Measuring Dynamic Competitive Intensity Among the Global Coal Importing Trade

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ABSTRACT

The International Energy Agency has provided the data that coal consumption is a major source of carbon dioxide (CO_2) emissions. Up to now, the evolution of the global coal trade volume still tends towards increasing. However, whether there is a possibility of downward trend in global coal trade competition? This paper offers a comprehensive exploration and discussion of dynamic competitive intensity among the global coal importing trade from a continuous time series perspective. First, the results indicate that global coal trade competitive intensity has continued to rise. Next, we find that the role played by the Asian-Pacific region, led by Japan and China in sequence, in the evolution of this competitive pattern is becoming increasingly prominent. The competitive intensity of European importers has declined since 2007. Finally, based on the results, it is recommended that the policy makers in Asian countries should make out strategies such as adopting environmentally friendly technologies to decrease the CO_2 emissions.

Keywords: Competitive coal import network• Evolution• Network features• Complex network

NONMENCLATURE

Abbreviations	
CICN	coal import competition network
CO_2	carbon dioxide

1. INTRODUCTION

The proportion of carbon dioxide (CO_2) emissions derived from coal resource around the world was up to 62% in 1996. Despite a drop thereafter, the share of 40% in 2017 nonetheless is also considered to be high, according to the International Energy Agency (IEA, 2018). In recent years, coal demand in Europe, Canada, and the United States have experienced a decline, however, Asia saw notable rise on coal consumption, which offset the reduction in coal demand in those countries (IEA, 2018). Overall, the coal trade volume and density all over the world still remain increasing (Wang et al., 2019), which is not a favourite trend for mitigating climate change. However, whether there is a possibility of downward trend in global coal trade competition? If so, this means that countries are becoming less dependent on coal and thereby the high level of CO_2 emissions would be gradually reduced in the near future. However, if the global competition among coal importers

has become more drastic and complex, further extensive study is required for the purpose of controlling the global coal trade competition. For example, identifying regions or countries that the complex competitions concentrate in, discussing the driving reasons behind the increasingly complex competition in these regions and countries, and proposing policy implications regarding declining the competition in the global coal trade. To gain a definitive answer to this question, it is necessary to investigate systematic structure and dynamic competitive relationship and intensity of global coal trade competition in a long time period.

The main contribution of this paper to the literature is: (1)We investigate an interesting question that whether there is a possibility of downward trend in global coal trade competition, which would be helpful to see clearly the trend of global coal consumption and induce countries to make out coal strategies that lower CO_2 emissions rates and better utilization of the energy. (2)We measure and map the temporal evolution of the CICN by employing a complex network model, which fills the research gap in the coal resource trade from the perspective of competition. (3)We discuss potentially effective implications for investors and policymakers with respect to facing the current situation of global coal-trading competition, which can further extends the literatures considering strategies for coal trade and reducing CO_2 emissions.

The paper is organized as follows. Section 2 presents the data source and methodology used to analyse the CICN. Section 3 discusses empirical results and discussion. Conclusions and strategic policies are given in Section 4.

2. METHODOLOGY

2.1 Data sources

The data source used in this research is from the website of UN Comtrade[1], which is an authoritative and widely covered database that contains all the export and import flows among 226 countries. Each type of commodities in the database has a code in terms of HS code, and the HS code of the coal we use is 2701. We select the annual data of all the available countries for the1998 - 2017 period to calculate competitive relationship and intensity of global coal importing trade.

2.2 Coal import competition network modelling

Given the facts that the overbalance of coal resources, it is inevitably that at least two coal importers import coal from the same coal exporter, which drive the importers to compete coal resources with another one. In addition, the intensities of competition between coal importers are necessarily different due to the otherness in the coal demand of importers.

Thus, in this paper, we construct a symmetrical weighted model to comprehensively grasp the characteristics of the evolution of the competitive relationships that exist between coal importers using complex network theory, which has been widely used in many studies analysing competition and the trade network(Zhang et al.,2014; Li et al.,2014; An et al.,2014; Chen et al.,2016; Hao et al.,2018; Dong et al., 2018; Kitamura and Managi, 2017; Gao et al., 2015; De Andrade and Rêgo, 2018; Bian et al.,2016; Zhang et al., 2017).

This network model representation is a graph of a fully connected network made by nodes, connected by links that represent

[1] https://comtrade.un.org/data/.

bilateral relationships. In particularly, countries taking part in global coal import trade are the nodes, and all of the coal stations a country contains are aggregated into one node. Links correspond to the coal competition between nodes, representing that there exists coal import competition between any pair of nodes. To give a detail explanation for links, we take a simple example. In Fig.1, nodesV1, V2, V3, and V4 are coal importers, and nodes C1and C2 represent coal exporters. A competitive relationship exists between V1, V2, and V3, because they all import coal from C1, meanwhile, V3 also has competition with V4 due to their joint coal resource, C2.The intensity of the link is characterized by the level of competitive intensity, which is calculated by Eq. (1)(An et al., 2014).

$$S_{ij} = \sum_c \left\{ \left(\frac{M_{ic}+M_{jc}}{M_w} \right) * \left[1 - \frac{\left| \frac{M_{ic}}{M_i} - \frac{M_{jc}}{M_j} \right|}{\frac{M_{ic}}{M_i}+\frac{M_{jc}}{M_j}} \right] \right\} * 100 \quad (1)$$

where S_{ij} representsthe competition intensity between coal importer v_i and v_j, c represents the common coal import source v_c, M_{ic} denotes the coal import volume that importer v_i imports from v_c, M_{jc} represents the coal import volume that importer v_j imports from v_c, M_w is the world's total coal import volume, M_i is the total coal import volume of importer v_i, and $M_j$is the total coal import volume of importer v_j.

As the competition is mutual, the direction of the edges is undirected. On the whole, the competitive coal import relationships among countries, or the network connections, represent a certain intensity and heterogeneity.

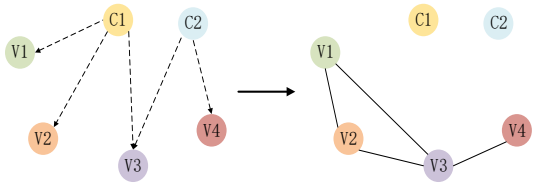

Fig.1. The diagram of competitive relationships

3. RWSULTS AND ANALYSIS

To deeply detect the competitive intensity between importers, we take the link weights into consideration and depict the extent of coal trade competition between any country-pair by conducting a weighted network, where the weight of each link is given by Eq. (1) in section 2.2. This part first presents the overall features of CICN in terms of the competitive intensity, then, the importing competition evolution from the regional and national perspective respectively are showed.

3.1 The overall features

To capture the overall situation of competitive intensity between countries involved in the coal import trade, the distribution of competition intensity is computed, which is shown in Fig.2. It is clear that the distribution of competitive intensity is rather unbalanced. Approximately 80% of the competitive intensity arise from 20% of competition relationships, which means that the fiercest competition for coal is generated by a handful of countries. This also provides in part an evidence that the competition between countries is a competition for resources.

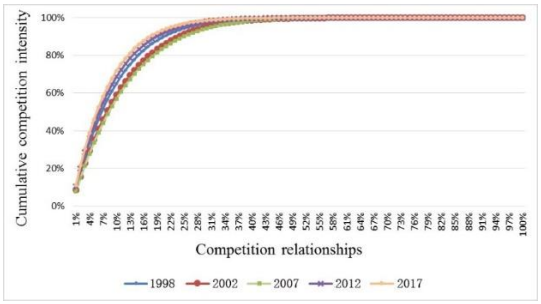

Fig. 2. Competitive intensity distribution of CICN in 1998, 2002, 2007, 2012, and 2017

3.2 The competition evolution from the regional perspective

Fig.3 allows us to understand the level of intra-region import competitions and competitive relationships in each region. As shown by Fig.3, the ranking position of intra-region competitions of the Asian-Pacific, European, and South American region remain relatively stable, ranking first, second, and third, respectively. In contrast, Africa has weaker intra-region competition since 2007, and its ranking decreased from fourth to fifth, which can be seen by its different colour in Fig.3.For the competitive intra-region relationships, the greatest competitive import relationships of the Asian-Pacific region are concentrated in the northeast Asian countries such as Japan, China, and South Korea. Particularly, all the greatest competitive relationships in different years are related to Japan, which indicates the important role of Japan in the CICN. The situation is similar in South America, where Brazil is the major driving force in the growth of coal competition in the South American region. Regarding North America, the increasing competitive intensity of the USA had led to the growing trend of coal import competition of the whole region. It is clear that the Netherlands have lost their dominant position in the intra-region competition of Europe when comparing the figures of different years.

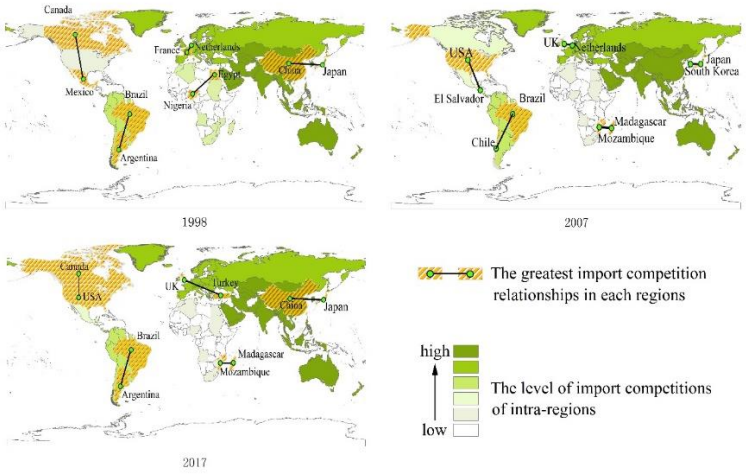

Fig. 3. The level of intra-region import competitions and the greatest import competition relationships in each regions

From Fig. 4 as a whole, we can see that the coal import competitive intensity exists primarily in intra-Asian and intra-European contexts, as well as between the European and Asian-Pacific markets, which is related to the fact that most coal importers are located in the Asian-Pacific region and Europe, such as China, Japan and the

United Kingdom. In addition, in 2007, most competitive intensities between regions decreased obviously. The reason may be that importers expanded their importing sources and reduced their competitive intensity with single import competitors through an import diversification strategy to enhance their coal supply security.

Specifically, the Asian-Pacific region faces the largest amount of competitive pressure, of which intra-Asian competition is the major source, particularly in 2017, when the competitive intensity in intra-Asian countries increased significantly to twice its value from 1998.Except for intra-Asian competition, Europe and South America are the greatest competitors with the Asian-Pacific region, of which the increasing coal consumption of China has made a significant contribution. Nevertheless, the competition between Europe and rest of the regions is on the decline, compared with that in 1998, because of its diminishing demand for coal. Regarding North America, South America, and Africa, because of the development of the Asian-Pacific region, the competition between these three regions with the Asian-Pacific region obviously increased. In contrast, due to the relatively stable competitive structures between North America and the countries of South America, competition among them remains extremely steady during the whole period.

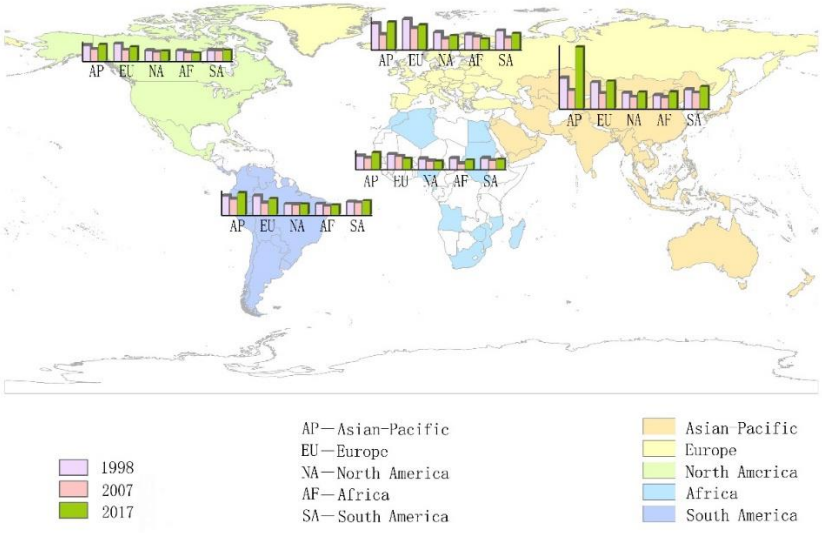

Fig. 4. The competition intensity among regions

4. CONCLUSIONS AND POLICY IMPLICATIONS

We applied the complex network analysis method to reveal dynamic competitive intensity of the global coal trade system. The results and analysis above might help us to understand how network topology and function in the coal trade competition system interact and what roles countries play in global coal trade competition, furthermore help national governments adopt feasible and targeted policies on coal trade reducing and CO_2 emissions. Additionally, we can imagine the possible development trends according to the present competitive pattern. Conclusions are reached and some policy implications are proposed, which consist of the following.

First, we gain a specific answer to the question that whether there is a possibility

of downward trend in global coal trade competition. Not as we expected, the coal import market is becoming complex. Meanwhile, the increasingly complex competitive relationships have strengthened the restrictions on interactions among coal importers. As a result, a conflict or sanction incurred by a country or the adjustment of a coal importer's import strategy will influence the competition faced by their competitors and the stability of the coal trade, and this impact will spread very quickly through the network, which will lead to a serious impact on the coal import security. Thus, joint efforts such as conducting a systematic framework at global level should be made for coal trade cooperation in a healthy competitive environment.

Second, the results indicate that the countries with the highest import volume are also the most intense competitive importers; furthermore, the most intense competition for coal is generated in a handful of countries, especially Asian countries such as China, Japan, South Korea, and India, as well as European countries such as Germany and Turkey. Accordingly, these countries should undertake the responsibility of participating in addressing growingly drastic trade disputes and improving the sustainable development of the coal trade to ensure the steady operation of coal import competition.

Third, as shown by our analysis above, in recent years, the growing demand for coal in Asian countries, led by Japan and China in sequence, had made the coal competition related to the Asian-Pacific region more active and drastic, which enhances the pressure of competition and the level of competition for global coal resources. Facing such challenges, each highly competitive coal importer in the Asian-Pacific region should develop corresponding strategies to adapt to the current competitive coal-trading environment. This approach will help them to avoid blind competition and to develop free and healthy circumstances for coal import abroad.

Furthermore, the fact of record-high levels of coal competition in Asia should be given high attention, due to the huge effects of Asian coal consumption on the global CO_2 emissions. It is also necessary for Asian coal importers to take reducing CO_2 emissions into account. Emissions from coal consumption can be reduced by lowering the rate of emissions per ton consumed, the number of tons consumed, or both (Riker, 2012). For example, a re-examination or a better framework ideally involving regular evaluation of the coal resources at the stages of the development, application, and post-implementation should be taken into consideration in Asia. In addition, investing in appropriate use of the coal and sophisticated technology to promote new resources of energy and sources of renewable energy are also great way of reducing coal consumption levels.

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