Investigating the price linkage between the Asian LNG spot and East Asian LNG prices and its implications

Jeremia Dwi Martono
ESCP Europe Business School,
527 Finchley Rd, London NW3 7BG, UK
Email: jeremia.dm@gmail.com

Kentaka Aruga*
Faculty of Economics,
Saitama University,
255 Shimo-Okubo, Sakura-ku,
Saitama-shi, Saitama, Japan
Email: kentaka.aruga@gmail.com
*Corresponding author

Abstract: This study investigates the price linkages among the Asian LNG spot and East Asian LNG prices to examine the existence of a long-run relationship among the spot, Japanese, South Korean, Taiwanese, and Chinese LNG prices using co-integration analysis over the 2009–2014 period. The results show that the Asian LNG spot price did not have a price linkage with both monthly averages of Japanese and Taiwanese LNG prices. The analyses also indicated that the South Korean LNG market moved together with the Asian LNG spot market. Lastly, the study discovered that the Chinese LNG market was somewhat influenced by the dynamics of the Asian LNG spot market. The findings corroborate the International Energy Agency’s views on the importance of creating a natural gas trading hub in Asia that reflects the dynamics of the gas market in the Asia Pacific Basin and making the Asian gas market to become more uniform.

Keywords: price linkage; Asian LNG spot prices; LNG spot and short-term cargoes; long-term contracts; spot prices.


Biographical notes: Jeremia Dwi Martono is an oil and gas professional, who received a BEng in Mechanical Engineering from Nanyang Technological University in 2010, and an MSc in Energy Management from ESCP Europe Business School in 2015. He has developed a deep knowledge about the LNG market in Asia Pacific region, having previously dedicated significant time and efforts in preparing a master thesis on the Asian LNG gas market integration.

Kentaka Aruga is an environmental and natural resource economist, who received a PhD from the Department of Environmental and Natural Resource Economics at the University of Rhode Island. He has been an associate
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professor at the Ishikawa Prefectural University from 2012 to 2016 and is now working at the Graduate School of Humanities and Social Sciences, Saitama University, Japan as an associate professor. He has been conducting research on various commodity markets such as corn, soya beans, seafood, gold, silver, copper, and energy. He has recently published several papers on the US shale revolution and investigating the impacts of the revolution on the global oil and gas markets.

1 Introduction

The Asia-Pacific liquefied natural gas (LNG) markets consist of two pricing mechanisms: the long-term LNG contract and the spot LNG pricing. The long-term contract mechanism uses the crude oil indexation in its pricing formula, whereas the spot LNG pricing uses the gas hub price indexation.

International LNG trade in Asia has been established based on Japan Crude Cocktail (JCC) pricing mechanism since its introduction in the 1970s. The long-term LNG contract has been the backbone of LNG trade in Asia for years, as it gives certain degree of security to both buyers and sellers (Flower and Liao, 2012). On the other hand, as a complement of the LNG long-term contract purchases in Asia, the demand for the spot LNG trades have grown significantly over the past few years. The Asian spot LNG contract emerged in the early 2005, because there were needs to meet the supply gaps caused by a combination of unexpected increases in demand. Such increased gas demand occurred due to the effects of nuclear plant problems in Japan, and a shortfall in supplies from some producers in the Asia-Pacific Basin. As a result, these LNG consuming countries began to find the LNG cargoes outside the Asia-Pacific Basin under spot or short-term contract.

The spot LNG pricing in the Asia-Pacific region is still at a nascent stage and there is not a fixed structure for establishing the LNG spot prices. The spot market in Asia is relatively less liquid and transparent, leading to a wider range of traded prices. This situation brings much concern about the higher LNG long-term contract prices in the Asia-Pacific Basin (Miyamoto and Ishiguro, 2012) compared to its counterpart in the Atlantic Basin where LNG prices are not indexed to the crude oil prices. The long-term contract pricing formula seemed to work well when the Brent crude oil prices were well below USD100/bbl. However, the mechanism resulted in expensive LNG long-term contract prices when the Brent crude oil prices were above USD100/bbl.

Therefore, it is interesting to investigate the presence of price linkages between the Asian LNG spot and East Asian LNG prices. If a price linkage is found for particular countries, it could imply that those countries can use the LNG spot price as a reference price during their price discovery process when purchasing LNG. Furthermore, it could mean that there is an LNG market integration to some extent between the Asia-Pacific and the Atlantic Basins as well because most Asian LNG spot prices are derived from gas hubs in the Atlantic Basin. This could imply that some domestic events in the Atlantic Basin could affect the dynamics of the LNG market in the Asia-Pacific Basin. On the other hand, if these Asian LNG prices move independently, then their price discovery process is not influenced by the LNG spot price.
This study examines the relationships among the Asian LNG spot prices, Japanese, Korean, and Taiwanese (JKT) LNG prices. These spot and long-term contract prices are well established and they are mostly adopted in the Asia-Pacific Basin. Many export scale LNG projects rely their investment on these price indices. Moreover, the study includes the Chinese LNG price as well. This is because we wanted to have a thorough understanding of the Asian LNG spot prices.

This is one of the first studies attempting to measure, if any, the level of market integration between the Asian LNG long-term contract and the Asian LNG spot markets. Through this investigation, we will find out whether the Asian LNG long-term and spot markets share price information. We believe the study will provide useful resource for policymakers and stakeholders involved in the Asian LNG market.

The findings from our study could be useful for policy-makers and stakeholders involved in the Asian LNG market in devising a more transparent LNG market mechanism. This process involves considering the pros and cons of any gas agreements regarding oil- and gas-indexed long-term contracts, and spot and short-term contracts.

Moreover, the fact that there is no price linkage between the long-term contract and spot LNG prices indicates that the LNG market in the East Asian region does not reflect its market fundamentals that are based on the region’s supply and demand volumes. Hence, this study supports the International Energy Agency’s idea about creating a gas hub for this region in order to make the market to become more transparent (Warner et al., 2013).

2 Literature review

Spot LNG trading in the Asian region is growing at a significant rate, and it is becoming more important to investigate the linkage, if any, between the Asian LNG spot price and East Asian LNG prices. However, at the moment, there are few studies examining the price linkages for the Asian LNG markets. This paper will fill this gap and investigate the price linkages among the Asian LNG spot and the East Asian LNG markets.

There have been many research papers investigating the co-movements among different energy markets by applying time series analysis techniques. Aruga (2013) investigated the price linkage between the Japanese natural gas price and other international natural gas prices, i.e. US and European. Furthermore, Argenton (2012) examined the statistical relationship between prices of imported LNG in Japan and crude oil prices. Asche et al. (2003) discovered a long-run relationship between crude oil and refined oil products in the UK market based on monthly price data in 1995–1998. Siliverstovs et al. (2005) discovered the natural gas market integration within Europe, between European and Japanese markets, and also within the North American market in the time period between the early 1990s and 2004. However, they did not discover a market integration between the European and the North American natural gas markets. Bachmeier and Griffin (2006) found a weak price linkage among the crude oil, coal, and natural gas markets. They revealed that these types of energy sources were not integrated as one economic market. Finally, Hartley et al. (2008) found the presence of co-movement between the US natural gas and petroleum markets in the long-run and identified that this relationship could be affected by weather, inventories, and hurricanes in the short-run. All these previous studies apply co-integration analysis to examine the behaviour of the economic variables in the long-term.
More recent and related research on Asian energy market integration was initiated by Ji et al. (2014). They used European, US, and Asian monthly data from January 1997–August 2011, and global economic activity variables to examine the co-integration between the Asian natural gas and oil prices. They discovered that the Japanese LNG import prices were greatly influenced by international oil prices and weakly influenced by global economic activity.

The main difference between this paper and Ji et al.’s research is that this paper is focusing on the relationship between the Asian spot LNG prices and East Asian LNG import prices, which include Japan, South Korea, Taiwan, and China. Hence, our study delivers a deeper understanding about the current price discovery process within the East Asian LNG market.

3 Methodology

A co-integration test is a statistical technique which is able to determine the existence of co-movement among historical economic variables. Ssekuma (2011) made a comparison study among the Engle-Granger method (Engle and Granger, 1987), the Phillips-Ouliaris (Phillips and Ouliaris, 1988) method, and the Johansen method (Johansen and Juselius, 1988). He found that the Johansen method was superior to the other two methods in identifying more than one co-movement relationships when present.

While many research papers have used the Engle and Granger test to investigate the price linkage (Goodwin and Schroeder, 1991), the Johansen co-integration test was selected for this study. The reason for the selection of the Johansen co-integration test is that it is more advantageous and efficient when investigating economic variables as endogenous in the model, and thus, it is handy in a multivariate framework (Aruga and Managi, 2011). Furthermore, the Johansen test is superior over the Engle and Granger test in a bivariate co-integration framework, because Gaussian errors are not required in the Johansen test (Darrat, 1998).

Before conducting this co-integration method, the data have to be verified for their stationarities and the order of integration of the series. A stationary time series is a situation when the mean of a particular series of data does not vary significantly in a certain period. We used the ADF, PP, and KPSS unit root tests for this stationarity test.

4 Data

To proceed with this study, the monthly average of the Japanese, South Korean, Taiwanese, and Chinese LNG prices are used for the prices of the LNG long-term contracts. For the Japanese, South Korean, Taiwanese, and Chinese LNG prices, Argus’ monthly midpoint LNG prices were used from February 2009 to July 2014. These monthly LNG prices were not simply the prices of LNG long-term contracts, but they were the average prices of all LNG cargoes these countries consumed. The unit of price series is 1 US Dollar per million British thermal unit (USD/MMBtu).

Figure 1 shows the plots of the historical Asian LNG prices that were used in our investigation. For the Asian LNG spot prices, we used the graph of “Figure 4: Global Marker Prices Annotated” on page 13 of “Natural Gas Price in Asia: What to Expect and What It Means” (Medlock III, 2014). We estimated the data from this graph by using
GetData Graph Digitiser, a free software available from the internet, over the February 2009 to September 2011 period. For the Asian LNG spot price data for the October 2011 to July 2014 period, we used the data from the Platts Spot JKM prices, which is free and available from the internet.

Figure 1  Historical LNG average monthly import prices

Source:  Argus Global LNG; Platts JKM

5 Results

To decide whether the price variables have unit root or not, the ADF, PP, and KPSS tests were performed on both levels and first-differenced series. Table 1 shows that all the price variables are not stationary on the level series. However, the price variables are stationary on the first-differenced series. Thus, the price variables are integrated of the same order on their first-differenced series, or I(1). This situation fulfils the prerequisite before proceeding to the Johansen test.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th></th>
<th></th>
<th>First Differences</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADF</td>
<td>PP</td>
<td>KPSS</td>
<td>ADF</td>
<td>PP</td>
<td>KPSS</td>
</tr>
<tr>
<td>Japan</td>
<td>-0.872</td>
<td>-1.005</td>
<td>0.854***</td>
<td>-6.835***</td>
<td>-6.813***</td>
<td>0.122</td>
</tr>
<tr>
<td>South Korea</td>
<td>-0.846</td>
<td>-0.964</td>
<td>0.904***</td>
<td>-5.557***</td>
<td>-6.944***</td>
<td>0.166</td>
</tr>
<tr>
<td>Taiwan</td>
<td>-1.700</td>
<td>-1.633</td>
<td>0.901***</td>
<td>-12.610***</td>
<td>-14.445***</td>
<td>0.430</td>
</tr>
<tr>
<td>China</td>
<td>-1.830</td>
<td>-2.118</td>
<td>0.964***</td>
<td>-6.780***</td>
<td>-24.610***</td>
<td>0.500</td>
</tr>
<tr>
<td>Asian Spot</td>
<td>-1.682</td>
<td>-1.486</td>
<td>0.883***</td>
<td>-4.894***</td>
<td>-3.821***</td>
<td>0.164</td>
</tr>
</tbody>
</table>

Note:  *** Represents significance at 1% level.

A multivariate Johansen co-integration test was conducted, in which all the economic variables are tested concurrently. The test indicates that there is a weak long-run relationship among the five selected Asian LNG prices. Table 2 shows the trace and
max-eigenvalue results. Based on the trace statistic, the figures of \( r = 0 \), \( r \leq -1 \), and \( r < -2 \) are significant. The results of the trace statistic imply that there are three co-integrating equations in the multivariate Johansen test. On the other hand, the figures of \( r = 0 \), and \( r \leq -1 \) are significant according to the max-eigenvalue statistic. The max-eigenvalue statistic indicates that there are two co-integrating equations in the multivariate Johansen test.

**Table 2**  Multivariate Johansen co-integration test

<table>
<thead>
<tr>
<th>Hypothesised No. of CE(s)</th>
<th>Trace Statistic</th>
<th>Max-Eigen Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r = 0 )</td>
<td>99.988**</td>
<td>39.141**</td>
</tr>
<tr>
<td>( r \leq -1 )</td>
<td>60.847**</td>
<td>29.952**</td>
</tr>
<tr>
<td>( r = -2 )</td>
<td>30.895**</td>
<td>20.516</td>
</tr>
<tr>
<td>( r \leq -3 )</td>
<td>10.380</td>
<td>6.748</td>
</tr>
<tr>
<td>( r \leq -4 )</td>
<td>3.632</td>
<td>3.632</td>
</tr>
</tbody>
</table>

Note:  ** Represents significance at 5% level.

To give a better understanding of the long-run relationship between the Asian LNG spot price and the East Asian LNG markets, bivariate Johansen co-integration tests were carried out. Table 3 shows the results of these tests.

**Table 3**  Bivariate Johansen co-integration test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Hypothesised No. of CE(s)</th>
<th>Trace Statistic</th>
<th>Max-Eigen Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian Spot vs Japan</td>
<td>( r = 0 )</td>
<td>16.606**</td>
<td>12.709</td>
</tr>
<tr>
<td></td>
<td>( r \leq -1 )</td>
<td>3.897**</td>
<td>3.897**</td>
</tr>
<tr>
<td>Asian Spot vs South Korea</td>
<td>( r = 0 )</td>
<td>22.080**</td>
<td>19.131**</td>
</tr>
<tr>
<td></td>
<td>( r \leq -1 )</td>
<td>2.950</td>
<td>2.950</td>
</tr>
<tr>
<td>Asian Spot vs Taiwan</td>
<td>( r = 0 )</td>
<td>14.900</td>
<td>10.455</td>
</tr>
<tr>
<td></td>
<td>( r \leq -1 )</td>
<td>4.446**</td>
<td>4.446**</td>
</tr>
<tr>
<td>Asian Spot vs China</td>
<td>( r = 0 )</td>
<td>16.216**</td>
<td>12.650</td>
</tr>
<tr>
<td></td>
<td>( r \leq -1 )</td>
<td>3.566</td>
<td>3.566</td>
</tr>
</tbody>
</table>

Note:  ** Represents significance at 5% level.

The bivariate co-integration tests indicate that the Japanese and Taiwanese LNG prices do not have long-run relationships with the Asian spot LNG price. However, the tests indicate that a long-run relationship persists between the Asian spot and South Korean LNG prices and the Asian spot and Chinese LNG prices.

6 Discussions

Within the time frame of this study, i.e. 2009–2014, all the East Asian countries had an increment in their LNG import volumes annually (see Figure 2). The Japanese LNG import volumes plateaued to around 87 million tons per annum (mtpa) from 2012 to 2013 before reaching just under 89 mtpa in 2014. Taiwanese LNG import volumes also
stabilised to around 12 mtpa from 2011 to 2013 before reaching middle 13 mtpa in 2014. Moreover, the Chinese LNG import volumes had an increment to 20 mtpa in 2014. On the other hand, the South Korean LNG import volumes reached its peak to around 41 mtpa in 2013.

Figure 2  LNG import volumes

Source: GIIGNL and IGU

Furthermore, the proportion of spot and short-term LNG transactions also increased for all East Asian countries in general, according to METI (2016). However, METI (2016) shows that the growth of proportion of the Taiwanese spot and short-term LNG transactions declined from 2012 to 2014.

Both findings from Figure 2 and METI (2016) are likely to corroborate our findings, i.e. Japan and Taiwan do not have price linkage between spot and long-term LNG prices, while South Korea and China have.

6.1 The Asian spot and the Japanese and Taiwanese LNG prices

Japan has traditionally engaged in long-term LNG trades to ensure uninterrupted supplies. The long-term contracts made up a huge portion of its LNG imports. Over the past decade, Japanese companies have signed 56 long- and medium-term contracts in 8 countries (GIIGNL, 2014). On the other hand, spot LNG cargoes became more important after Fukushima aftermath in March 2011, which led to shutdowns of nuclear plants. Although there was a surge in the spot LNG buying, no co-integration between the Asian spot LNG and Japanese LNG long-term contract prices was observed. It could be due to a relatively short period for the price linkage to exist between these economic variables. This study examined the dynamics of these prices in the 2009–2014 period, whereas, the spot or short-term LNG cargoes became more important to Japanese LNG portfolio after the Fukushima aftermath in 2011.

However, because the Japanese companies have to pay a high price for spot LNG cargoes, these companies prefer to use an LNG price based on long-term contracts. Japan is still active in securing long-term LNG contracts with different price indexation when
possible. For example, Japan has recently used the Henry Hub (HH) gas prices as its reference price (Miyazaki and Limam, 2013).

Traditionally, Japanese LNG buyers tied the LNG prices to oil price indexation in form of long-term contracts. When the Brent oil prices were around USD100/bbl, the LNG buyers in East Asian countries had to pay more dollars to buy the LNG cargoes. On the other hand, the situation was not totally applicable to the gas buyers in the Atlantic Basin, because the US HH and UK National Balancing Point (NBP) gas prices were established based on gas-on-gas market pricing mechanism. There was a big gap in the gas prices between the long-term contract and the Atlantic Basin gas prices. For example, from mid-2011 to mid-2012, the US HH gas prices were below USD5/MMBtu, and the UK NBP gas prices were mostly below USD10/MMBtu, whereas the Japanese long-term contract LNG prices were above USD15/MMBtu (Miyazaki and Limam, 2013). Therefore, the Japanese LNG buyers were trying to move away from the oil-linked to gas price-indexed LNG prices.

Similar to Japan, Taiwan relied on the long-term LNG contract for its LNG purchasing portfolio to secure supplies from reliable and stable sources at reasonable prices. According to Lin (2012), LNG demand in Taiwan was projected to increase from 12 million tons in 2011 to 20 million tons in 2030. For this reason, Taiwan secured more long-term contracts and has attempted to diversify its LNG sources. Taiwan has diversified its LNG suppliers dramatically over the period from 2002 to 2012. Indonesia and Malaysia made up to 90% of the Taiwanese LNG imports in the 2002 to 2006 period. This situation changed by 2012, with a mixture of several countries in East Africa and Middle East.

Although, Taiwan has increased its dependence on spot LNG supplies to meet its additional gas demand, the long-term contract LNG supplies will be the backbone for its main LNG supply base (Rogers and Stern, 2014). This might be the reason for not finding a price linkage between the Asian spot LNG and Taiwanese long-term LNG prices.

6.2 The Asian spot and the South Korean and Chinese LNG prices

The price linkage between the Asian LNG spot and South Korean monthly average LNG prices was observed for the South Korean LNG prices. This is because there was a major restructuring in South Korea in the domestic gas industry beginning in the early 2000s. The restructuring event delayed South Korea in securing new LNG long-term contracts. Thus, it increased the proportion of mid- and short-term or spot contracts in its LNG supply portfolios to secure uninterrupted energy supplies.

For comparison, in 1998, the LNG long-term contract supply made up around 99% of the total LNG supplies in South Korea. However, the share of long-term contracts reduced significantly, to only around 72% in 2007 (Tae-Hoon, 2009). The decrease in the long-term contract percentages of the supplies was caused by the increase in mid- and short-term contract percentages.

Finally, we will discuss our findings regarding the relationship between the Asian spot and Chinese LNG prices. The result of the trace statistic indicates that there is one co-integrating equation between the Asian spot and the Chinese LNG prices. However, the max-eigenvalue statistic indicates that there is no co-integrating equation between them. In this case, the conclusion based on the trace statistics is preferred, as the power of the trace test is superior to that of the eigenvalue test (Lutkepohl et al., 2000).
The price linkage between the Asian LNG spot and the Chinese LNG prices could be traced from the introduction of LNG imports in Chinese natural gas demand portfolios. In 2006, China received the first long-term LNG cargo from Australia at Guangdong Dapeng LNG terminal. Furthermore, LNG spot cargoes emerged in the Chinese import portfolio, complementing the LNG long-term contract cargoes to meet the strong demand and competition in the area, although the prices were high. Spot LNG prices were high in the region due to an extraordinary surge of demand from Japan, caused by the outage of nuclear power plants in 2007 (Higashi, 2009).

Although, China mainly relied on its LNG supply from medium and long-term contracts during 2010–2012, the proportion of LNG spot cargoes kept increasing to 23% in 2012. Thus, it might be the reason why the monthly average Chinese LNG prices have somewhat linkages with the Asian LNG spot prices.

6.3 The effect of US shale gas revolution on the East Asian countries

The effect of the US shale gas revolution has increased the global oil and gas production. This has put a downward pressure to the international oil and gas prices, and hence, the East Asian countries are more likely to import shale gas and oil to feed their energy needs.

Furthermore, as China estimates its technically recoverable shale gas and oil resources as 1,115 Tcf and 32 billion barrels respectively (according to EIA/ARI in June 2013), it is likely that the East Asian countries will depend more on shale gas resources for their energy needs.

6.4 The impact of other region gas price references for the LNG prices in East Asian countries

There are two main international gas prices that are widely used as price references by many LNG players around the world, US HH and UK NBP gas prices. These price references will likely affect the dynamics of the LNG prices for the East Asian countries because the US HH and the UK NBP can be used for the Asian spot or short-term gas price indexations.

In general, both UK NBP and US HH gas prices are determined by their domestic gas supply and demand. The effect of UK NBP gas prices on the East Asian LNG prices has been implicitly examined in our analysis, because the Platts’ JKM includes it in its price assessment. On the other hand, the effect of the US HH gas prices on the East Asian LNG prices cannot be examined in this study because US made its maiden LNG export to Brazil in February 2016 while the data source of our study only covers until end of 2014.

6.5 The overall implications from our analyses

The results above show that the Asian LNG markets are not unified, and these facts need serious attention from many governments in Asia to have more robust Asian LNG pricing mechanism, which reflects only Asia-Pacific Basin market fundamentals.
Creating gas trading hub could be viewed as a long-term solution towards achieving regional LNG spot price assessments and moving away from the traditional Asian LNG pricing mechanism. This outcome would be driven by the mechanics of the trading hub, which would show the real supply and demand fundamentals in the region. The LNG consumers will pay the prices for what they consume. A considerably high Asian LNG spot price in the current situation is due to the transportation cost to ship the spot cargoes and the premium to attract the LNG cargo shipments. To eliminate or reduce these hidden costs, building an Asian gas hub will be a necessity.

There should be enough time to develop a liquid and transparent gas trading hub in Asia, because the market in this region has some physical limitation, such as interconnectedness of the gas networks (Warner et al., 2013). Therefore, many countries could begin preparations to restructure their gas markets to support the creation of gas trading hubs in the region in the future.

7 Conclusion

This study investigated the presence of price linkage among the Asian LNG long-term contract price and the Asian LNG spot price. The results indicate that both historical Japanese and Taiwanese LNG prices do not have price linkage with the Asian LNG spot prices. On the other hand, the historical South Korean LNG prices have long-run relationships with the Asian LNG spot prices. Furthermore, the historical Chinese LNG prices have price linkage with the Asian LNG spot prices according to our test results.

The proportion of LNG long-term contracts is still dominated by Japanese and Taiwanese LNG markets. Hence, their monthly averages of LNG prices were not greatly affected by the natural gas market dynamics in the Atlantic Basin. Their price discovery process is not influenced by the LNG spot price.

In contrast, the South Korean and Chinese LNG markets have price linkages with the gas markets of the Atlantic Basin. The presence of price linkage in South Korean and Chinese LNG markets is expected because a number of spot LNG cargoes have been growing during our investigated term. It could imply that these countries can use the LNG spot price as a reference price during their price discovery process when purchasing the LNG cargoes.

As the Asian LNG markets are still fragmented, many governments in Asia will have to put significant effort towards building a more robust Asian LNG pricing mechanism, which reflects only the supply and demand dynamics of the Asia-Pacific Basin. It becomes apparent that having an Asian gas hub is necessary to reduce other external effects on LNG prices, such as the choice of price references from gas market in other regions.

The importing LNG countries in Asia could start by restructuring their gas markets to support the creation of gas trading hubs in the region. However, it should be kept in mind that the presence of an Asian gas hub does not guarantee that the LNG prices will become lower in the future. It might, rather, lead the markets to price natural gas at its relative value in a specific energy mix, such as coal, oil, and so on.
References


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