Exploring the driving factors of global LNG trade flows using gravity modelling

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ABSTRACT

Taking into account the attributes of the liquefied natural gas (LNG) trade and the space-time characteristics of trade flows, this paper identifies the multiple dimensional factors that influenced the global LNG trade between 2004 and 2015. Following an analysis of the data via the application of gravity models, the empirical results of this study indicate that these influencing factors possess both general and regional characteristics. In contrast to general trade, the LNG trade is mainly affected by the economic magnitude of the demand side. Regionally, pipeline natural gas has a significant substitute effect on the LNG trade within the global model, though not within the Asian model. Additionally, the LNG trade in Asia is more sensitive to the influence of import prices and research and development investment than in the global model. Our subsample analyses show that the results are robustness across different periods. Finally, this paper discusses pertinent policy implications for the LNG trade, especially as related to Asia.

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1. Introduction

In recent years, many nations have faced urgent challenges related to global climate change. These challenges have forced the global energy market to readjust, and the economic development of clean and low-carbon energy systems has become a common goal of society. In the process of developing a low-carbon civilisation, natural gas has irreplaceable advantages. Among fossil energy sources with rich reserves, natural gas is unique in that its low carbon emissions are cleaner than either coal or petroleum. Additionally, natural gas production technologies are improving. For instance, the shale gas revolution instigated by North America quickly developed and generalised the practices of directional drilling and hydraulic fracturing. As a result, the level of shale gas exploitation has risen sharply (Geng et al., 2016). As the production of natural gas in various countries increases, utilization of natural gas is also growing rapidly. Worldwide, natural gas use was 3.47×10^{12} m^3 in 2015 (IEA, 2016), comprising 23.8% of primary energy consumption. This figure is expected to continue to rise. By extension, the role of natural gas in the future of energy consumption will become increasingly important.

To meet the rising demand for natural gas, the international natural gas trade has been forced to expand. In 2015, 30.1% of the fuel consumed was natural gas, a figure which includes both liquefied natural gas (LNG) and pipeline natural gas. The natural gas trade has become a crucial aspect of global energy trade patterns, and the formulation of a natural gas trade strategy is of vital importance for any country that wishes to ensure the security of its energy supply. It must be noted that natural gas is traded and transported via pipelines or as LNG. Transport by pipeline is limited by geographical factors, and most trade partners who utilise this method are neighbouring countries on the same continent. However, LNG's mode of transport is more flexible, thus enabling long distance trade and contributing to the global liquidity of the natural gas market. As liquefaction and regasification technologies become more advanced, transportation costs are reduced. The latest figures indicate that LNG's current share of the global natural gas trade exceeds 20%. In the future, it is anticipated that LNG will be the main source of growth in the natural gas trade. Thus, studying the factors that influence the global LNG trade can provide additional insight into the development of the global natural gas market.

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Furthermore, such studies can also be used to guide natural gas trade policies for both LNG-importing and -exporting countries.

In comparison to the factors influencing general trade, the LNG trade is influenced by a more complicated group of factors that include global political and economic conditions, individual countries' energy structures, changes in the price of natural gas, the patterns of the world energy market and the resource endowments of both trading partners. For instance, since 2014, international crude oil price shocks have driven down the price of natural gas, as well as the prices of related products LPG and fuel oil. As a result, natural gas prices have continually weakened, reducing the growth of the natural gas trade in the international market. In another example, North America's shale gas revolution has brought about an expansive growth of regional natural gas production, a shift which has the potential to transform the area from an importer into a net exporter. This scenario would alter the direction of the international natural gas trade and lead to a profound adjustment of the global energy system, increasing the importance of understanding the factors that influence the global LNG trade and considering those various dimensions in order to better grasp the evolution of LNG-related law, trading and market characteristics.

Previous research has mainly focused on the global oil trade, using complex network theory and gravity models to address its globalisation and high liquidity (An et al., 2014; Ji et al., 2014; Zhang et al., 2014; Hao et al., 2016). However, the development of LNG has caused the natural gas trade to become a hot topic (Mahmood et al., 2014; Osorio-Tejada et al., 2017; Sharafian et al., 2017). Existing research on the global natural gas trade has focused on LNG technology, trade strategy, trade security, regional characteristics and price law (Dieckhoner et al., 2013; Aguilera, 2014; Solarin and Shahbaz, 2015; Shaikh et al., 2016; Zhang et al., 2016). Paltsev et al. (2011) employed two computable general equilibrium models to investigate the influence of various uncertainties on natural gas demand and trade. They found that international natural gas resources may prove to be less costly than those in the United States, and that the emergence of an integrated global natural gas market could result in significant natural gas imports to the United States. Ritz (2014) investigated the influence of LNG arbitrage on the global natural gas market, estimated the market power in short-term sales by Qatar and discussed the potential impact of the United States' LNG exports. Moryadee et al. (2014) estimated the influence of the Panama Canal expansion on global natural gas trade. They found that Japanese and South Korean prices are significantly reduced when the Panama Canal tariff is low due to increased supply from the Atlantic Basin. Vivoda (2014) evaluated the potential effect of Japan's LNG strategy on regional pricing, arguing that LNG pricing in the region will only partially shift away from oil indexation by the end of the decade. Egging and Holz (2016) built a stochastic global natural gas market model to investigate the influence of market agents' intertemporal hedging behaviour on the timing of investments. They found that investment in increased LNG capacities is driven more by demand side pull than by supply side push. Shi (2016) examined lessons and experiences from European hub development and suggested that East Asia needs to develop its indigenous natural gas or LNG trading hubs, even in periods of low oil prices. Oglend et al. (2016) investigated the relationship between LNG shipping costs and regional natural gas price spreads. They found that the price convergence of regional natural gas is stronger when controlling for variations in transportation costs, rather than using fixed or exogenous costs.

However, few pieces of research have examined the factors that influence the LNG trade from a global perspective. Some studies have qualitatively analysed the factors that influence importation or exportation in individual countries. The general view is that, in recent years, regional differences have diminished and there is an increasing trend toward integration. Researchers have sought to verify this stance and further explore the causes of any trends. The International Energy Agency (IEA, 2011) argued that the increased use of unconventional gas in North America has reduced the demand for imported natural gas in the region, thereby impacting the global natural gas market. Wood (2012) analysed global and regional LNG trading over the past 20 years, pointing out that the European LNG market has experienced rapid development during the past decade and positing that Asia is likely to remain dominant in the global LNG trade. Arora and Cai (2014) evaluated the potential global impacts of an increase in United States natural gas exports and concluded that natural gas importers were better off under exogenous United States export systems (LNG or pipeline). Medlock III (2009) examined the degrees of integration between various natural gas markets and showed the important role of LNG trade. Barnes and Bosworth (2015) examined the impact of LNG trading on the global natural gas trade and found that the trading of LNG has de-regionalised the entire natural gas market.

Meanwhile, geographical factors and market structures have hindered the integration of the world's natural gas markets. Neumann (2009) regarded LNG trading as the main motivator of such integration. However, Brown and Yücel (2008) found that the effect of LNG trading on the integration of various markets is not clear. Geng and Ji (2014) built complex network models of LNG and pipeline natural gas trading systems and found that the connections of the LNG trade network were tighter than those of the pipeline natural gas trade network. Shi and Variam (2017) demonstrated that low oil prices, and the subsequent oil indexed natural gas prices, have affected the supply and demand for natural gas and have influenced trade in ways that can only be explained by a study of the distinctive natural gas economics of East Asia.

The above review shows that most research has focused on the spatial features of the LNG trade and the relevance of those features to the integration of global natural gas markets. The existing literature has proven the contribution of LNG trading to the globalisation of natural gas trade. However, few studies have focused on the exploration of potential factors that can drive the global LNG trade. Some research considers the influence of a single factor on the LNG trade, such as transportation costs or the United States' natural gas exports, but little evidence has been provided to reveal the formation mechanisms of the natural gas trade from a global perspective.

In this paper, the main factors that influence the LNG trade are identified and investigated to supplement existing research and to further examine the influences of resource endowment, supply and demand relations and political risk. To achieve this analysis, an integrated indicator system was built and additional dimensions were considered and compared within different periods and regions. Furthermore, a gravity model was introduced, and eleven influencing factors of the LNG trade were chosen using the following seven dimensions: economics, supply and demand, price, technology, energy structure, trade feasibility and politics. The influence of these factors on LNG trade patterns was analysed and a separate analysis of the Asian market, which imports the largest share of LNG, was conducted. The first main contribution of this study is the synthetic consideration of the commodity, geopolitical and resource properties of the LNG trade and the construction of a gravity model that considers multiple dimensions in order to comprehensively analyse the driving mechanisms of the global LNG trade. The findings indicate that the LNG trade is more significantly affected by geopolitical attributes than general trade. The study also provides a local analysis of Asian LNG trading with consideration given to regional characteristics and trade directions. The driving mechanisms for LNG trade in Asia are similar to the results in the global model, but the LNG trade in Asia is more sensitive to the