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Estimating the price premium of LNG in Korea and Japan: The price formula approach

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ABSTRACT

Focusing on the price premium, which reflects the negotiation power of exporting and importing countries, this study empirically investigates the liquefied natural gas (LNG) price formula for Korea and Japan. Applying the state-space model and Kalman filter to the price formula adopted in the LNG contracts in the Asia–Pacific region, this study estimates the long-run price formula and time-varying premiums on the LNG import prices by trade routes, from Qatar, Oman, Indonesia, and Malaysia, to Korea and Japan. Furthermore, this study also discusses the differences between Korea and Japan and the event-based changes in the price premiums, namely, the appearance of Russia as a new supplier to Korea and Japan in April 2009, and the Fukushima nuclear disaster in March 2011. The estimation results show that the appearance of a new supplier does not always lead to a decrease in the premium. In addition, LNG importers in Northeast Asia should pay attention to demand and supply in Europe as well as Asia because Northeast Asia and Europe share the same Middle Eastern exporting countries. Furthermore, Korea, Japan, and other Northeast countries need to establish close cooperation to enhance their negotiation power within the global LNG market.

1. Introduction

One of the unique characteristics of Asian countries, especially the Northeast Asian countries, is that the majority of their natural gas imports comprise liquefied natural gas (LNG, hereafter). Korea and Japan, two of the world's biggest natural gas importers, have imported all their natural gas requirements as LNG since natural gas exporters such as Indonesia and Qatar are geographically far away and no pipelines connect Korea and Japan with Russia, which produces natural gas on the island of Sakhalin. Although the imported amount of piped natural gas (PNG, hereafter) is forecast to increase considerably for Asia, the proportion of these imports to the total amount of imported natural gas comprised only 18% of the total natural gas imports in 2017 (IEA, 2013). It means that LNG will remain the dominant natural gas import in Northeast Asia, comprising 82% of the total natural gas imports.

Despite the important position of LNG in Asia, there have been several problems with regard to its trade environment. First, the trade in LNG in the Asia–Pacific region is rigid since most of the LNG volume is traded as a long-term contract containing clauses such as a take-or-pay clause and destination clause, which are considered to be disadvantageous to importing countries (Doh, 2005; Jensen, 2004; Namikawa, 2003). Several researchers claim that the take-or-pay clause is advantageous to both sellers and buyers in European and American markets (Asche et al., 2002; Creti and Villeneuve, 2004; Croaker and Masten, 1988; Hubbard and Weiner, 1991) but Korea and Japan in the Northeast Asia have consistently maintained that the take-or-pay clause is a disadvantage. Doh (2005), who studied LNG contracts in the Northeast Asian region, pointed out that there is no compensation in terms of price in the take-or-pay clause and the destination clause limits the opportunity of buffering the quantity risk which comes from the take-or-pay clause. Second, there is a lack of regional trading hubs pricing natural gas competitively in Asia, unlike the Henry Hub in the United States and the National Balancing Point in the United Kingdom. Consequently, a price index or benchmark price, which reflects the conditions of supply and demand of natural gas, does not exist in this region. Thus, linear indexing of the crude oil price has been the dominant mechanism for pricing LNG ever since Japan and Indonesia used the crude oil price in their contract as the substitute price for natural gas (Stern, 2012).

Given this background, deciding upon a specific indexation mechanism or a slope–intercept formula for the LNG price in Asia is critical to prevent unreasonable prices, which can inflict financial losses on exporting or importing countries. In such contracts, as Doh (2005) indicated, the negotiation powers of exporting and importing countries based on the market environment play a significant role when they

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negotiate and renegotiate the price formula. If the negotiation power of an exporting country is predominant over that of an importing country at the negotiation or renegotiation table, then the price formula for LNG is decided in favor of the exporting country. Thus, the LNG price increases even if the oil price remains unchanged. If the negotiation power of an importing country, on the other hand, is predominant, then the price formula for LNG is advantageous to the importing country. Consequently, negotiation powers are reflected in the LNG import price, and there can be a price premium or price discount against the long-run average price formula according to shifts in the balance of the negotiation powers. Thus, it is important to conduct an empirical investigation into the price formula of the LNG traded in Asia, while considering the price premium and discount in order to capture the dynamic relation between sellers and buyers as well as the price structure.

Considering this need, this study empirically investigated the LNG price formula for Korea and Japan, the largest and second-largest LNG-importing countries in Northeast Asia. In particular, this study focused on measuring the changes in the price premium, which reflect the negotiation power, following modifications in the trading environment, since negotiation power is a crucial factor in determining the LNG price. Applying the state-space model and Kalman filter to the price formula generally adopted in LNG contracts, this study estimated the long-run average price formula and time-varying premiums on the LNG import prices by trade routes, from Qatar, Oman, Indonesia, and Malaysia to Korea and Japan. Furthermore, to derive policy implications, this study also discussed the differences between Korea and Japan with regard to event-based changes in the price premium, namely, the appearance of Russia as a new supplier to Korea and Japan in April 2009 and the Fukushima nuclear disaster in March 2011.

Several empirical analyses of the long-run equilibrium relationships between natural gas and oil prices have been conducted. However, the literature lacks empirical analyses of the price formula of LNG in Asia considering countries' negotiation powers and the price premium. This may be because the LNG price in Asia is not a "market" price, and therefore, collecting data is relatively difficult. Also, negotiation power can vary over time, complicating the analysis. Studies on the long-run equilibrium relationships between natural gas and oil prices have largely focused on the prices' relationships in the United States and the United Kingdom, not in Asia (Asche et al., 2006, 2012; Atil et al., 2014; Brigida, 2014; Dahl et al., 2012; Erdos, 2012; Hartley et al., 2008; Panagiotidis and Rutledge, 2007; Ramberg and Parsons, 2012). Ji et al. (2014) studied the long-run relationship between the Japanese LNG import price and Brent crude oil price by estimating the cointegrating equation between the two prices. However, as they used the Kilian index to capture economic activities when estimating the cointegrating equation, it is difficult to confirm that the estimated LNG price formula applies to all of Asia. Agerton (2012, 2014) conducted empirical studies on the price formula of LNG traded in Asia. Agerton (2012) estimated the price formula by trade route for Japan, considering structural breaks in the price formula, and Agerton (2014) expanded the study by Agerton (2012) by adding the cases of Korea, Taiwan, and Spain. However, both studies suffer limitations, since neither considered the time-varying premium or discount according to changes in negotiation power in response to the prevailing market environment.

This paper is structured as follows. Section 2 explains the model specification regarding the LNG price formula and methodology applied in this study. Section 3 explains how the empirical data were collected and handled. The empirical result of the estimation is presented in Section 4, and the changes in the premiums and differences between the premiums of Korea and Japan are discussed in Section 5. Finally, Section 6 discusses the policy implications and concludes this paper.

2. Model specification and methodology

LNG import prices for Korea and Japan in term contracts are usually linked with crude oil prices. The LNG pricing formula in these contracts can be expressed as a simple linear Eq. (1).

$$P_{LNG} = A \times P_{crude} + B \tag{1}$$

where P_{LNG} is the LNG import price in U.S. dollar per million British thermal units (MMBtu, hereafter) and P_{crude} is the crude oil price in U.S. dollar per barrel. Slope A refers to the rate of the crude oil price linkage. Constant term B can be interpreted as the term related to the LNG transportation cost (Seo, 2012), or the premium part, which is determined by negotiation (Doh, 2005). It is logical for the premium to vary according to LNG supply and demand, and the strategies of the exporting and importing countries. Slope A and constant term B are adjusted quarterly by renegotiations between the exporting and importing countries, but fundamentally, such changes are limited (Stern, 2014). Thus, the LNG price formula is not wholly fixed, and there can be a price premium or discount under the long-run price formula. If the negotiation power of an exporting country at the negotiation or renegotiation table is stronger, then slope A and constant term B increase compared to the former price formula.

Considering the long-run LNG price formula and the varying premium or discount, Eq. (1) can be re-written as Eq. (2) by adding the premium term.

$$P_{LNG} = A' \times P_{crude} + C + FR + PR \tag{2}$$

A' is the long-run rate of the crude oil price linkage, C is the constant term, and FR is the freight rate from the exporting country to the importing country, which indicates the transportation cost. PR is the premium or discount on the LNG import price defined in this study. PR can capture changes in slope A and constant term B caused by the modifications in negotiation powers. The freight rate can be excluded if the LNG import price is measured as a Freight on Board (F.O.B.) price. However, the LNG import price data, which are used in this study, are cost, insurance, and freight (C.I.F.) prices, and thus, the freight rate should be included.

In Eq. (2), P_{LNG}, P_{crude}, and FR can be observed but the time-varying premium, PR, cannot be observed though it is an important variable that determines the LNG price. In this respect, to estimate the time-varying premium with the LNG pricing mechanism simultaneously, a state-space model can be constructed based on Eq. (2).

$$P_{LNG,t} = A' \times P_{crude,t} + C + FR_t + PR_t + \varepsilon_t \tag{3-1}$$

$$PR_t = \gamma \times PR_{t-1} + \nu_t \tag{3-2}$$

The model, which consists of Eqs. (3)–(1) and (3)–(2), is the state-space model. Eqs. (3)–(1) is the observation equation used to estimate the LNG pricing mechanism with the observation error term ε_t. Eqs. (3)–(2) is the state equation of the premium on the LNG price with the state error term ν_t. The error terms, which are distributed independently, have normal distributions with zero means and are not autocorrelated. In this study, the coefficients of FR and PR are constrained to be 1, assuming that the freight rate and the premium are fully included.

This state-space model can be estimated using the Kalman filter, which has been extensively employed to estimate unobservable components (Murry and Zhu, 2008). The Kalman filter estimates the dynamic behavior of state variables, based recursively on the "prediction" and "update." First, the state variable is predicted by Eqs. (3)–(2) conditional on the current information. Next, the Kalman filter procedure calculates new information that can be inferred based on Eqs. (3)–(1). Then, the predicted state variable is updated by this new information, and the updated state variable is used to predict the one-step-ahead state variables. The time-varying state variable is obtained by performing this process recursively. Finally, the unobservable