



Competition pattern of the global liquefied natural gas (LNG) trade by network analysis



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ABSTRACT

Liquefied natural gas (LNG) has been categorized as a global commodity because of the continuous globalization of the LNG trade, and there is very close competition between LNG exporters worldwide. However, the overall competition structure and degree of the global LNG trade system were not well portrayed or quantified in the existing literature. This paper examined the trade competition pattern of the global LNG trade by building LNG trade competition networks (LTCN) from 2005 to 2014. Overall, the competitive relationship growth and competitive globalization features of the LNG trade were analyzed, and the main LNG exporter group and its evolution were studied. Moreover, the market competitiveness of LNG exporters was measured, and accordingly, these exporters were divided into three categories to depict their different development prospects, which would form a more complicated competition pattern of LNG trade in the future.

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1. Introduction

The development of the international Liquefied natural gas (LNG) trade in the past decade has led to an increasing amount of competition among LNG exporters, both in terms of trade volume and scope. The reasons are varied, one of which is the demand growth for clean energy worldwide. The use of natural gas, serving as a form of 'bridging fuel' to a sustainable energy system, has grown rapidly since the 21st century for its clean burning properties and will be the second-largest fuel in the global energy mix after oil, according to the forecast of the *International Energy Agency* (IEA). On the other hand, LNG has been favored more as another form of natural gas than pipeline gas. For a long time, the pipeline was the main transit form for the gas trade, and gas security was a primary issue, as seen in the conflict between Russia and the Ukraine. LNG, due to its flexibility, has become an important tool for gas security and has linked the world gas trade market as a global

commodity. The proportion of the natural gas trade, 43% in 2012, is projected to increase to 48% in 2040, according to the estimates of the IEA. The important role of natural gas played in smart grids will also promote its demand (Bliek et al., 2011). Over the next 25 years, the demand for natural gas will grow by an annualized 1.4%, of which two-thirds will come from LNG (*World Energy Outlook 2014*) (IEA, 2014). Moreover, an emerging niche market has been forming due to the development of floating liquefaction plants. Shell's FLNG facility will be the largest floating offshore facility in the world, which will significantly promote the flow capacity of LNG (Wood, 2012). In addition, according to the BP statistical review of world energy, the number of main LNG exporters more than doubled from 2005 to 2014 (BP, 2015). All of the factors mentioned above have complicated LNG trade competition. Actually, we know that there exists competition among LNG exporters, as well as importers, yet the competition among exporters caused by capturing more market share with the expansion of LNG trade is our focus, and we want to explore the features and laws detailedly in this study, the competition pattern for LNG importers may be our further research. Therefore, we want to understand the dynamic competitive relationships among LNG exporters and the laws of its evolution, which can help explain the development features and patterns of the global LNG trade.

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A large amount of research has been done to depict the development and reflect the competition of the LNG trade from the perspective of global or regional trade over the past few years. Considering the current status of LNG demand and supply and future trends, natural gas has been a major source of energy, and the technical and economic advantages drive the unceasing growth of gas trade. In the foreseeable future, no fossil fuel will grow faster than natural gas (in terms of LNG), and the expanding global LNG production may result in an evolution toward a world gas market (Kumar et al., 2011; Holz et al., 2015). Unlike other primary sources of energy, such as oil and coal, gas is not generally considered part of the global trade because of the regional limits of pipelines. Compared with the pipeline gas trade network, Geng et al. (2014) found that the countries in the LNG trade network are linked more closely. Barnes and Bosworth (2015) employed a gravity model to test the function of LNG for the integration of the total gas market. The results indicated that LNG is indeed a global commodity, whereas compressed natural gas markets are more regional, and the trade in liquefied natural gas has de-regionalized the entire natural gas market. Ritz (2014) believed that it is partly a matter of definition as to whether gas is a global commodity. The answer is yes — in the sense that several LNG exporters sell in almost all major markets — and no as there is currently no clear tendency toward a single uniform gas price. The competition caused by the decrease in gas prices will ultimately promote the integration of the LNG market. Considering the relationship between natural gas prices and LNG imports, and as shipping technology improves and transport costs fall, lower LNG value chain costs have made LNG a viable and attractive substitute for domestic and imported pipeline natural gas (Maxwell and Zhu, 2011). In past years, LNG was likely traded on long-term contracts. Although the situation has changed in recent years, a continuing evolution of global LNG markets is moving toward a larger proportion of volumes being traded on short-term contracts or sold as spot cargoes, which will promote the liquidity of the LNG market (Khalilpour and Karimi, 2011; Hartley, 2015). Different regions have made different decisions on whether to obtain gas resources. Natural gas plays an important role in satisfying the regional demand of the Asia-Pacific region and transitioning the region to a low-carbon economy. Over the past decade, LNG has reached the Asian market from a wide range of producing regions, and the attractive investment climate will promote the development of small-scale floating LNG technology (Aguilera, 2014). Although parts of Central and South America have a well-developed natural gas pipeline infrastructure, supply disturbances and political differences in recent years have raised concerns about the security of its supply and have encouraged several countries to consider importing LNG as a long-term supply solution (Kumar et al., 2011). The EU has established the commoditization of natural gas through the socialization of several costs of trade, which aims at accessing more liquid markets. Compared with a pipeline, it may be more efficient to invest in storage or LNG regasification terminals Vazquez et al. (2012) (Dieckhoener et al., 2013). Thus, the increasing demand for LNG for gas consumption compels importers to seek more LNG suppliers, which allows more competitive relationships to form between LNG exporters.

The characteristics and increasing global competition of the LNG trade have changed in response to the development of the global LNG trade. Inter-regional competition status has been changing unceasingly with the different development postures of the regional LNG industry. Some researchers analyzed the competition changes and influence of the region's development on the LNG trade market. The MENA region is facing a competitive situation, in which Africa will compete with MENA in the world's LNG markets and where Australia is soon set to overtake Qatar as the world's

largest LNG supplier. Moreover, subsidies and energy overuse are affecting their export potential (Khatib, 2014). With the shale gas boom of the U. S., natural gas exports will have a global impact on both LNG importers and other exporters. Arora and Cai (2014) evaluated the potential impact of U.S. gas exports, and the results showed that natural gas importers will fare better with exogenous U.S. exports (LNG or pipeline), whereas natural gas exporters will be pressured to some extent. The growth of the LNG trade and the increase in LNG exporters will also result in a game between the two opposing sides of the LNG trade. The EU intended to redefine its relations with its main suppliers, such as Russia, by imposing a model based on competition, the unbundling of network industries and privatization, but Russia disagrees, which may be the reason for their subsequent disputes (Locatelli, 2015). Following the dissolution of the Soviet Union, various gas pipeline projects have been proposed to diversify the transit routes and export markets of landlocked Central Asian states (Cobanli, 2014), which would result in a direct competition between Europe and Asia. At the same time, the LNG from MENA and Africa also competed with the Central Asian gas, thus, the competition and power game within these regions are fairly complicated.

The present literature about the natural gas trade reflects the LNG trade competition from the supply and demand side in the context of industrial development and technological progress. However, the overall structure and degree of the global LNG trade competition were not portrayed or quantified. Considering the global LNG trade as an entire system, the intricate competitive relations between LNG exporters has already formed a complex network. Understanding the structure of this network and the role of nations in the network may help us to grasp the practical influence caused by the change of network. The complex network theory provides a quantitative method to analyze the global trade system as a whole and as part of a whole (An et al., 2014), which can help identify the structural features of the system, as well as its individual role and status in the system. An LNG trade competition network (LTCN) was built to analyze the global competition pattern and national role in the LNG trade market. Overall, the competitive relations' growth and competitive globalization features of the LNG trade were analyzed, and the main LNG exporter group and its evolution were identified. Moreover, the market competitiveness of LNG exporters was measured, and accordingly, these exporters were divided into three categories to show their different development prospects.

2. Data and method

2.1. Data

A network model was developed using data from UN Comtrade, which includes information on the global LNG trade flow among all countries or regions in the LNG trade. The name of the commodity is "Natural Gas, liquefied," (the HS code is 271,111). Data from 2005 to 2014 were used for our study.

2.2. Method

2.2.1. Network building

Competitive relationships exist between LNG exporters in LNG markets, so we built an LNG trade competition network based on the complex network theory. The competitive relationship has no direction, and weight is used to measure the competitive strength between LNG exporters.

As shown in Fig. 1 above, nodes P and Q are LNG importers, and nodes A, B and C represent the LNG exporters. A competitive relationship exists between A and B because they both export LNG to

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