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East Asia's gas-market failure and distinctive economics

—a case study of low oil prices

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Abstract

This paper proposes that the gas economics in East Asia (including Southeast Asia and Northeast Asia) is different from standard economics due to its exogenous oil-indexed pricing and certain region-specific and industry-specific factors. Based on a hypothesis of distinctive economics, this paper proposes an analytical framework that studies East Asian gas markets. We demonstrate this framework through a case study of the effects of a low oil prices. The qualitative and quantitative results demonstrate that low oil prices, and subsequent gas prices, have affected gas supply and demand, and trade and pricing dynamics in ways that can be explained by the distinctive gas economics. This paper demonstrates that the distinctive economics may cause market failure and that the analytical framework based on the distinctive economics can be used to assess policy options that can address these market failures.

Keywords: oil indexation; hub; gas economics; liquefied natural gas (LNG); low oil prices; East Asia

1 Introduction

The global market in liquefied natural gas (LNG) is undergoing seismic changes: markets are more globally integrating, gas and LNG pricing mechanisms and business practice in relation to contractual terms are changing, and unbalanced supply and demand in the past few years. The low oil prices in the past years add further complication to those changes. Over the past two years, oil prices have declined more than 70%—with Brent benchmarks dipping from US$110 in June 2014 to below US$30 a barrel in early 2016, and remaining at approximately US$50 for most of 2016.

In this context, studying the effect of oil prices on natural gas in East Asia (including Southeast Asian and Northeast Asia) is important for East Asian and world gas markets for three principal reasons. First, the expected prolonged period of low oil prices has affected global gas markets and will continue to do so for the foreseeable future. Studies have observed independent short-term fluctuation in gas prices with long-term interdependence (co-integrated processes) with oil prices [1-4]. Ramberg [2] found a statistically significant relationship between oil and gas prices in the short and long terms. According to Hartley *et al* [4], oil and gas prices can decouple in the short term but the long-term dependence is hypothesised to continue due to technology interdependence. Even in the United Kingdom (UK) where gas prices are generated by hub, there is long-term relationship between oil prices and spot gas prices [5].

Second, fluctuations in the oil prices have a particularly significant effect on natural gas in East Asia because the region's imported gas and LNG are traded under oil-indexed contracts. The oil-indexed gas trade (both LNG and pipeline) in East Asia as a percentage of the region's total gas trade reached 88% in 2014, which is a great deal higher than the global average of 65% [6]. East Asia's natural-gas spot prices have declined along with oil prices, although with some time lag.

In October 2016, Japan's LNG import Cost, Insurance and Freight (CIF) price was less than US$6 per MMBTU, which was down from more than US$16/MMBTU in June 2016 [7]. The LNG spot prices then went to even lower levels. On 18 April 2016, the free-on-board Singapore Exchange (SGX) LNG Index Group (SLInG) prices for June 2016 fell below US$4 per MMBTU [8].

Third, East Asia is a critical player in the global gas and LNG markets. East Asia possesses the world's fastest growth rate in natural-gas demand in recent years—a trend that is expected to continue in until 2035[9]. Given that gas accounted for only 5% and 9% of the 2013 total primary energy supply in China and India, respectively, the demand of these countries for natural gas is expected to surge due to increasing pressure from their citizens to reduce air pollution immediately and mitigate climate change and coal emissions in the long term [10]. According to BP [11], East Asia's share of the global gas market is expected to increase from 18.8% in 2012 to 26.3% in 2035. Given that the overall scale of East Asia's demand for natural gas vastly outstrips intraregional supplies and most countries in the region (except for China and Singapore) have no pipeline imports, the region has relied heavily on LNG imports to satisfy gas demand. In 2015, 72% of globally traded LNG went to Asia, with the world's top three LNG importers (i.e., Japan, South Korea, and China) residing in the region and importing 56.5% of globally traded LNG, despite a decline in gas imports in Japan and South Korea for the first time since 2009 [12]. The International Energy Agency (IEA) predicts that Asia may absorb 80% of the incremental LNG imports over the medium term, with China alone absorbing 30% [13].

This paper analyses the extent to which gas prices, trade and production in East Asia is influenced by world oil prices with particular focus on the current scenario of low oil prices. The paper argues that East Asia's gas economics is different from standard economics due to East

Asia's specific regional factors such as a prevailing gas-pricing mechanism, commercial practice, and national institutions. This distinctive economics and some sector-specific factors such as high capital intensity and long lead time provide a theoretical framework for assessing the effect of low oil prices on supply, demand and investments in natural gas in the East Asian region. Based on this hypothesised distinctive economics, a case study is employed to examine how low oil prices affect the gas sector using quantitative and quantitative research methods. The quantitative assessment is conducted using a world gas trading model. The study demonstrates that many market failures in the gas and LNG markets are explained by the proposed distinctive gas economics and associated sector-specific factors. This analytical framework coming from the distinctive economics provides a tool for policy makers and industry to assess policy options that can address these market failures .

This research makes three major contributions. First, the proposal of the existence of distinctive gas economics in East Asia is new to the literature. This hypothesis provides an analytical framework to explain many unexpected behaviours and is useful for the gas and LNG industry and East Asian policy makers in understanding future market dynamics that are critical for their decisions in related to gas business and policies, relatively. Second, given that the global integration of gas markets is hypothesised to bring closer movement of regional prices, but the distinctive economics in the East Asian market has seen gas prices departing from those in the European and United States (US) markets, further study of the unique factors for the East Asian market can make important contributions to the literature. Third, it is the first simulation analysis of the effect of low oil prices on East Asia's gas sector.

The paper proceeds as follows. Section 2 reviews the literature on debates in the East Asian gas market, and relationships between oil prices and the gas sector. Section 3 explains the

methodology, and proposes the distinctive gas economics of East Asia as an analytical framework to assess the effect of oil prices on the East Asian gas sector. Section 4 analyses qualitatively the effect of low oil prices on the gas sector according to the framework identified in Section 3. Section 5 presents a simulation analysis of a scenario of lower oil prices and the effect this would have on global gas production, trade and prices. The final section concludes the paper with a discussion of policy implications.

2 Literature review

The relationship between oil and gas prices is a long traditional topic in the literature. Ji *et al* [14] investigate a traditional issue in the oil and gas nexus: the co-integration of oil and gas prices in three major markets. The most popular tool for studying this relationship empirically is structural vector autoregression (VAR), for example, Jadidzadeh and Serletis [15]. The evolution of the literature often depends on the development of new economics techniques or the creation of more sophisticated data. For example, using a long dataset, a recent study [14] claims that oil and natural-gas prices may become decoupled, and that contrary to earlier research, natural gas may lead to crude-oil prices over a long sample. However, another recent study [16] uses a recently developed quantile autoregressive distributed lag (QARDL) model but yielded no new findings in the results. In addition, Brigida [17] allows multiple regimes when studying the co-integration relationship between natural-gas and crude-oil prices.

Even in the recent literature, there is no consensus on the relationship between oil and gas prices. Many studies have found departures in the relationship between oil prices and gas prices in the US and Europe due to supply changes (either through newer production technologies or the commissioning of significant production capacity), technology improvements and changes in

contractual agreements. A recent analysis of Henry Hub prices and crude-oil prices with increased shale-gas production argued that the oil–gas long-term relationship ceased after 2009 [18]. Erdos [19] investigates US and UK natural-gas prices and crude-oil prices, finding a decoupling phenomenon around 2009, and that natural-gas prices in the US and UK appear to be separate from each other. In addition, Ji *et al* [14] found that the oil-price shock is weak in North America, lags in Europe and is the most significant in Asia.

In contrast, many researchers argue that the two prices remain interdependent. For example, Villar and Joutz [20] found a co-integration relationship between Henry Hub natural-gas prices and WTI crude-oil prices. Asche *et al* [21] found that European continental contracted gas prices are driven by oil prices, and that the new spot markets in Europe follow the same process of price determination as those in the UK gas market, meaning that all spot prices are determined by the oil price in the long term. However, this relationship is hypothesised to change due to start of US LNG exports, changes in price linkage in gas contracts and the development of spot trading in gas markets [1].

Another group of studies observes a different relationship between oil and gas prices in the short and long term. Hartley *et al* [22] found that there are short-term departures from the long-term equilibrium between crude-oil prices and natural-gas prices. They argue that seasonal factors such as inventories, weather and supply shocks are the principal reasons for this short-term decoupling. Brigida [17] found that there exists a regime-switching mechanism, but that the prices of oil and gas are co-integrated and they faced a temporary shift rather than a permanent decoupling in the early 2000s.

While the dependence of natural-gas prices on oil prices in Europe and the US is weakening, this may not be the case in East Asia due to oil indexation. Therefore, it is important to simulate how the East Asian gas markets will respond to low oil prices.

Most studies on East Asian gas-pricing issues focus on pricing mechanisms and associated contract arrangements. The IEA [13, 23] discusses how East Asia might achieve a transition from oil indexation to hub indexation. Stern [24] observes that oil-indexed gas pricing no longer reflects market fundamentals but East Asia has only begun to address the issue after 2011. Rogers and Stern [25] argue that Asian buyers should develop a price-formation mechanism that reflects their national or regional market fundamentals, a viewpoint that is similar to that of the IEA. Vivoda [26] evaluates the potential effect of Japan's LNG strategy on regional pricing of gas in the broader institutional context. Shi and Variam [27] examine the effect of changes in indexation and contract terms in East Asia on world gas markets. Lin and Li [28] use a comprehensive econometrics framework to study regional segmentation and the different pricing mechanisms of natural gas. More broadly, there are discussions on the effect of future gas-market integration on trade patterns and infrastructure [29]. Chang and Li [29] found that with an integrated and competitive regional natural-gas market, supply should come more from within the East Asian region, which allows cheaper transportation costs than the costs associated with sourcing from external suppliers that offer relatively cheap production and transportation costs.

With the low oil prices after 2014, studies of the effect of low oil prices on natural-gas prices have been conducted but no study has performed a quantitative analysis including modelling simulation. Through quantitative scenario analysis, Rogers [30] explores the effect of lower oil and lower gas prices on existing and future gas and LNG projects, with an outlook for the period to 2030. Corbeau *et al* [31] conduct a comprehensive assessment of how low oil and gas prices

affect the world gas sector, with an emphasis on emerging gas markets. Shi [32] discusses how low oil prices might affect supply, demand, trade and investment in the Asia–Pacific gas sector. There are also several studies on the effect of high oil prices on natural-gas prices. For example, Barden *et al* [33] demonstrate that higher oil prices lead to a higher production and consumption of natural gas, which is contradictory to the usual expectation of low consumption, but this unusual behaviour was not investigated further. The simulation conducted in this paper demonstrates the likely future scenarios of the gas sector in a persistent scenario of low oil prices, and thus can help policy makers and industry to make policy decisions on investment and policy, respectively.

Thus far, no study in the literature has considered how oil indexation will affect economic behaviour in the East Asian gas sector. Most studies in the literature focus on short-term price shocks. They neither study the effect of low oil prices nor the East Asian gas market. Despite the many studies on the relationship between oil prices and the gas market, there is a lack of research on the effect of long-term low oil prices on the natural-gas sector, and no explanation of how and why the gas market will respond to persistent low oil prices.

3 Methodology: distinctive economics of the East Asian gas sector

This paper argues that the economics of the East Asian gas markets are distinct from standard economic theory in which price is decided by the interaction between supply and demand. A case study of the effect of low oil prices on the East Asian gas sector is employed to test this hypothesis. The case study is conducted using qualitative and quantitative research methodology.

3.1 Computational modelling

The quantitative simulation is conducted using the Nexant World Gas Model (WGM) [34]. The WGM is formulated as a linear program with minimisation of global gas-procurement costs (including production costs and transport costs) as the objective subject to technical constraints such as pipeline, LNG liquefaction and regasification capacity, storage capacity and their associated costs, as well as institutional constraints such as contract arrangements, destination restrictions and minimal 'take-or-pay' (TOP). The model includes all known sales contracts, including source and destination, annual contract quantity (ACQ), start and end dates, price formulae, and active and planned infrastructure. It also includes essential variables such as seasonal-demand variations, supply swing and storage capacities (working volume and deliverability). The historical data are available for 2006 to 2014 and the outlook period is up to 2035. In the model, trade LNG and gas prices are linked to certain benchmark prices. In East Asia, the benchmark price is oil price, which reflects the exogenous pricing of traded gas. The model outlook does not consider the East Asian gas hub pricing that is emerging. Readers who are interested with the effect of hub pricing may refer to two recent studies [27, 35]. For more details of the model and model assumptions, please refer to several recent studies [35-37].

3.2 Qualitative analytical framework

As stated, the economics of the East Asian gas market are distinct from standard market economics in that gas prices are exogenously set from market supply and demand. In standard economic theory, gas prices will be endogenously determined by supply and demand—a fall in gas prices will stimulate gas demand and discourage gas supply and thus create a market shortage or a gap. The gap will force the gas market to be rebalanced at a new equilibrium, with

a higher price level. In contrast, in increase in gas prices will reduce demand and increase supply and thus rebalance the gas market at a lower price level. However, prices of most traded natural gas (both through pipeline and LNG) in East Asia are indexed to oil prices. Gas prices are typically calculated at a rate of 12 to 15% (in the unit of MMBTU) of the oil price per barrel [38]. Given that the market fundamentals of the oil and gas markets are different, the oil-indexation price mechanism would not necessary lead to equilibrium in the gas markets [13].

The time lag in the oil-indexed gas-pricing formula further deviates the gas prices from the contemporary market fundamentals. The oil-indexed gas prices will often have a time lag reported at approximately four to eight months [39], or even six and 12 months [9]. In a time lag of this length, changes in gas market fundamentals will often not be reflected in traded gas prices. This divergence has been particularly serious during the past two years when oil prices have slumped. This serious divergence in crashing oil prices mean that India and Qatar must rework the pricing formula for LNG trade [40].

The S-curve[1] further encourages suppliers to ignore market equilibrium prices because producers will be guaranteed a floor price during a period of low oil prices. The S-curve's price formulae are common in current gas contracts, which set floor prices and ceiling reference oil prices.

Moreover, the long-term contract practice and the TOP obligation in East Asia's gas trade distort demand for import to respond to world prices and further deviate the gas economics of East Asia from the standard economic theory. East Asian pipeline gas and LNG are often traded with 10-year and even longer term contracts. According to the latest report from the International Group

[1] The S-curve is defined by its slope (LNG price relative to reference oil price). The slope becomes flat where the oil price is above and below a certain oil price to dampen the effect of high oil prices on the buyer, and low oil prices on the seller.

of Liquefied Natural Gas Importers (GIIGNL), gas trade in 2015 with contract terms above four years accounts for 72% of the global traded LNG [12]. Terms in these LNG contracts reflect the status of the market at the time of negotiation, but not the time of delivery. While some contracts can reopen terms every few years, there is a lack of flexibility to handle the short-term market conditions. Therefore, the long-term contracts often deviate from current and future market fundamentals. The deviation is often unilateral: long-term gas-contract prices are often (except in very tight markets) the ceiling for hub prices because otherwise, either high nomination or more spot trading will occur to restrain the hub prices [30].

Further, the TOP obligations put a floor on gas import volume. The TOP liability requires that buyers pay for a minimum volume such that the specified volume of gas must be purchased regardless of demand. The TOP transit's volume risks to downstream buyers which guarantee the volume of supply even the market equilibrium supply should be lower. The commercial practice of long-term contracts and TOP help to explain why the number of proposed projects still far exceeded the demands of likely customers in a low-price period [41].

Finally, because of some national institutional settings, low oil and gas prices in the international markets may not be able to channel to domestic consumers and therefore undermine demand response. One key national institutional setting is price control in the final markets, which limits the effect of low gas prices on gas consumption. According to an International Gas Union (IGU) [6] report, approximately 35% of global gas consumption in 2014 was under various regulated prices.[2] Most of the East Asian domestic gas market is vertically integrated or even monopolised

[2] Meanwhile, the share of consumption under gas-on-gas competition prices and oil indexed prices was 43 and 17%.

[13]. A monopolised gas market most likely prevents the transition of low international gas prices to domestic gas and electricity markets. Despite declining gas prices, East Asian demand has not been boosted, but rather has decreased in some areas [32].

Regulation of domestic gas prices is another factor that prevents the channel of low international prices to domestic consumers and thus discourages market response to low prices. In many East Asian countries, domestic gas prices are regulated by the government [13]. For example, the regulated prices in China fail to keep pace with market dynamics [35]. In contrast, the dramatic decline of global oil prices has resulted in low prices for gas alternatives and thus the gas demand in China in 2015 was lower than expected by the majority of the market players [12]. Globally, despite the decline in oil prices, IEA revised down the natural-gas demand outlook in its 2015 *Medium-term Gas Market Report* [42].

Some sectoral characteristics distort the East Asian gas market from standard economic theory. The capital-intensive nature and long lead time imply that the supply will not reflect current market fundamentals. Gas projects (LNG projects in particular) are capital intensive, which means they have low variable (operational) costs and thus low shutdown prices for gas exports. This means producers will usually not shut down production as long as operating costs are covered. Therefore, natural-gas extraction from fields will continue despite prices being below the full cost incurred by off-takers.[3] Further, the long lead time of gas projects causes delay of supply response to price signals. Short-term price swings are unlikely to have a strong effect on new investments that will take five or 10 years to come online. A recent example is that the UK's

[3] Australia's LNG from coalbed methane will be exceptional because these plants have extremely high ongoing operational costs due to the need to drill hundreds of wells every year to maintain feed-gas production.

biggest deep-water fields, the Laggan Tormore project, had started production in February 2016 [43]. The capital-intensive characteristic of LNG industry prevents supply to response to market in lower price cases. The factors that cause the distinctive gas economics are summarised in Table 1.

Table 1 Framework for analysis of economics of East Asian gas markets

Pricing mechanism		Oil indexation: gas prices are determined by oil prices and thus will not reflect the gas-market fundamentals Oil indexed gas price is set with significant time lag from oil prices and thus will not reflect current market fundamentals Pricing formula: the S-curve will fix prices in extreme cases
Commercial practice		Long-term contracts: these do not reflect current and future fundamentals Minimum TOP level places a floor on gas import volume causing supply inflexibility
National institutions		Monopolised market, and regulated wholesale or retailing prices undermine demand response
Sectoral specific factors	Capital intensive	Low variable costs and high capital costs cause low shutdown prices
	Long lead times	Projects were decided long ago and thus cannot respond to current market fundamental changes

4 Qualitative assessment of East Asia's gas markets in period of low oil prices

Based on the distinctive gas-market economics in East Asia presented in Section 3, East Asia will more directly feel the effect of low oil prices on natural gas than will the US and Europe. The distinctive economics of the East Asian gas markets will cause a persistence of lower gas prices in a low-oil-price regime that is driven primarily by inflexible contractual terms in an anticipated over-supplied market in the context of predominantly oil-indexed gas prices. Oil indexation will lead to lower LNG and gas prices when oil prices are low. By intuition, as well as

using economic theory, it can be expected that the price drop will discourage supply. However, despite lower-than-equilibrium gas prices, the supply shortage may not occur in the short to medium term. Due to these special market economics, the East Asian LNG market will continue have a supply glut until at least 2020.

4.1 Supply side

Although many market players have expressed concern that low gas prices could disrupt gas supplies in the medium to long term due to lack of investment, few market players expect that the LNG glut will disappear, at least not before 2020. For example, the IEA believes that global LNG export capacity will increase by more than 40% by 2020, with 90% of the additional export capacity coming from Australia and the US [42]. The gas-supply glut is particularly relevant to the East Asian LNG market because most of the planned LNG development projects are in Australia and Papua New Guinea, which could introduce approximately 90 bcm of new supply per year to the market [9].

Several factors could contribute to an ongoing glut despite low gas prices. First, the projects that have already received final investment decision (FID) and are under construction are unlikely to be ceased. These sites will come online over the next few years because large portions of their volume are usually committed to buyers. A considerable number of liquefaction projects in Australia and the US are already under construction and will go ahead despite low gas prices, which will add to the LNG supply glut up until 2020 [44]. In Australia alone, 14.4 million tonnes per annum (mtpa) of new production capacity has been added to the market and 42 mtpa are expected to come on stream in 2016 [12]. In the US, gas prices are relatively independent from oil prices, and the US Energy Information Administration forecasts that US natural-gas production growth will rise from late 2016 to 2017 despite current low gas prices [45].

Second, the new business model in LNG liquefaction terminals will also boost LNG export despite low oil and gas prices. The new players that are building, or proposing to build, LNG export projects in the US and Canada are not traditional players and have access to the requisite technology and financing.[4] Given that tolling fees have been committed for a long period and thus become sunk costs, exporters may continue export, at least for a short term without recovery of the sunk investment costs. These players will produce the majority of incremental LNG in the next 10 years if they can overcome and absorb their own financial strains. However, not all proposed LNG projects in the US will begin exporting LNG in their initial planned periods, which will slightly alleviate the supply glut. The TOP obligations delink supply from prices and further contribute to the supply glut. This means that sellers must produce gas at the minimum required levels and take on the added risk of low prices.

Third, the resilience of the gas sector, including shale gas, will add pressure to the world gas markets. The cost of production for gas projects is flexible and could be reduced with low prices for reasons that include capital restructuring, management improvement, and technology innovation [46]. Capital costs for production and exports could be reduced by using floating LNG facilities, introducing competition into liquefaction processes, synergies by share of costs, and simplifying the engineering design stage [30]. Further, technology innovations could reduce the production costs of gas and thus boost supply in lower prices. It has been reported that drilling efficiencies and well performance have been improved in the US, which reduces the unit cost of gas production [31]. The effect of low oil prices on shale-gas activities in particular could be weaker than many observers anticipated. For example, the US Energy Information Agency

[4] US LNG exports are supplied by independent companies—not international oil companies and national oil companies—and operate under tolling models.

(EIA) projects that production of shale gas will increases in the situation of high and low oil prices [46]. The Chinese shale-gas sector is also somewhat insulated from low international prices due to regulation that sets China netback prices[5] at a floor of US$6/MMBTU. The participation of state-owned enterprises (SOEs) add power to weather the price storm because SOEs are less sensitive to declining profits than are private companies. Even amid the lower gas prices, China will continue its efforts to develop shale gas and coalbed methane to improve its energy security, employment rates and efforts in technological innovation. Nevertheless, the supply of conventional gas may still come under pressure due to reduced gas prices and the increasing amount of LNG and pipeline-gas imports.

Fourth, the entrance of new players, such as private and non-oil and gas players, into the oil and gas market, and the investment from these new players, could mitigate some investment reduction from existing oil and gas companies. The retreat of oil and gas majors could make room for new players to enter projects or areas where they were previously disadvantaged. The lower asset value makes traditional oil and gas projects more affordable to many investors, both inside and outside the oil and gas industry. Oil and gas companies from importing countries such as China, India, Japan and Thailand will have an opportunity to acquire and develop LNG for their domestic markets under attractive terms and may partially fill the gap created by reduced activities from international oil companies [47]. For example, Baosteel, a major Chinese steel company, two Chinese insurers, and a number of funds were allowed to acquire stakes in three pipelines that were owned by China National Petroleum Corp (CNPC), which has lost revenue due to the oil-price drop [48]. In March 2016, a private Chinese oil and gas company announced

[5] The netback price is the city-gate price to the gas producer, which is based on the market price minus charges for delivering the gas to market.

its bid to take over Bankers Petroleum Ltd in a deal worth C$575 million [49]. Both examples indicate a trend that many private Chinese companies consider this low-price period an opportunity to acquire overseas oil and gas assets [50].

However, over the medium and long term, gas supply will be undermined due to reduced or delayed investment. Many more companies will have to reduce their investments in new natural-gas and LNG projects due to difficulty in accessing capital, regardless of the investment value of these projects. With lower oil or gas prices, companies will logically cut capital expenditures and refocus on lower cost assets, despite the slight possibility of counter-cycle investment.[6] According to a report from Bain & Company published in November 2015 [51], the oil and gas industry deferred or cancelled US$200 billion worth of planned investments over the past two years and another US$1.5 trillion of future spending due to calculations that these projects might not be economically viable given oil prices at that time.

Further, market volatility and low gas prices will make it difficult to begin new projects. Industry analysts have observed that an FID for large greenfield projects in high-cost areas such as Australia and Canada is likely to be postponed or permanently cancelled, whereas FID for projects in relatively low-cost areas such as the US is likely to continue [44].

4.2 Demand side

Given that the supply of natural gas is unlikely to change in the short term and the glut is expected to continue until at least 2020, generating new demand for gas will be necessary to

[6] However, counter-cycle investment could occur to help prepare for a future rebound in prices. A prominent past example is the go-ahead decision on Gorgon LNG made in 2009 after the oil-price crash (see Stoppard 2015).

rebalance the market. Despite relatively rigid market demand in East Asian countries, low oil prices can provide a stimulus for demand for at least three reasons. First, low-cost LNG will cause increased demand from some LNG-importing countries. For example, the low-price of LNG makes natural gas competitive in India's power sector. In 2015, India recorded high LNG imports, and its imports in 2017 are expected to be double the 2010 levels [52].

Second, low LNG prices will push the development of new markets to new destinations (e.g., Bangladesh, Egypt, India, Jamaica, Pakistan, the Philippines, Panama, South Africa and Vietnam) that are sensitive to prices. These markets have been or will be developed and will help offset the supply glut [41]. The emergence of new technologies and infrastructure has enabled breakthrough into these new markets, which often cannot afford the immense scale and costs associated with natural-gas infrastructure. For example, floating LNG terminals could provide a low capital cost (but not a low operational cost) solution for LNG importers in these less developed countries. Egypt, Jordan and Pakistan began to import LNG through floating terminals in 2015. Nevertheless, technological innovation may not be sufficient to generate new demand. For example, to develop the natural-gas sector further in less credit-worthy emerging economies, LNG developers may also need to provide credit and investment support in downstream infrastructure [41].

Third, expanding the use of LNG in the transportation sector is another option for further utilising a seeming overabundance of viable natural-gas resources. For example, only a 10% switch of transport fuels to gas globally would create demand for 70 million tonnes of LNG equivalent (an amount that is similar to Japan's LNG imports and represent 30% of global LNG trade in 2015) [53]. While low oil prices enable LNG to compete more widely with coal, they will reduce the incentive for gas-to-oil substitution in the transport sector.

As the IEA predicts, low natural-gas import prices could turn gas into an increasingly attractive option from an environmental standpoint [42]. The demand for cleaner air, which is seen in China and India, could be a significant driver of natural-gas demand given that natural gas produces fewer emissions per unit of energy than coal. According to recent data from the World Health Organization, 56 of the top 60 globally polluted cities (in terms of particulate matter 2.5) are located in Asia, and most of these cities are in either China or India [54]. Natural gas is the immediate solution to replace coal and can help reduce air pollution in these countries.

In the long term, the 2015 United Nations Conference on Climate Change (COP21) could provide the necessary momentum to spur natural-gas development due to the growing global consensus and push towards cleaner energy sources. According to a recent IEA report, coal combustion generates more than 40% of carbon dioxide emissions despite constituting only approximately 30% of the total primary energy supply [55]. Given that natural gas has approximately half the emissions intensity of coal, a shift from coal to natural gas could be an immediate strategy to meet COP21 targets without limiting the energy needed for economic growth, particularly for developing countries. However, in the short term, low oil and gas prices could worsen the level of emissions as fossil fuels gain cost competitiveness over alternatives.

5 Simulation of effect of low oil prices on East Asian gas markets

To test the effect of low oil prices on the natural-gas sector, we conducted simulation exercises using the Nexant WGM [34]. In this model, the specified demand for each node (some countries may have more than one node) is exogenously forecasted based on economic growth, energy intensity and population growth at a sectoral level. Supply data by field is included as a cost

curve for the producing country. Oil prices are used to derive gas prices under long-term gas contracts (oil-indexed contracts) into Europe and Asia.[7] Given that contracted gas prices are linked to oil prices, the demand may not be met and thus leave a gap between demand and consumption in a low-oil-price period because of insufficient production resulting from low prices. The results are presented as a difference between the policy scenario and the baseline scenario. Shi and Variam [27] provides a detailed explanation of the model, the regional classification, key assumptions and inputs, and the baseline scenario.

5.1 Baseline scenario

The baseline scenario is developed as a reference case to study how the international gas market might evolve to 2035. The original oil prices assumption was taken from IEA and World Bank price projections.

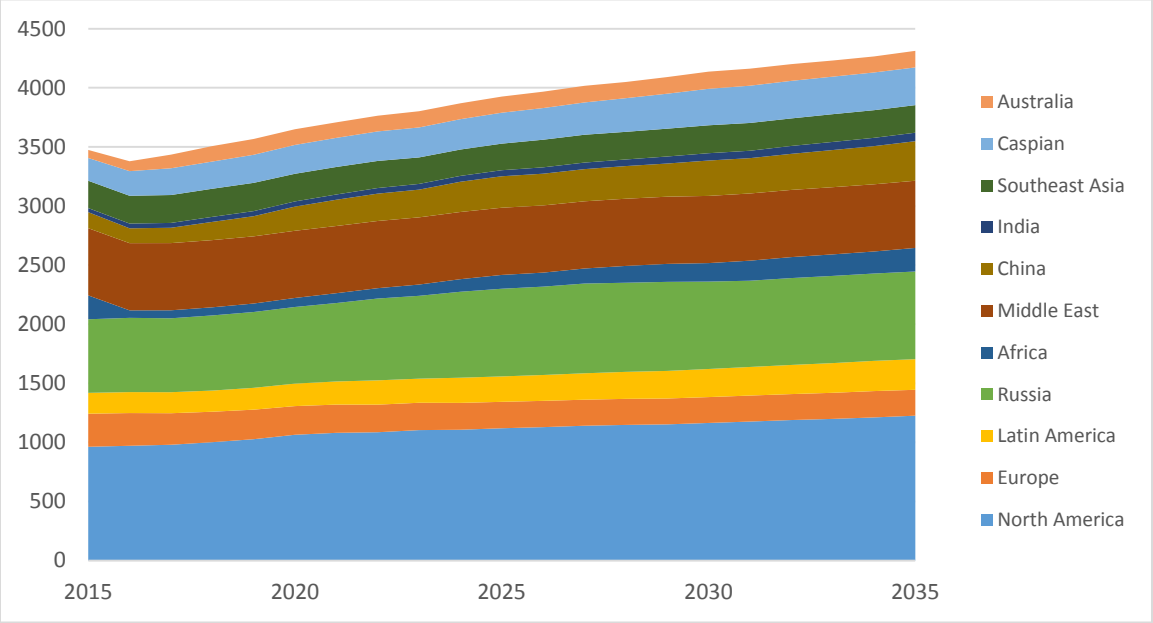
In the baseline scenario, global gas production and consumption is projected to increase from 3550 bcm in 2015 to 4860 bcm in 2035, with a compound annual growth rate of 1.6% (Figure 1). LNG exports will grow faster than pipeline exports, signifying the great potential of LNG export growth. Global LNG exports will grow 3.6% per year from 330 bcm in 2015 to 670 bcm in 2035. In contrast, pipeline-gas trade increases at a moderate 1.9% per year from 2020 bcm in 2015 to 2920 bcm in 2035.

Natural-gas spot prices are expected to decrease from 2015 to approximately 2020, in line with a decline in oil prices, before rising steadily to original price levels at approximately

[7] Specifically, the Japan Crude Cocktail is often used as a benchmark for LNG contracts, particularly in the Far East, and high sulphur fuel oil price is the benchmark for pricing gas contracts in Europe.

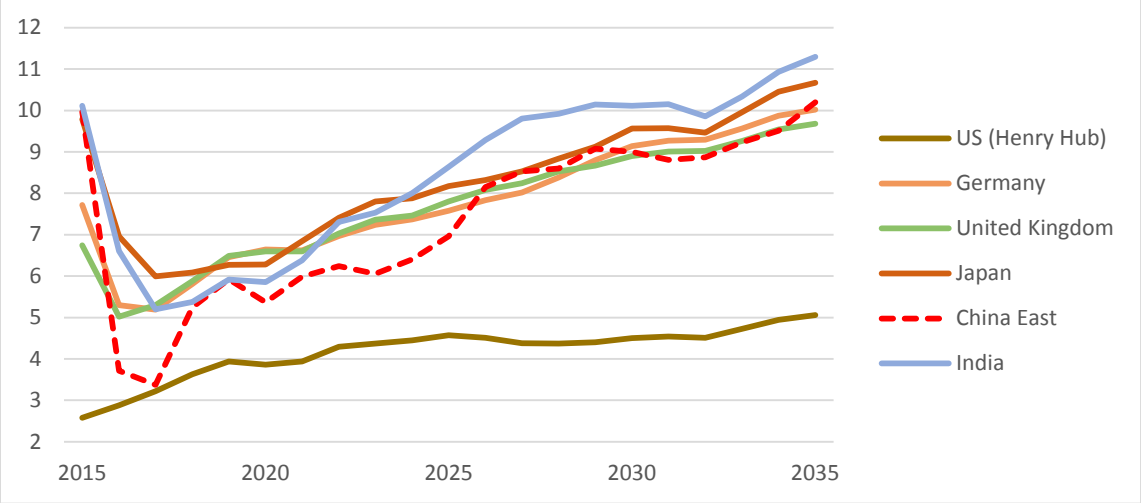
US$10/MMBTU in Asia and Europe. Asian prices are generally higher than European and North American gas prices (Figure 2).

Figure 1 World natural-gas production in baseline scenario (bcm)



Source: model results

Figure 2 Spot gas prices in key markets in baseline scenario (US$/MMBTU)

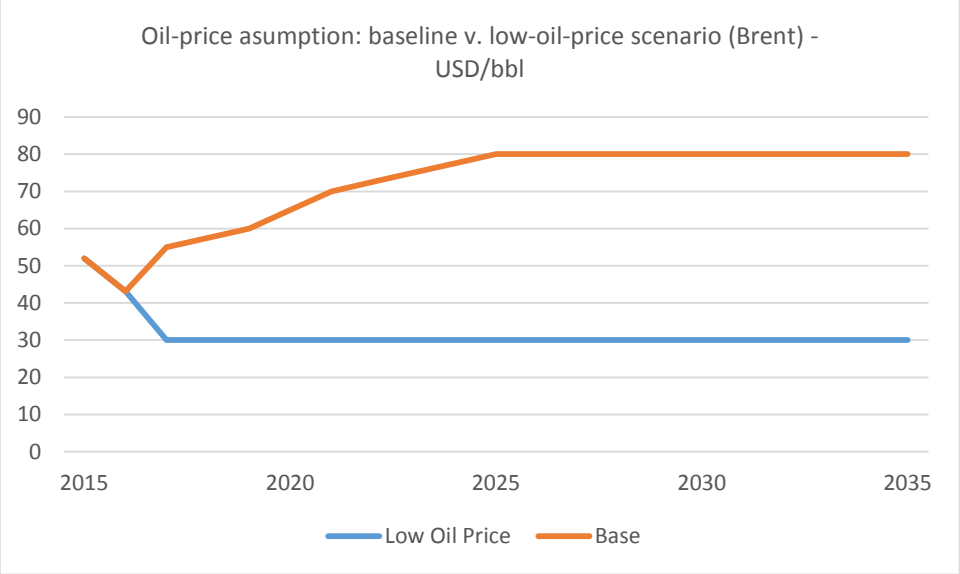


Source: model results

5.2 Effect of persistent low oil prices

As we are creating an illustrative case and for the sake of simplicity, in the simulation of the effect of low oil prices, we assume a low oil price of US$30/barrel across the study period. The oil-prices assumption in the baseline and in the low-oil-price scenarios are presented in Figure 3.

Figure 3 Oil-price assumption: baseline v. low-oil-price scenario



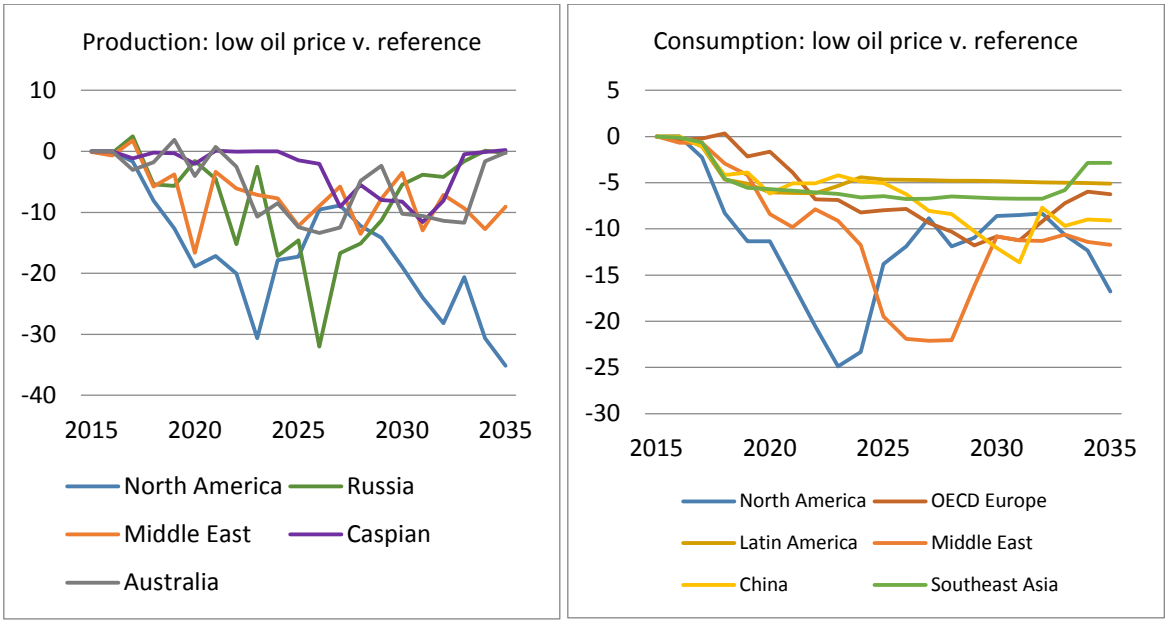
Source: Model assumptions

From the simulation, the largest effect of low oil prices is observed in the production and consequently, the consumption of natural gas. Due to the low prices for oil-indexed gas and LNG exports, there is a decline in the production due to a shut-in of higher cost fields. The low oil prices discourage production and thus leave a significant gap between demand and consumption.[8] On the supply side, production from North America, Russia, the Middle East and

[8] The forecasted natural-gas demand is different from realised consumption. Demand is an input to the model and consumption is an output of the model. Consumption is almost always equal to demand; however, consumption can

Australia declines. On the demand side, the Middle East, the OECD, China and Southeast Asia experience a fall in consumption (Figure 4). Science demand is exogenously set and will not change with lower oil prices, some demand will not be met due to lower production, thus creating shortage when compared to the baseline scenario.

Figure 4 Natural-gas production and consumption in bcm, baseline v. low-oil-price scenario



Low oil prices make US LNG more expensive than Asian buyers' expectations and thus, less attractive to these buyers. LNG exports from North American to Japan and Korea will be reduced in the largest amount of all the destinations (Figure 5). However, earlier developed LNG export facilities such as Cheniere's Sabine Pass LNG and Freeport LNG are less affected by low

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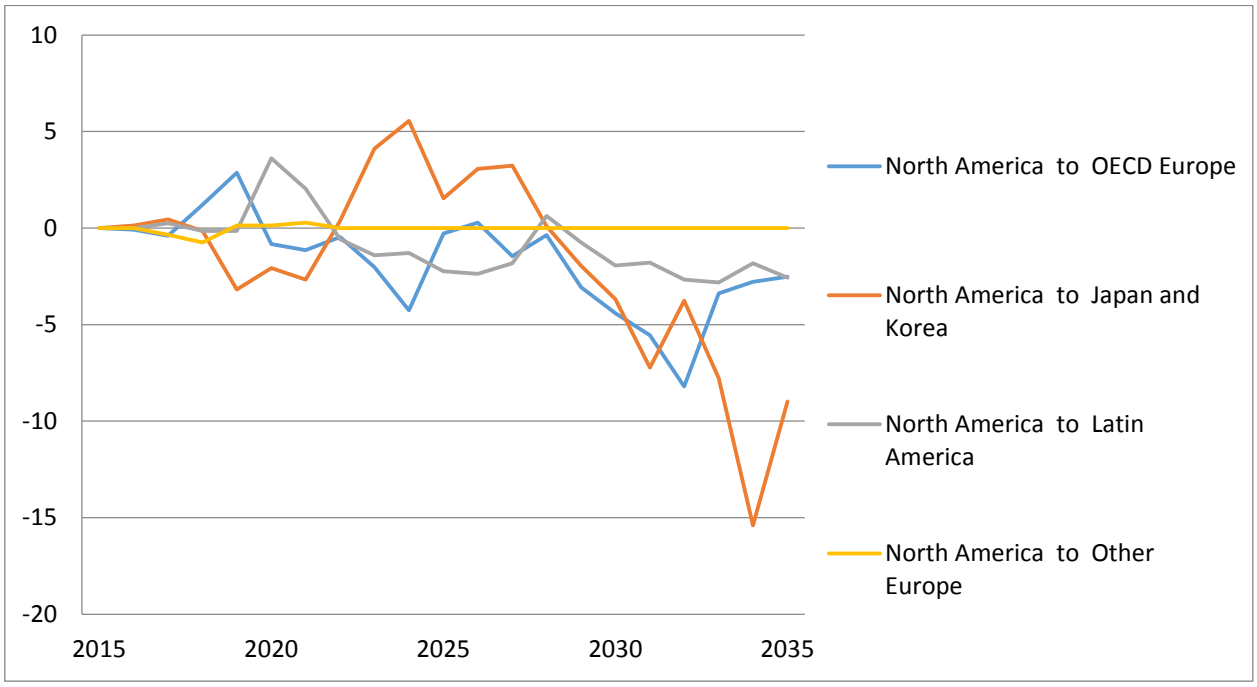
be less than demand (i.e., demand side reduction) due to supply bottlenecks and increases in gas prices to above the price of alternative fuels, which leads to fuel switching.

gas prices given that they are already fully contracted [56]. Nevertheless, US LNG may be in demand for other reasons (e.g., supply security and diversification, flexibility from destination clauses, liquidity of spot markets, and non-oil-linked pricing). This part of US LNG demand will not likely be affected by low gas prices. This is reflected in the steady contracted US LNG exports to China and India in the low-oil-price scenario, where supply is taken up to TOP level in both the baseline scenario and the low-oil-price scenario.

Figure 5 North American LNG export in bcm: low-oil-price scenario v. baseline scenario



Source: simulation results.

The adverse effect on North American LNG exports is due to the different price mechanisms. Given that the North American gas prices are independent from oil prices, the low oil prices will make other oil-indexed LNG exports to East Asia more competitive. Even if US Henry Hub

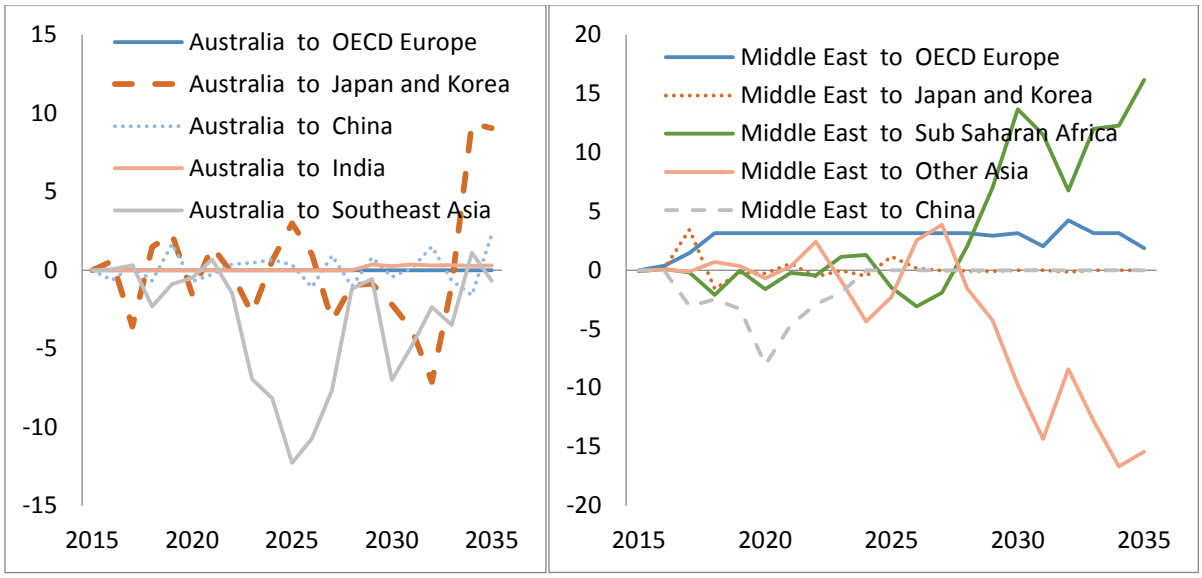
prices remain at the US$2 level, the US LNG cost, insurance, and freight prices to Japan will be at least US$6.5 per MMBTU given the prevailing tolling fee of liquefaction (currently between US$2.37 and US$3 per MMBTU [57]) and freight (another US$2–3 per MMBTU, including boil off) [44].[9]

The US may become the swing LNG producer and put a ceiling on world LNG prices in the future. The competitiveness of US LNG could change either if oil prices increase to above US$60 a barrel or US LNG export costs are reduced through technical and financial innovations. When oil prices are above US$60 a barrel, US LNG will be competitive with LNG in Asia based on Japanese customs-cleared crude prices.

As expected, the behaviour of the oil-indexed Australian LNG exports is different from that of the hub-indexed US LNG exports due to the difference in pricing mechanisms (Figure 4). Australian exports are largely unchanged, except those to consumer countries in Southeast Asia (i.e. Vietnam, Thailand and Singapore), where low oil prices make the Southeast Asian LNG more attractive to local consumers. Australian LNG even gains market in Japan and Korea by replacing North American LNG (spot sales). The Middle East LNG shows a similar pattern to that of Australia, except that exports are diverted from India to Africa.

Figure 6 LNG exports from Australia and the Middle East in bcm (low-oil-price v. baseline scenario)

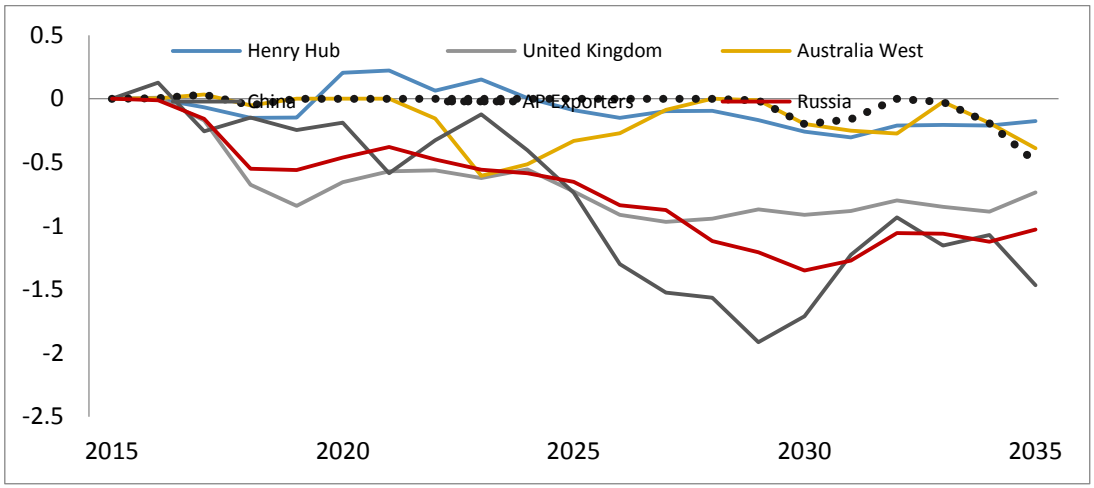
[9] Transactions used on a cost, insurance, and freight basis mean that the price includes all costs of transporting the goods from the point-of-origin to the destination.



Source: simulation results

All the major gas spot prices will be reduced in the low-oil-price scenario (Figure 7). The prices (apart from the Henry Hub and National Balance Point (NBP) prices) are lower because their oil-indexed nature. The representative hub prices (Henri Hub and UK) are also lower due to the competition from the other lower prices gas in the market.

Figure 7 Spot prices: low-oil-price v. baseline scenario in US$/MMBTU



Source: simulation results

6 Conclusion and policy implications

This paper examined the implications of oil indexation in the East Asian gas sector and identified the distinctiveness of East Asian gas economics from standard economic theory, which holds that the interaction between supply and demand determines prices. Given abundant gas resources, growing demand, and the need to reduce greenhouse-gas emissions created by the use of fossil fuels, there are strong incentives—and needs—to ensure continued development of natural gas as an attractive low-emissions source of fossil fuel. Today's prolonged period of low oil prices has had a massive effect on natural-gas markets, particularly in the East Asia, where it plays a significant role in the energy mix of many countries in the region.

The economics of East Asia's gas sector has some characteristics that distinguish it from standard economics. The most distinctive factor is the exogenous determination of gas prices. That is, traded gas prices in the region are driven by oil prices due to the dominance of oil-indexed and long-term contracts. Other sector-specific factors such as its capital-intensive nature, and long lead time also contribute to the distinctive economic factors affecting the East Asian natural-gas market.

This distinctive economics causes some unique behaviour in the East Asian gas markets in a period of low oil prices. While low oil and low gas prices have created turbulence in global markets, the oversupply of natural gas in East Asia is unlikely to change in the short term, and the glut is expected to continue until at least 2020. This short-term inflexibility in supply is due to TOP arrangements, high capital requirements for projects, and long lead times for project development. In the medium to long term, delayed or reduced investment for new projects because of present lower prices and supply abundance could disrupt the gas supply.

On the demand side, low gas prices will increase the consumption of natural gas in existing markets—a trend that will be accelerated by the global momentum to combat climate change—along with new markets that will be developed due to cost attractiveness. Low gas prices also create the essential environment to drive innovations to reduce costs and open new markets. However, the demand response is often limited by a distortion of domestic prices that prevents low international prices from being channelled to end users. Additionally, weakening coal prices will cause competition among resources and can potentially depress demand for gas. While uncertain factors such as oil prices, Chinese demand and COP21 will shape the future of the gas industry, one key determining factor is cost competitiveness between coal and gas in local markets.

The simulations reveal that lower oil prices would lead to overall lower global gas prices, which discourages investment and thus leads to a significant supply shortage in the long term because gas prices are linked to oil prices and thus cannot respond to a shortage in the gas markets. Low oil prices make US LNG less attractive to their global buyers. In contrast, Australia and Middle East LNG gain market by replacing North American LNG.

Although total investment will be depressed, some structural changes could contribute to rebalancing the gas markets in the medium to long term. The retreat of current market players makes room for new oil and gas companies—even non-oil and gas companies—and financial investors to enter the gas sector. The fact that traditional oil companies are transitioning to the gas business is also a positive momentum for the industry.

The current low oil and gas prices have affected trade dynamics in many ways. They have helped phase out destination restrictions, reduced the attractiveness of US LNG, and facilitated market liberalisation in East Asia.

The paper has demonstrated that the distinctive economics related to the gas market in East Asia may cause market failure, and the gas market in this region will not be cleared in a low-oil-price scenario. In this scenario, producers will struggle to find markets to which to sell their gas, and consumers will struggle to find supply with prices that are competitive with gas alternatives. The analytical framework based on the distinctive economics of the East Asian gas market provides a tool for policy makers and industry to assess and search for policy options that address this market failure.

Specifically, this paper could lead to the following policy implications:

- Investment in the natural-gas sector should be better coordinated over time to avoid supply disruption. Further liberalisation of markets is needed to attract different investors and other players (e.g. financial institutes) that can help mitigate market volatility.
- Additional demand for natural gas should be developed either through creating new markets or by boosting consumption in existing markets to rebalance and develop a sustainable and robust natural-gas sector in East Asia and globally. Development of new markets not only creates a demand to solve the supply glut, but also mitigates carbon dioxide emissions from energy use. In the existing markets, extending the use of gas to the transport sector could also be a means of meeting the often-contradictory needs of creating energy and reducing pollutants and carbon dioxide emissions.
- The transition of pricing mechanisms from oil indexation to hub pricing should be advanced even in in the low-price period. While there is an indication that Asian buyers do not feel a great sense of urgency in initiating such a transition, the market failures due to exogenously pricing demonstrates the need of hub pricing.

- East Asia needs to accelerate gas market liberalization and hub building to improve market sustainability. While a regional LNG spot market may provide much needed benchmark prices, the lack of liberalization will delay the pricing transition process in domestic markets, which will further discourage the optimal utilization of gas.
- The buyers should take advantage of the low oil price that diminishes the gap between oil-indexed prices and hub prices. Changing the pricing mechanism in a low-price period will not cause a significant shock to buyers and sellers because the difference between oil-indexed prices and competitive hub prices in such a period is not significant.

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