary to the third block (density is 0.629). The block is made up of 13 countries, including China, India and Israel.

In 2016, the distribution and countries of the arms trade complementarity network block changed greatly (see *Table 6* and *Table 7*). In 2016, the average density of the arms trade complementarity network (TCO-0.3 standard) was 0.1730, and the goodness of fit R^2 was 0.705.

Table 6 Density matrix of arms trade complementarity network (TCO-0.3 standard) in 2004

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	0.252	0.029	0	0.044
The 2nd block	0.003	0	0	0
The 3rd block	0	0	0	0
The 4th block	0.989	0.825	0	0.543

Table 7 Image matrix of arms trade complementarity network (TCO-0.3 standard) in 2016

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	1	0	0	0
The 2nd block	0	0	0	0
The 3rd block	0	0	0	0
The 4th block	1	1	0	1

The first block belongs to the dual type. The complementarity of arms trade in the block is significant (density is 0.252), and there is also a significant complementarity with the fourth block (density is 0.989), with strong import momentum from the latter. The block is made up of 18 countries, including South Asian countries such as India, Central Asian countries such as Kazakhstan and Southeast Asian countries such as Indonesia. The second block belongs to the outward type. The trade with the first block and the fourth block is highly complementary, providing these two block countries with more export opportunities of arms. The block consists of 21 countries, mainly Poland, Bahrain, Romania and many other Central and Eastern European countries, as well as a few Southeast Asian countries such as the Philippines and Vietnam. The third block belongs to the isolated type. There are few countries with TCO greater than 0.3 calculated inside and outside the block, and the complementarity of arms trade is not obvious. The block is mainly composed of Mongolia, Bosnia and Herzegovina, Sri Lanka and other 12 countries. The fourth block belongs to the dual type. This block plays a key role in the network. Not only is the internal arms trade highly complementary (density 0.543), but it is also significantly complementary with the arms trade in the first block (density 0.989) and the second block (density 0.825). The block consists of China, Russia, Israel, some Central and Eastern European countries (such as Belarus and Slovakia), and central Asian countries (Kyrgyzstan, Uzbekistan, etc.).

3.4.2 Block model analysis of arms trade competitiveness network

The density matrix and image matrix were calculated based on the arms trade competitiveness network (CTI-0.3 standard) in 2004 (see *Tables 8* and *Table 9*). In 2004, the average density and goodness of fit R^2 of the arms trade competitiveness network (TCO-0.3 standard) were 0.2401 and 0.846, respectively.

Table 8 Density matrix of arms trade competitiveness network (TCO-0.3 standard) in 2004

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	0	0	0.986	0.857
The 2nd block	0	0	0.167	0.857
The 3rd block	0.986	0.167	0	0.857
The 4th block	0.857	0.857	0.857	0.714

Table 9 Image matrix of arms trade competitiveness network (TCO-0.3 standard) in 2004

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	0	0	1	1
The 2nd block	0	0	0	1
The 3rd block	1	0	0	1

The 4th block	1	1	1	1
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The first block is outward type. There is no significant arms trade competition within the block, but there is significant trade competitive between the block and the third block and the fourth block. The countries in the block are widely distributed, including 48 countries from Central and Eastern European countries such as Albania and Croatia, Central Asian countries such as Tajikistan and Kazakhstan, Middle Eastern countries such as Iran and Saudi Arabia and South Asian countries such as Nepal. The second block is extroverted. This block only has a significant trade relationship with the fourth block. It is made up of 8 countries, including China, India and Turkey. The third block belongs to the outward type. This block has obvious arms trade competition relation with the first block and the fourth block. Consisting of only Greece, Slovakia and Bulgaria, it is the block with the smallest number of countries. The fourth block belongs to the dual type. The arms trade between countries inside and outside the block has a significant competitiveness. It is mainly composed of 7 countries including Russia, Ukraine, Israel and other arms trading powers.

The density matrix and image matrix were calculated according to the arms trade competition network (CTI-0.3 standard) in 2016 (see *Tables 10* and *Table 11*). In 2016, the average density of the arms trade competitive relationship network (TCO-0.3 standard) was 0.3100, and the goodness of fit R2 was 0.795.

Table 10 Density matrix of arms trade competitiveness network (TCO-0.3 standard) in 2016

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	0	0	0.714	1
The 2nd block	0	0	0.714	0.81
The 3rd block	0.714	0.714	0.381	0.714
The 4th block	1	0.81	0.714	0.095

Table 11 Image matrix of arms trade competitiveness network (TCO-0.3 standard) in 2016

	The 1st block	The 2nd block	The 3rd block	The 4th block
The 1st block	0	0	1	1
The 2nd block	0	0	1	1
The 3rd block	1	1	1	1
The 4th block	1	1	1	0

The first block is extroverted. This block has obvious arms trade competitiveness with the third block and the fourth block. There are many countries in the block and they are widely distributed, including 49 countries in total, mainly composed of Albania, Poland and other Central and Eastern European countries, South Asian countries such as India and Nepal, Southeast Asian countries such as Thailand and the Philippines, Middle Eastern countries such as Saudi Arabia and Iran, and Central Asian countries

such as Kazakhstan and Tajikistan. The second block is outward and has significant arms trade competition with the third and fourth blocks. The block consists of only three countries: the Czech Republic, China and Indonesia. The third block is of a balanced type, with competitive arms trade relations between internal and external countries. The block is made up of seven countries, including Russia, Israel and Belarus. The fourth block is an export-oriented block. Except for no obvious competitive trade relations in the block, there are relatively significant arms trade competitiveness with countries in the first, second and third blocks. Mainly by Bulgaria, Turkey, Georgia and other 7 countries.

4. Research conclusion

This paper uses the complex network analysis method to study the competitiveness and complementarity and dynamic changes of arms trade of countries along the "Belt and Road" in the recent 10 years during 2004-2016.

The main research conclusions are as follows: (1) From the perspective of the basic pattern and evolution trend of arms trade, from 2004 to 2016, the arms import and export growth rate of countries along the "Belt and Road" is generally faster than the world average, accounting for more than 60% of the world's total amount, and the annual arms import is about 76.33% higher than the exports. In the past ten years, there has been a more obvious centralization trend in both arms imports and arms exports. Among them, Russia, China, Israel, Ukraine, Turkey and other countries occupy the leading position in arms export, while China, India, United Arab Emirates, Saudi Arabia and other countries occupy the main position in arms import. (2) In the past 10 years, the arms trade relationship between countries along the "Belt and Road" has been increasingly strengthened and the trade network density has increased. On the whole, competitiveness is greater than complementarity, but the latter is more obvious. Up to 2016, more than a quarter of countries along the "Belt and Road" have complementary arms trade relations, and around 17% of countries have close complementary arms trade relations. More than half of the countries have arms trade competitiveness, and nearly 30% of countries have intense arms trade competitiveness. (3) The "Belt and Road" countries have two distinctly important arms trade complementarity blocks. One is an outward block made up of Russia and several Central and Eastern European countries, and the other is a dual block made up of China, India, Israel and other countries. In 2004, the block represented by Russia had strong arms export capability, which played an important dominant role in other blocks. On the one hand, the blocks represented by

China and India and the three countries have certain complementarities with the former; on the other hand, they play an increasingly important role in other block countries along the "Belt and Road". In 2016, two blocks in the depth of fusion, form a complementary relationship with both type blocks, the blocks containing China, part of the commonwealth of independent states (Russia), parts of Central and Eastern European countries such as Belarus, Central Asian countries such as Uzbekistan and part of the Middle East (Israel). This block has a profound impact on the complementary relationship of arms trade along the "Belt and Road". (4) In the countries along the "Belt and Road", there are three major arms trade competitiveness groups. The first is made up of traditional military manufacturing and export powers like Russia, Israel and some Central and Eastern European countries, among which 71% of countries have fierce competitiveness, while the competition with other blocks is also intensifying. The second is China, India and other emerging military giants, with no fierce internal competitiveness, but increasingly fierce competitiveness with the first group. The third group is numerous and widely distributed, including most of the countries of Central and Eastern Europe, some of the countries of Central Asia and some of the countries of Central and North Asia. In 2016, the first group members did not change obviously, internal and external arms trade is still fierce competition, the second group of the three countries, only China, the Czech republic and Indonesia and plays a significant role in the first group of arms trade competition, great changes have taken place in the third group members, but improve on the arms trade competitive with other blocks have strong trade competition.

References

- Balassa, B. 1989. *Comparative Advantage, Trade Policy and Economic Development*. Harvester Wheatsheaf, New York.
- Balassa, B. 1965. *Trade Liberalization and Revealed Comparative Advantage*. Manchester School of Economics and Social Studies, (3).
- Breiger, R. L. 1976. Career Attributes and Network Structure: A Block Model Study of a Biomedical Research. *American Sociological Review*, (41): 117-135.
- Carbaugh, R. J. 2012. *International Trade*. Beijing: Renmin University of China Press, 15th edition.
- Doreian, P., Batagelj, V., Ferligoj, A. 2004. Generalized Block Modeling of Two-Mode Network Data. *Social Networks*, (26): 29-53.
- Drysdale, P. 1967. *Australian-Japanese Trade*. Canberra: Australian National University,

PhD. Thesis.

Freeman, L.C. 1978. Centrality in Social Networks: Conceptual Clarification [J]. *Journal of social networks*, (1): 215-239.

Schwartz, J. E. 1978. An Examination of CONCOR and Related Methods for Blocking Sociometric Data. *Sociological Methodology*, San Francisco, CA: Jossey-Bass.

Scott, J. 2012. *Social Network Analysis*. London and Beverley Hills, Sage Publications, Third Edition.

Snyder, D., Kick, E. L. 1979. Structural Position in the World System and Economic Growth, 1955-1970: A Multiplication-Network Analysis of Transitional Interactions. *The American Journal of Sociology*, (5): 1096-1126.

Wasserman, S., Faust, K. 1994. *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge University Press.

White, H.C., Boorman, S.A., Breiger, R. L. 1976. Social Structure from Multiple Networks: Block Models of Roles and Positions. *American Journal of Sociology*, (81): 730-779.

Hu, J. 2005. Comparative Advantage Analysis in International Arms Trade. *Economic and Social Development*, (1): 35-55.

Li, J., Chen, N., Wan, G. H., Chen, S. 2017. Competitive and Complementary Relations and Dynamic Changes of Goods Trade in Countries along the "Belt and Road" and Based on Network Analysis Method. *Management World*, (4): 10-19.

Li, J., Chen, S., Wan, G. H., Fu, C. M. 2014. Spatial Correlation and Its Interpretation of Regional Economic Growth in China: based on Network Analysis Method. *Economic Research*, (11): 4-16.

Liu, J. 2006. Research on the Overall Structure of FaCun Social Support Network Block Model Machine Application [J]. *Society*, (3): 69-80.

Liu, J. 2004. Research on Social Network Model. *Sociology Research*, (1): 1-12.

Qiu, X. L., Li, P., Qin, G. P. 2003. On China's Arms Trade and Its Development Countermeasures. *Journal of University of International Business and Economics*, (4): 17-23.

Zhao, Y. 2006. Brief Analysis of Arms Trade. *Taiwan Sound·New Perspective*, (1): 263-264.

Zhu, Q. C. 2002. Why Do We Sell Death? *International Outlook*, (20): 41-45.