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Joint Oil Stockpiling between Middle East Exporters and Northeast Asian Importers: A Winning Formula?

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Key Points

When oil owned and commercially traded by an exporting country is stored in an importing country in exchange for first drawing rights by the host country in times of emergency, that process is known as 'joint oil stockpiling'. It can thus be classified as both commercial and strategic storage, offering benefits to both parties. The first Middle East (ME)–Northeast Asia (NEA) joint stockpiling deal was concluded in 2006 between Kuwait and South Korea. Since then there have been several similar agreements by which the national oil companies (NOCs) of Saudi Arabia, Kuwait and the UAE have stored crude in in South Korea and Japan. An accord between the UAE and India, concluded in December 2016, is the most recent example.

The unique character of the joint oil stockpiling agreements between ME exporters and the NEA importers means these can meet two objectives simultaneously:

- The perceived energy security needs of net oil-importing countries and their objectives of enhancing their respective strategic petroleum reserves at low cost. This is because the oil-importing country does not purchase crude oil up front, but retains the pre-emptive right to purchase the oil in case of an oil disruption emergency.

- By obtaining free or cheap storage facilities within close proximity to large consuming countries, ME NOCs can take advantage of the flexibility provided by effectively having short-haul crude on offer to both their term contract clients and to other crude oil refiners that are not term clients. Joint oil stockpiling offers a platform for opportunistic access of Asian spot markets, an important consideration for the ME NOCs in the current low oil price environment.

Assuming a crude oil price of around $40/barrel (bbl), 5 percent interest cost of carry and an equal division of the carrying cost savings with the host government, the ME NOC could gain $9 to $18 million a year if it enjoyed 50 percent of the cost savings in storing 15-30 million barrels (MMbbl).

The host NEA country saves about $2.00/bbl in carrying costs while retaining the pre-emptive right to buy the stored oil during oil supply emergencies. If 15-30 MMbbl are stored, the NEA country would save an estimated $31.5 million to $63 million per year.

Summary for Policymakers

Joint oil stockpiling is the term used to refer to an agreement under which crude oil, owned and commercially traded by an exporting country, is stored in an importing country in exchange for first drawing rights by the host country in times of emergency. It has both commercial and strategic dimensions. Joint oil stockpiling can serve the perceived energy security needs of net oil-importing countries by enhancing their respective Strategic Petroleum Reserves (SPRs) at lower cost, while at the same time it can work as a channel for downstream integration by the national oil companies (NOCs) of the oil exporting countries whose objectives are to ensure market share at competitive prices for their crude exports to the large oil importing regions.

Building up and maintaining SPRs have long been part of the energy policies of Japan and South Korea. Both are members of the International Energy Agency (IEA), which carries SPR obligations, as well as being among the world's largest oil importers. The emergence of China, and more recently India, as very large Asian net crude oil importers has been accompanied by ambitious SPR plans as part of their national defence and energy security strategies.

The potential benefits represented by joint oil stockpiling agreements is of increasing interest to the NOCs of both regions, Northeast Asia (NEA) importers and Middle East (ME) exporters. To the extent that ME crude oil stored in host country facilities enhances the host country's definition of SPR – despite the ME NOC's retaining title to the crude until an oil supply emergency occurs – there are potential gains to trade. The cost of production and storage for the ME NOC is much less than the Asian buyer's cost of purchasing and storing their oil. The availability of storage facilities close to destination markets also provides an oil producer with significant advantages: it offers logistical flexibility and the ability to supply oil cargoes on a prompt basis. Deliveries can be made within days rather than the three weeks or more it takes to transport oil from the Arabian Gulf to Northeast Asia.

An early agreement by Statoil with South Korea in 1999 was probably the first example of a joint oil stockpiling agreement between a net crude exporting country and a net importer (Oil and Gas Connections 1999). It was the first of what South Korea hoped would be several similar arrangements with crude suppliers, including ME exporters, aimed at increasing its SPR volumes. Since 1999, there have been a number of similar joint oil stockpiling arrangements between leading ME NOCs and the large NEA oil importers, specifically Japan and South Korea, and more recently India. There have been high level talks between Chinese energy officials and ME oil producers regarding similar joint oil stockpiling arrangements over the past decade but these have so far proved unproductive.

The oil glut that led to plummeting oil prices in the second half of 2014 led key Asian refiners to buy a larger share of their crude oil requirements on the spot market, where it is able to be delivered immediately, rather than at some future date under the typical term contracts offered by the ME crude sellers. As competition in Asian crude markets has intensified in a volatile trading environment, opportunistic buying of crude oil cargoes in spot markets has become more common. ME exporters see their market share in Asia challenged because of the latter region's increased accessibility to non-traditional long- and short-haul flows. Long-haul flows include imports from Latin America and West Africa, while Russia's ESPO crude provides Asian refiners with a nearby alternative. By storing their oil closer to the large Asian demand centres, ME exporters are better able to compete with short-haul crudes in the region.

ME crude stored in NEA locations offers buyers oil that has been 'de-risked', in that the stored volumes have already transited the choke points of the Straits of Hormuz and Malacca. Joint stockpiling agreements offer crude oil sellers and buyers the flexibility to nominate smaller cargo sizes and permit break-bulk options. Joint stockpiling agreements also offer the ME NOCs a platform for opportunistic access to spot markets, an important consideration in the current low oil price environment. Joint oil stockpiling agreements between ME producers and large Asian importers can be expected to become an important feature of the oil trading relationships between the two regions.

Introduction

In this paper, joint oil stockpiling refers to an arrangement where crude oil, owned and commercially traded by an exporting country, is stored in an importing country in exchange for first drawing rights by the host country in the event of an emergency. It can thus be classified as both commercial and strategic storage. Joint oil stockpiling can serve the perceived energy security needs of net oil-importing countries by enhancing their respective Strategic Petroleum Reserves (SPRs) at lower cost. It can also work as a channel for downstream integration by the national oil companies (NOCs) of the oil exporting countries in their objectives of ensuring market share, at competitive prices, for their crude exports in the large oil importing regions. Though our focus here is on joint crude oil stockpiling agreements between Middle East (ME) crude oil exporters and key Northeast Asia (NEA) importers China, Japan and South Korea, we also touch on India, another key Asian crude importer, where relevant.

Probably the first joint oil stockpiling agreement between a net crude exporting country and a net importer was the one reached between Statoil and South Korea in 1999. According to state-owned Korea National Oil (KNOC), Statoil paid $8.6 million to stockpile 8 MMbbl of North Sea oil at its Yeosu and Ulsan storage plants (Alexander's Oil and Gas Connections 1999). Under the agreement, Statoil delivered the oil over a three-year period, beginning July 1, 1999. KNOC retained the right to have a 'pre-emptive' choice to buy the stored oil in the event of an 'emergency'. According to press reports, the agreement was the first of what South Korea hoped would be several with crude suppliers including ME exporters, aimed at increasing its SPR volumes. Since then there have been a number of similar joint oil stockpiling arrangements between leading ME NOCs and large NEA oil importers, specifically Japan and South Korea.

High-level talks between Chinese energy officials and ME oil producers on this topic have been reported over the past decade, but these have not yet led to any agreements.

It should be noted that the joint oil stockpiling agreements discussed in this paper are entirely different from the situation where oil-importing countries stockpile oil as part of their SPR requirements in a multilateral framework of cooperation for oil emergencies. The latter was among the fundamental motivations for the founding of the International Energy Agency (IEA), following the 1973 Arab oil embargo. Proposals for other regionally-based joint stockpiling agreements have been discussed on and off since the oil price shocks of the 1970s. For instance, Association of Southeast Asian Nations (ASEAN) member countries have long discussed a regional stockpiling agreement for Southeast Asian group countries, but no binding treaty with mandatory sharing rules has been signed. To date, the IEA remains the only multilateral agency with an oil emergency agreement covering its members.

For IEA Asian members Japan and South Korea, among the world's largest oil importers, building up and maintaining their SPR has long been part of their energy policy. The emergence of China, and more recently India, as very large Asian net crude oil importers has also been accompanied by ambitious SPR plans as part of their national defence strategies. In the context of heightened concern over energy security, as the ME region's turmoil has continued unabated since the December 2010 Arab Spring, the NOCs of both regions have become even more interested in the potential trade gains represented by joint oil stockpiling agreements. To the extent that ME crude oil stored in host country facilities enhances the host country's definition of SPR – despite the

ME NOC's retaining title to the crude until the event of an oil supply emergency – there are potential gains inherent in joint oil stockpiling. The cost of production and storage for the ME NOC is much less than the cost of buying and storing oil for the Asian buyer. The availability of storage facilities close to destination markets offers an oil producer significant advantages, enabling logistical flexibility and the ability to supply oil cargoes on a prompt basis. Deliveries can be made within days rather than the three weeks or more it takes to transport oil from the Arabian Gulf to Northeast Asia.

From the adoption of crude formula pricing in 1987, through the extended commodity boom and period of high oil prices since 2002 – which ended emphatically in the second half of 2014 – the focus of oil producers has been on maximizing long-term contracts, within the OPEC or country quota targets, if any, with standard pricing terms for large buyers which would pick up free on board (FOB) Arabian Gulf cargoes in large crude oil carriers. Their customers in Asia are typically the large NOCs or privately-owned conglomerates with their own shipping arms. Joint oil stockpiling agreements are seen by the ME NOCs as advantageous logistical investments, which provided added flexibility to serve their regular clients in Asia.

In the context of the low oil prices that followed the second half 2014 price collapse, joint oil stockpiling agreements have seen renewed interest, this time with different bargaining dynamics between the ME exporters and NEA importers. The new crude market environment has led to increased competition in the Asian oil market, with Asian buyers adding greater weight to spot purchases in their crude oil buying portfolios. This tendency has led even the most conservative ME NOCs to engage in spot market sales, albeit intermittently. The ME NOCs who had long preferred to sell their oil under long-term crude oil sales agreements (COSAs) have begun to engage in opportunistic spot market sales in order to protect or grow their market share, while minimizing price discounts in their formula pricing.

As the ME NOCs see the need, in a context of heightened competition, to engage in spot markets to access new market niches, the commercial options provided by leasing storage facilities in NEA markets have gained in importance. Even though it is far more efficient to move crude in large crude carriers direct to the delivery ports of the large NEA NOC refining facilities, reaching smaller customers located at or near ports that cannot handle large vessels has become an important option for ME NOCs. Their intermittent engagement in spot sales can be seen as attempts to convert new customers into clients with long-term COSAs. It is hard to imagine the ME NOCs having any intention of 'cannibalizing' their own term-contract COSAs, which account for the vast majority of crude oil exports, through spot sales in weak markets.

The case for SPRs in enhancing energy security is much debated. Nevertheless, the governments of the large Asian importers such as India and China look set to proceed with building up large SPRs. Oil supply security is high on their national agendas, despite the uncertain economic benefits of building and maintaining large SPRs which impose significant financial costs. The fact that a storage facility can be used for commercial purposes by the owner of the stored crude oil while simultaneously being credibly committed to an enhancement of the host country's SPR program provides the basis for mutual gains for both the country hosting the storage facility and the owner of the stored crude oil. Unlike international investments in oil refining and marketing (R&M) by the NOCs, where returns may have been at best modest, the storing of crude oil in key destination markets such as the NEA countries may prove both much cheaper and more effective in the marketing of ME crude oil. Joint oil stockpiling agreements could become a more common and important mode of business cooperation, with mutual gains for the ME NOCs and their partner NEA host countries.

In Section 1, we briefly review the downstream integration ventures of the crude oil-exporting NOCs in the major oil-consuming countries to establish a context for assessing joint oil stockpiling agreements. In Section 2, we examine the role of SPRs in theory and practice, with a focus on NEA SPRs. In Section 3, we describe the existing and proposed joint oil stockpiling agreements and their commercial and strategic benefits for both sides. In Section 4, we examine in detail the relevance of joint oil stockpiling to host country SPR programs and the potential cost savings. In Section 5, we analyse how ME NOC formula pricing norms might influence the pricing of cargoes supplied from NEA joint stockpiling terminals.

OPEC and NOC Downstream Integration

Downstream integration through joint ventures or sole ownership of oil refining and marketing (R&M) facilities in crude oil importing countries has been an important goal of many oil-producing countries (Stevens 2000; Verleger 1994). Beginning in the 1980s, NOCs Petroleos de Venezuela (PDVSA) and Kuwait Petroleum Corporation (KPC) acquired downstream R&M assets in the U.S. and Europe from the large international oil companies, or oil majors that were in the midst of rationalizing their asset portfolios after having lost their large upstream concessions in the Middle East and Latin American to host country nationalizations in the 1970s (Moneef, 1998). Following suit, Saudi Aramco established its first joint R&M venture with Texaco, Star Enterprise, in the U.S. eastern and Gulf coasts in 1988. In 1991, an acquisition of a 35 percent equity interest in the SsangYong Oil Refining Company – renamed S-Oil in 2000 – in South Korea followed. Saudi Aramco also acquired a 40 percent interest in Petron, the largest crude oil refiner and marketer in the Philippines (1994), a 50 percent interest in its first joint venture in Europe with Greek refiner Motor Oil (Hellas) Corinth Refineries S.A., and its marketing affiliate, Avinoil Industrial Commercial and Maritime Oil Company S.A. (1996), and a 10 percent interest in Showa Shell Sekiyu K.K. – a Royal Dutch/Shell refining and marketing arm in Japan – in 2004. It also formed two joint ventures with ExxonMobil, Sinopec Corp and the Fujian Provincial Government of China: Fujian Refining and Petrochemical Co. Ltd. (FRPC) – a refining and petrochemicals venture – and Sinopec SenMei (Fujian) Petroleum Co. Ltd. (SSPC), a marketing venture (Saudi Aramco website 2007).

Planners in oil-producing countries believed downstream acquisitions would provide a range of benefits: maximizing value added by capturing R&M margins, smoothing out revenue streams during periods of crude price volatility by portfolio diversification and, not least, 'securing' outlets for crude oil during periods of intensive competition for markets. A further argument was that such downstream acquisitions, particularly in deep conversion refineries, offered added value to heavy crude oils, which otherwise would have to be sold at steep discounts (Moneef 1998; Krane 2015).

Assessments of the performance of international downstream investments by the NOCs are not readily available, given that these companies are owned by sovereign governments and their commercial metrics are confidential. Nevertheless, industry data suggests that the financial returns in the refining sector have likely been marginal, if not loss making, compared with the rents achieved by the ME NOCs in upstream exploration and production (E&P). Table 1 provides indicative economics for refining three Arabian crude streams, using average delivered crude prices and product prices in the U.S. Gulf Coast (USGC) based on a 10-year period, 2004–2014, an assumed capital expenditure of $10 billion for a 320,000

Table 1. Hypothetical returns on U.S. Gulf coast oil refining 2004–2014.

Type of Refining	Input Crude	Average Margin $/bbl	IRR	NPV @ 8.5% discount rate (million $)
Cracking	Arab Light	8.30	1.18%	($3,683)
	Arab Medium	4.57	-6.90%	($6,878)
	Arab Heavy	2.40	-16.60%	($7,893)

Coking	Arab Light	12.53	7.27%	($663)
	Arab Medium	12.48	7.20%	($700)
	Arab Heavy	12.39	7.09%	($765)

Source: KAPSARC calculations; USGC delivered crude and domestic refined product price data, courtesy of Platts.

barrels a day (bbl/d) refinery with an economic life span of 30 years, operating costs of $1.50/bbl, a capacity utilization rate of 93 percent and a weighted average cost of capital of 8.5 percent, broadly within industry norms.

Coking, the typical refinery configuration in the USGC, has higher margins by far, compared with those for cracking. Nevertheless, coking margins for any of the three Arabian crude grades fail to meet the hurdle rates of return implied by the 8.5 percent cost of capital in our example. It should be noted that these refining margins exclude any wholesale and retail margins that could improve the economic performance for our hypothetical investment. Further downstream processing into petrochemicals or specialty products could also yield additional margins. Given the competitive markets for refined products in the USGC, marketing margins are not likely to substantively improve the results. The relatively similar coking margins for each of the three crude grades in this example also suggest that the argument that refining investments can add significant value to heavy crude oil grades is not borne out.

The assertion that vertical integration can reduce risk and smooth income volatility assumes that various stages of the production chain have negatively correlated incomes. There have been well-documented episodes, for example in the second half of 2014 and early 2015, when the overall economic performance of the oil majors has been improved by higher revenue streams from R&M when crude oil prices fell steeply and led to losses in the E&P segment (Blas 2016). In general, though, there is little evidence for negatively correlated incomes in successive stages of the oil industry, as shown in Figure 1. As shown, crude oil prices, as a proxy for upstream margins, and refining margins have low but not negative correlation. Hence downstream integration by crude producers may reduce but not outweigh the volatility of their revenues.

The question remains: at what cost can oil majors reduce their earnings volatility? Based on a 10-year price dataset provided by Platts, internal indicative calculations suggest a 5 percent reduction in the relative standard deviation, or coefficient of variation, of income. (Both of these are standardized measures of dispersion of a probability distribution or frequency distribution.) This is at a cost of $13.75/bbl, assuming an upstream margin of $40/bbl and average USGC coking refinery margins over the 10-year period. While shareholders of any company would prefer less to more volatility, all else being equal, they would also prefer higher to lower incomes. It is not clear that the indicative trade-off ratio noted above would favour a reduction in volatility at such high cost, assessed as the maximum amount a risk averse agent would pay to avoid risk, measured by the volatility of revenues.

Perhaps the argument most often cited by proponents of NOC downstream integration

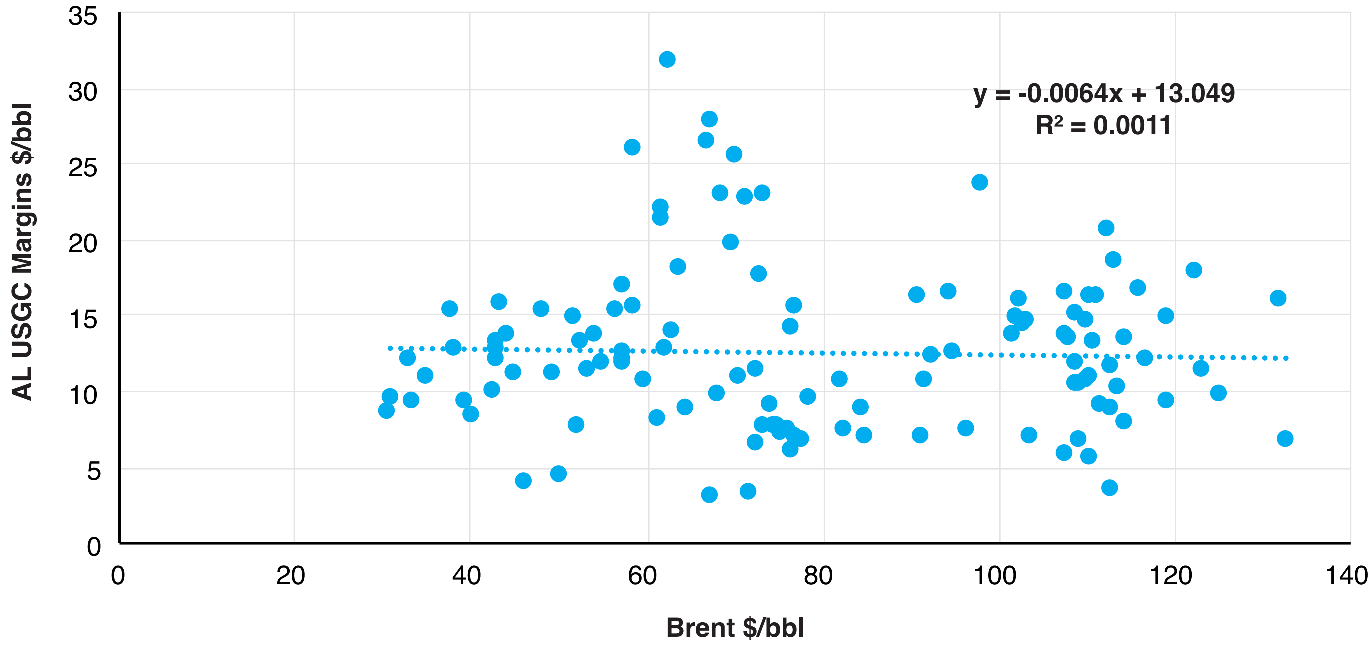

Figure 1. Correlation between Arab Light coking margins in USGC and Brent prices ($/bbl; 2004–2014).

Source: KAPSARC calculations; USGC delivered crude and refined product price data 2004–2014, courtesy of Platts.

ventures is that of 'securing markets' for crude oil. Joint venture refining assets typically have an obligation to process crude supplied by the NOC joint venture partner. Indeed, a key requirement for ME NOCs in investing in international R&M ventures is securing long-term COSAs, generally accounting for 50 percent of the refinery's distillation capacity. The crude sold by NOCs to their international R&M joint ventures is typically priced at arm's length, as if sold to any other customer in the same region. Any discounts offered on the crude oil would only serve to transfer rents away from the crude-producing NOC to its joint venture R&M affiliate downstream, at a loss to itself and to the benefit of the joint venture partner in the refinery.

The joint venture refinery typically has first right of refusal and can choose to buy crude from elsewhere to maximize its margins. This ensures, from the refining affiliate's point of view, that the NOC supplies crude at prices competitive with other available crude oil of similar quality. To the extent that these joint venture R&M facilities are run on clear commercial principles, both parties can benefit from operational efficiencies that may arise from the downstream integration of the oil-producing NOC into refining and marketing facilities located within destination markets. As economist and Nobel laureate Ronald Coase pointed out long ago, in some cases the transaction costs of using markets to coordinate economic activity may be such that it is cheaper for a company to internalize such transactions (Coase 1937). Nevertheless, oil markets are well developed across the production stages and any operational efficiency savings will tend to be relatively modest.

In the context of fungible and well arbitraged global markets for crude oil, owning refineries is not necessary in order to sell crude oil competitively. As long as an oil producing company can adjust prices to market levels, it can sell all the crude it wants. The demand for crude oil does not depend on the ownership of refining and marketing assets, as may have been the case in the early period of the oil industry when large international oil companies (IOCs) dominated world trade and when the global crude oil trade was intermediated by transfer pricing among the affiliates owned by the IOCs.

Unlike the large and capital intensive investments in downstream R&M, the costs of ‘forward commercial storage’ of crude oil by an oil-producing NOC in or near large crude oil consumer markets are low, a small fraction of the former. Unlike investments in R&M, forward storage seems to offer the ME NOCs readier and more flexible access to traditional long-term crude buyers, at low cost, as well as a platform for opportunistic spot sales to non-traditional clients. These are important factors, with possibly ‘outsized’ impacts in a competitive market for crude oil. Clearly, NOCs may well benefit from thinking ‘small’ and achieving efficiencies in the marketing of their crude oil, without committing to substantial investments to try to ‘secure’ market share. It should be emphasized that market share as a commercial objective only makes sense with reference to the costs incurred to achieve targeted market shares. Ultimately, all investments, large or small, need to earn their risk-adjusted hurdle rates of return. A suite of smaller investments carries less risk than a few very large investments.

Northeast Asia and Energy Security

Today's widespread adoption of energy security policies dates back to the oil price shocks of the 1970s. The 1973 October War followed by the oil embargo imposed by the Organization of Arab Petroleum Exporting Countries (OAPEC) brought oil consumers' import dependence and oil security to the forefront of policy concerns. The IEA was founded in 1974 to respond to physical disruptions in the supply of oil as well as to serve as a source of statistics about the international oil market and other energy sectors. In 1975, the U.S. passed legislation which established the U.S. Strategic Petroleum Reserve (U.S. SPR).

The analytical literature on SPRs and their role in energy security policy objectives is vast. Any brief survey of the literature (see Appendix 1) would conclude that there are contradictory findings for almost every aspect of current SPR programs that has been subject to critical scrutiny. The estimated costs and benefits of an SPR, the optimal size of SPRs, release triggers and mechanisms for stock drawdown, the interaction between government SPR programs and inventory management in the private sector and the public goods aspects of commodity stockpiles of globally traded commodities are all subjects of deep disagreement in academia and policy circles (Taylor and Van Doren 2005). While the case for SPR programs in enhancing energy security remains much debated in the literature, governments of the large Asian importers such as India and China are nonetheless going to go ahead and build SPRs. In *realpolitik*, it is said that geopolitics trumps economics: oil supply security, however construed, is high on national agendas despite the uncertainties over the economic benefits of establishing and maintaining large SPR programs.

In the following sections, we examine the empirical evidence on the actual operation of the IEA oil emergency program. We include overviews of the SPR programs in each of the NEA countries, IEA member countries Japan and South Korea, and non-OECD member China, the remaining large NEA oil consumer. We also provide an overview for India, given the country's expressed interest in some form of joint oil stockpiling agreements with ME exporters.

Oil export and import diversification in the Middle East and Northeast Asia

In measuring energy security from a portfolio perspective, economists typically use the Herfindahl-Hirschmann Index (HHI). For each fuel (f), the HHI is defined by $HHf = \sum_i s_i^2$, where s_i is the percentage share of each supplier (i) in the country's fuel import portfolio, where the percentage is expressed as a whole number, not decimal. A lower HHI value indicates greater diversity of import sources, either because of a greater number of sources or a more even spread across the sources. (Lefevre 2010) The closer a market is to being a monopoly, the higher the market's concentration and the lower its competition. If, for example, there were only one company in an industry, that firm would have a 100 percent market share, and the HHI would equal 10,000 (i.e., 100^2), indicating a monopoly. Or, if there were thousands of companies competing, each would have a nearly 0 percent market share and the HHI would be close to zero, indicating nearly perfect competition. The U.S. Department of Justice characterizes a market with an HHI of less than 1,500 to be a competitive marketplace, an HHI of 1,500 to 2,500 to be moderately concentrated and an HHI of 2,500 or greater to be highly concentrated.

The HHI can be used to measure the diversity of customers of an oil exporter and vice versa – i.e., the diversity of suppliers for any particular crude oil importer – and can provide a way of assessing market concentration. We have calculated the HHI value for every major ME oil exporter – Saudi Arabia, Kuwait, UAE, Iraq, Iran, Qatar and Oman – and for every NEA oil importer – China, Japan, Korea and Taiwan – using trade statistics from the U.N.'s Comtrade website http://comtrade.un.org/db/.

The HHI has been calculated for the years 2000, 2005, 2010 and 2014 and shows how the diversity of exports or imports has changed over time. The lower the HHI value, the better an exporter is diversified in terms of exports, while the same is true of an importer in terms of import diversification. A high value means that an importer or exporter is more exposed to a smaller number of trade partners (see Figures in Appendix 2 and 3). It should be noted, however, that a diversification strategy successfully pursued by an oil importer across several countries may lead to an *increased* regional concentration of its imports. Thus, a given NEA country might in theory spread imports among several ME countries, and so improve its HHI score, yet remain highly dependent on the ME region as a whole (Halff, personal communication 2016).

Saudi Arabia is the most diversified ME crude exporter, reflecting the global scale of its exports, though this decreased somewhat during 2005-2014. Iran, by contrast, is the least diversified ME exporter, though we can reasonably expect it to try to increase its level of export diversification. Oman, a relatively small producer, is also heavily exposed to China with its crude exports. The UAE has made the most progress in diversifying its exports.

Among NEA oil importers, China is the most diversified. This is because China imports 'only' half of its crude from the ME and significant volumes from other regions such as Africa, Latin America and the FSU (EIA 2016). It also has import options available overland, as it is connected by pipeline to Kazakhstan and Russia. The other large NEA importers, Japan, Korea and Taiwan, are much more exposed to the ME and import more than 80 percent of their crude oil demand from the Gulf. They are not connected by pipeline to major oil fields and their refining capacity is geared toward a typical medium sour Mideast barrel. Japan is the least diversified, while South Korea's import diversification has steadily decreased.

The IEA Emergency Agreement: governance and performance

The efficacy of oil stocks as a policy tool depends not only on the nature of the instrument but also on how it is used. The focus of much of the applied economics literature has been on modeling the link between oil price shocks and economic activity and the role oil stock releases can or should play on alleviating such shocks. However, the institutional and governance aspects of the IEA's oil emergency management program and of the U.S. SPR have also received significant attention in research and policy circles.

Oil stock obligations for its member countries and emergency response to oil supply disruptions have been core missions of the IEA since its founding. To gain from the benefits of collective action in response to immediate threats to oil supply, the IEA legally requires each member country to have oil stock levels that equate to no less than 90 days of net imports (IEA 2016). The 90-day commitment of each IEA member country is based on net imports of oil, including crude oil and refined products, calculated using an average of daily net imports of the previous calendar year. This obligation can be met through both stocks held exclusively for emergency purposes and stocks held for commercial or operational use, including stocks held at refineries, at port facilities and in tankers.

IEA administrative structure and constraints to stock release consensus

According to the IEA, *"by temporarily replacing disrupted supplies, the action is intended to help oil markets re-establish the supply/demand balance at a lower price level than would otherwise have been the case"* (IEA 2016a). If any of the IEA's 29 member countries experiences a drop in crude oil supply exceeding 7 percent, then other members are obliged to share. It should be noted, though, that while the 7 percent criterion appears in IEA documents, its role in operational decisions during any IEA emergency oil releases may not be clear cut. If and when an IEA analysis were to identify a significant supply disruption "or the likelihood of one in the very near future," the executive director would inform member countries through the governing board. The board is made up of representatives of all 29 member countries, and in the case of a "significant supply disruption," the executive director would specify whether or not activation of emergency response measures is considered desirable and, if so, the amount of oil equivalent stocks that should be made available to the market. The agency states that: *"it takes most member countries two to seven days to implement the necessary approvals for the release, after which actual physical delivery to markets can take as little as one day or as long as three weeks, depending on the emergency stocks structure''* (IEA 2016a).

There are three levels of administration governing IEA action in ordering a release of stocks and in coordinating emergency oil sharing: the IEA secretariat, the management committee made up of representatives of member countries, and the governing board (Bohi and Toman 1986). In the context of closed room negotiations preceding any release of oil stocks by the IEA, it can be assumed that U.S. concurrence would be a requirement, given its dominating position as both a large crude oil producer and as the stockholder of the largest single SPR in the world. As large oil consumers, countries such as Germany, France, Japan and the U.K. would probably also play important roles in such negotiations, and could likely block any activation decision.

The description of how the IEA should work in theory is at variance with actual accounts of IEA actions related to oil disruption emergencies. Blake Clayton describes the behind the scenes negotiations and bureaucratic hurdles within the IEA to activate the emergency response in 2011 caused by the loss of Libya's oil exports from the market (Clayton 2012). His account indicates the extent of the IEA's inherent bargaining and coordination problems on joint action, and may represent the worst case scenario.

The IEA announced plans on June 23, 2011, to coordinate the release of emergency oil stockpiles to offset the loss of Libya's oil production. Over the previous six months or so, oil prices had jumped more than 20 percent. Policymakers feared that high oil prices would subvert a nascent global economic recovery in the aftermath of the 2009 financial crisis. A total of 12 IEA member countries released around 60 MMbbls of crude oil, diesel and gasoline in a 'Libya collective action' release taking place from July 23, 2011 to September 15, 2011. It was the third time in its nearly 30-year history that the IEA activated a coordinated release. The U.S. has several times unilaterally released strategic stocks for raising revenue or countering refined product price spikes resulting from bad weather.

However, it had been as early as March 2011 that U.S. officials began lobbying their IEA peers for this release. In other words, it took about four months for the IEA to reach a decision. According to Clayton, *"The Obama administration's early* *attempts at persuasion were met with 'nothing but resistance'* (Clayton 2012, 12). Not only did achieving consensus take time, but internal dissensions among negotiators were also leaked to the press (Boselli 2011; Blas 2011). Reporters, citing anonymous official sources, said France, Italy and Germany were hesitant about the first release announced by the IEA, and that these top European holders of SPR stocks were opposed to any talk of a second release. This was despite the IEA having announced that its governing board would "review the impact of [its] coordinated action and decide on possible future steps... within 30 days," which suggested that the board was ready to instruct a second release if required.

What oil analysts thought was a clear signal by the IEA to squash further speculative activity with the threat of further releases "as required" was followed by press leaks showing that key IEA members were in fact disunited and that there was little likelihood of a second release should prices continue in an upward trajectory. As Clayton concluded, *"Any power the IEA may have to tamp down short-term oil prices by threatening to draw down emergency stocks [was] undercut by the appearance of divisions among IEA member countries"* (Clayton 2012, 9). By contrast, the IEA's emergency response during U.S. Hurricane Katrina in 2005, when member countries in cooperation with the EU agreed to offer an additional 60 million barrels to the market over 30 days, may be an example of the exact opposite: how well the emergency response program can work in a best case scenario. One ex-IEA official suggests that the IEA response to Katrina demonstrated a release that was arguably consensual, fast, well-coordinated and effective in calming markets.

Perhaps the most fundamental shortcomings of the IEA's oil emergency program stem from public goods provision and the incentives to free riding for its member countries. Given the intrinsic fungibility of oil in today's integrated world oil markets, the release of oil stocks anywhere affects supply everywhere. In other words, an oil stockpile is a global public good (Hogan 1983). As any net oil-importing country's decision to release oil stockpiles will lead it to lower oil imports than would otherwise have been the case, this would mean more oil available to other importers. Yet each country that builds and maintains oil stockpiles does so at its own expense. Hence, each country incurs the costs of building and maintaining an oil stockpile while the international externalities of a global oil market – where traded crude is efficiently arbitraged and priced according to the quality of the oil, its location and time of delivery – mean that the release of oil stocks allows all other countries to benefit from the lower priced crude oil resulting from the increased supply. Most countries would have a natural reluctance to build large oil reserves for other countries to benefit from, unless other strategic policy objectives such as energy security were given higher priority.

Consequently, the IEA agreement was a result of each member country's negotiating for its 'fair share' of the burden, in which each, of course, had an incentive to overstate its contribution and to 'free ride' on the efforts of other members. (The free rider problem is defined as the difficulty of undertaking group efforts in which all individuals or individual nations in the group share in the benefits from the effort regardless of how much, or little, each has contributed to it. This comes about because each selfishly rational individual in the group tends to refuse to contribute to the effort, and instead hopes that others in the group will contribute.)

Inflating a contribution by including private working inventories as part of the strategic reserves was part of the negotiating strategies of IEA members. Reflecting the frictions in bargaining for equitable burdens in the provision of a global public good, the U.S. Energy Secretary warned fellow IEA members that the U.S. might not share its stocks with the group if others drew heavily on their own stored oil to avoid purchasing oil at higher prices. There are also differences in approach between its European members which see demand constraint as the first priority in facing oil emergencies and stock release only as a second, and the U.S. which sees SPR as the first step in oil shock policy response.

As participants in an international alliance are sovereign nation states, absent a supranational judicial institution with enforcement powers, the incentives to free ride would be strong for all participants. Taking account of free ride incentives, countries will see advantages in being the last to commit to policy targets, hence risking coordination failure in negotiating agreements. (Coordination failure in a game theoretic context is where agents' inability to coordinate their behaviour, or choices, leads to an equilibrium outcome that leaves all agents worse off than in an alternate situation that is also an equilibrium. This can occur due to lack of information, strategic miscalculation in negotiating strategies, or differing expectations.) In a relatively large group, such as the IEA, the incentives to free ride make the implementation of a tightly-defined universal agreement – with credible commitments by all member participants, of net benefit to all countries and in stable equilibrium – rather difficult to achieve.

The IEA oil-sharing agreement, in reflecting the complexity of strategic interactions within any alliance of sovereign states providing global public goods, has complex formulas to calculate the burden sharing program. Nevertheless, it is straightforward in its basics: if disruption occurs to the supply of oil to any country beyond a threshold of 7 percent of pre-disruption supply, then those member countries affected more than proportionately, relative to the pre-disruption period, are entitled in principle to transfers from less affected members (Bohi and Toman 1986). The application of this principle would thus cause the burden to fall more heavily on crude oil-producing members such as the U.S., U.K., Australia and Canada than other countries in the group which are almost wholly reliant on imports. (Norway, a major oil producer, is not party to the sharing agreement.) So that the oil-sharing plan does not lead to unintended wealth transfers among its members during an emergency, oil sharing is to take place "at prices prevailing on comparable international transactions." Only under market prices could government authorities of net donor countries expect private oil companies to participate in the oil-sharing program. And only by agreeing to oil sharing at market prices could contributing governments claim to their various constituencies that the stockpiling program did not impose a differential burden on them relative to their fellow member countries that were recipients of oil transfers.

But as observed by Bohi and Toman (1986), this leads to a conundrum in that, if the IEA emergency sharing mechanism were to emulate allocations on the basis of market prices, how would this differ from the allocation that would occur in any case as a result of autonomous market forces? If contemporary markets are highly competitive, and if markets adjust rapidly to allocate supplies during periods of supply disruption, according to willingness to pay, then any oil-sharing plan based on transfers at market price would differ little from free market oil supply allocations in any case. So why have the oil sharing plan in the first place? "Without market pricing, the oil sharing plan seems highly unlikely to be viable. On the other hand, given recent changes in the structure and performance of the oil market, the sharing plan with market pricing seems to offer little (if any) discernible gain to IEA members over the market outcome" (Bohi and Toman 1985, 43).

However, if the IEA oil-sharing plan was viewed by its members as robust and credible, such an agreement would serve the members' collective benefit by preventing panic buying and oil price spirals during supply disruptions. Transaction costs that occur in disrupted markets, such as the need to rapidly switch to new sources of oil supply and to arrange new transportation arrangements, and the need to test and handle different grades of crude oil that might not be efficiently refined in less complex refineries, can lead to escalating willingness to pay by those participants most vulnerable to the disruption. Panic buying will be exacerbated by oil suppliers reneging on long-term contracts to achieve higher premiums in spot markets which set the price of marginal barrels offered for prompt sale. Perhaps most important is the role of SPR as a potential deterrent against the use of oil as political weapon. Whether the IEA's oil-sharing program has in fact proved to be an effective deterrent to the use of oil supply as a tool of international diplomacy is a matter for speculation. Nevertheless, this aspect of SPRs remains an important consideration for many oil importers.

IEA cooperation with the large non-OECD Asian oil importers

The national security concerns of governments of the large Asian oil importing countries such as India and China suggest that they are also committed to building up their SPRs. Energy security issues are not only within the jurisdiction of each country's energy and trade ministries but of primary interest to both defence and foreign ministries as well. Despite the ambiguity apparent in empirical studies of the costs and benefits of SPRs (as covered in Appendix 1), it is clear that China, India and other significant Asian crude oil importers intend to follow through on all or at least some of their announced SPR plans.

Indeed, China has actively pursued the agenda of filling its SPRs over recent years (Bloomberg 2016), emerging as one of the world's largest holders of SPRs after the U.S. and Japan. In recent years, oil purchases by the Chinese state-owned oil companies have become a significant factor in the global market. China's intensified efforts to fill its newly built SPR facilities since 2012 have increased the country's crude oil imports and are one of the factors analysts see contributing to the oil price escalation during that period. Little or no regular data is available on China's crude oil and refined products inventories. Nevertheless, according to some reports, it was widely believed by oil market traders and observers that China was often accounting for anywhere between 250,000 bbl/d to 500,000 bbl/d during the trading year to fill its stockpiles (Blas 2012). This was why in 2011 IEA officials were concerned that if any IEA stock draw were to be negated by China's large volume build-up of its SPR, this would not only have neutralized any impact the IEA members would have hoped to achieve in global oil markets, but would have damaged the credibility of the agency in handling any future oil supply emergency. While details of the liaison talks between IEA and Chinese representatives that took place prior to the 2011 release are not public, Chinese officials were said to be supportive of the IEA move (Clayton 2012).

It is clear that for the IEA this kind of liaison with Chinese officials, and other large Asian importers such as India, would be a high priority to ensure the viability of its emergency stock release plans. As non-OECD countries increasingly dominate global oil demand growth, this priority will only become more critical. Since the large net oil-importing countries have a common interest in avoiding market disruptions and oil price spikes, there is a strong case for the IEA and the leading Asian oil consumers to seek to coordinate stock releases, or at least to credibly commit to avoid filling their SPR reserves during oil supply crisis episodes. As a global public good, such coordination would be critical for stock release actions to ameliorate oil price shocks. And while talks between IEA officials and the large Asian oil importers are expected to continue, it is too early to say whether credible international agreements on coordinated oil stockpiling will be achieved in the near future.

SPR in Northeast Asia and India

Similar to their OECD counterparts in the west, Japan and, to a lesser extent, South Korea were much affected by the OAPEC oil embargo of 1973 (Yergin 1991). Rapid industrialization and a near absence of domestic oil production had led these countries to an ever increasing dependence on foreign, predominantly ME, crude imports. Oil still constitutes the dominant energy source in both countries. In the wake of the embargo, when Japan and South Korea's exposure to Gulf exporters became apparent, both countries decided to take part in the IEA's emergency stockpiling initiative. While Japan was a founding member of the IEA, South Korea only became an OECD member in 1996 and an IEA member in 2002. Both countries are now an essential part of the developed world's attempt to provide a collective energy security umbrella.

As of 2013, Japan's SPR consists of 596 MMbbls of crude, according to the IEA's country profile (IEA 2014) (See Table 2). This equates to around 153 days of net import cover, a great deal more than the IEA's minimum requirement of 90 days, which shows how committed Japan is to maintaining sufficient emergency stocks. Japan's SPR is held both by the government (321 MMbbls) and the Japanese oil industry (275 MMbbls), the latter being mandated to hold the equivalent of 70 days of their daily imports. SPR terminals – 10, mainly crude, owned by the government and 16 by the private sector, half crude and half products – are widely dispersed across the country. The Japan Oil Gas and Metals National Corporation (JOGMEC), is responsible for managing the stocks, while the Ministry of Economy, Trade and Industry (METI) has the mandate for ordering an SPR release under the terms of the Oil Stockpiling Act. The Okinawa storage facility, where Saudi Aramco leases capacity and stores 6.3 MMbbls of its crude, is one of the country's six private terminals from which oil can be withdrawn in times of emergency (JNOC 2001). Oil is distributed during a crisis based on a competitive bidding system organized around a public tendering process (IEA 2014). It takes around 10 to 15 days for public stocks to be drawn from the SPR after a ministerial decision by METI.

Table 2. SPR by country (U.S., NEA and India).

	SPR volumes (MMbbl)	Net import cover (days)	Holders of SPR	IEA member state
U.S.	695	137	State	Yes
Japan	596	153	State and private	Yes
South Korea	286	114	State and private	Yes
China	400	53	State and private	No
India	39	13	State	No

Source: IEA, EIA, various media reports.

South Korea's total SPR capacity equals 286 MMbbls according to the IEA (IEA Country Review: Korea). Its current SPR comprises 87 MMbbls of public stocks managed by KNOC plus 86 MMbbls held by the private sector. South Korean refiners are required to maintain a minimum stock of 40 days' imports. Public and private oil stocks provide the country with 114 days of net import cover which, as in Japan, exceeds the IEA's minimum requirements. South Korea has since 1999 successfully invited producers from around the world – such as Statoil, Sonatrach, Total, Glencore, Chinaoil, KPC and Adnoc (Energy Intelligence 2005) – to store some of their oil in the country's SPR facilities. As part of the International Joint Stockpile (IJS) Project, oil-producing companies lease storage capacity in exchange for first drawing rights by the government in the event of an emergency. The South Korean government reserves 146 MMbbls of storage for public SPR purposes and international joint stockpiling deals, out of a total capacity of 286 MMbbls. Crude leased under this latter type of agreement, which the government classifies as part of its 'dynamic stockpiling' strategy, is not counted toward South Korea's 90-day IEA stockholding requirements. However, joint oil stockpiling is seen by the government as an inherent part of its SPR strategy. Japan has similar agreements in place with Saudi Aramco and ADNOC and counts half of these leased storage volumes as part of its 'secondary' SPR (Platts 2014).

If South Korea were to exercise its first right of purchase of those crude reserves, the producing companies stockpiling oil in the country would be required to deliver the crude to KNOC within 90 days. It is unclear, though, when the appropriate 'market price' would be assessed. It would make a material difference if this were to be done when the emergency was announced rather than at the delivery date for the oil. Although 90 days is a long time during episodes of heightened price volatility, South Korea's conventional SPR stocks should provide sufficient reassurance to the country's refiners as to the availability of feedstock. South Korea's SPR storage sites are also located across the country and consist mainly of crude oil, accounting for 87 percent of total reserves. The Ministry of Trade, Industry and Energy (MOTIE) is responsible for dealing with emergency situations and the SPR. It is advised by a number of high level ministry officials as well as industry representatives from KNOC, KOGAS, KEPCO and the refineries and the president of the Korea Energy Economics Institute (KEEI). When an SPR release is decided upon, oil stocks are released to the country's four refiners in the form of loans, proportional in volume to the refiner's market share. It takes KNOC, which manages South Korea's public stocks, about one week to deliver the crude to the refiners.

China, which is not part of the OECD and does not take part in the IEA's stockholding emergency scheme, imported 7.35 MMbbls of crude from the international market in mid-2016, which established it as the world's largest oil importer (Bloomberg 2016). China overtook the U.S. earlier than anticipated because of the latter's light tight oil production and resultant decrease in foreign imports from outside Canada. Although the country became a net importer of oil in 1993, China only began to construct SPR facilities in 2004, according to the authors' correspondence with Shanghai Jiao Tong University (SJTU). Since then its SPR, which is seen as a critical part of the country's energy security strategy, has been rapidly expanded. Table 3 describes China's phased build-up of its SPR facilities. Phase I saw a build-up of capacity, mainly concentrated along the eastern coastal cities, with storage being built in China's inland areas under Phase II. Phase III, intended to lift China's total SPR capacity to 620 MMbbls or 90 days of net imports, is currently being planned. China announced in 2016 as part of its new Five Year Plan that Phase II would be completed only by 2020, while the end of Phase III is delayed beyond that date (Bloomberg

2016). In 2016, China's SPR volumes are believed to have reached about 400 MMbbls of crude, providing the country with about 53 days of net import cover, according to a 2016 report by investment bank JP Morgan. China's SPR is managed by the National Petroleum Reserve Center (NPRC), established in 2007 and supervised by the National Energy Administration (NEA), itself part of the National Development and Reform Commission (NDRC) (Wu 2013). The NDRC divides China's SPR into three categories: a national SPR, commercial storage held by the NOCs and commercial storage held by local governments or private companies. Little is known about China's internal decision-making processes regarding oil supply disruptions and SPR drawdowns.

Table 3. Chinese SPR build-up phases, as of end-2015.

	Operator	Location	Capacity (MMbbls)	Status	Completion
Phase I	Sinopec	Zhenhai, Zhejiang	32.7	Filled	2006
	Sinochem	Zhoushan, Zhejiang	31.4	Filled	2007
	Sinopec	Huangdao, Shandong	20.1	Filled	2007
	CNPC	Dalian, Liaoning	18.9	Filled	2008
Phase II	CNPC	Lanzhou, Gansu	18.9	Filled	2011
	CNPC	Dushanzi, Xinjiang	18.9	Filled	2011
	Sinopec	Tianjin	20.1	Filled	2014
	CNPC	Shanshan, Xinjiang	39	Filled	2014
	Sinopec	Huangdao, Shandong	18.9	Filling	2015
	Sinopec	Zhoushan, Zhejiang Phase 2	18.9	Under construction	By 2020
	CNPC	Jinzhou, Liaoning	18.9	Under construction	By 2020
	CNOOC	Huizhou, Guangdong	31.4	Under construction	By 2020
	Sinopec	Yangpu, Heinan	16	Under construction	By 2020
	CNPC	Jintan, Jiangsu	15.7	Under construction	By 2020
	Sinopec	Zhanjiang, Guangdong	31.4	Under construction	By 2020
Phase III	PetroChina	Wanzhou, Chongqing	5	Planned	Post-2020
	Sinopec	Caofeidian, Hebei	32.7	Planned	Post-2020
	Sinopec	Yangpu, Heinan	12.5	Planned	Post-2020
	Yingcheng	Yingcheng, Hubei	15.4	Planned	Post-2020
	CNPC	Rizhao, Shandong		Planned	Post-2020
	CNPC	Daqing, Heilongjiang		Planned	Post-2020
	CNPC	Yunnan province		Planned	Post-2020
	CNPC	Qinzhou, Guangxi		Planned	Post-2020

Source: IEA OMR (09/2015), media reports (2016).

India, like China, has also rapidly increased its crude imports but has only recently started to build up its SPR capacity. The country imports 4.4 MMbbls of crude per day and plans to add 39 MMbbls in its SPR build-up during phase 1, which will provide India with 13 days of net import coverage according to the IEA. India is aiming to expand its SPR capacity to 130 MMbbls. The Visakhapatnam storage facility began filling in the summer of 2015 and the Mangalore and Padur SPR depots are expected to be completed by end 2016 (Hellenic Shipping News 2016). Like South Korea and Japan, India has invited foreign companies to store oil in its SPR facilities. It is planning to finance its SPR phase 2 through lease agreements with foreign exporters. As of mid-2016, India is in discussions with Abu Dhabi's NOC (ADNOC) on a joint stockpiling agreement under which ADNOC would store oil in Mangalore. It is said also to be interested in similar talks with KPC, Saudi Aramco and Shell. India's SPR facilities will be managed by the Indian Strategic Petroleum Reserves Limited (ISPRL), part of the Oil Industry Development Board.

Joint Oil Stockpiling in Northeast Asia

Existing and proposed joint oil stockpiling agreements

In 2005, David Nissen and David Knapp of the Energy Intelligence Group described ‘forward commercial storage’ as an arrangement by which oil producers could utilize storage facilities located in consuming regions as part of their normal commercial operations; the stored oil would remain under the producer's ownership, but with priority purchase rights for the consuming country in the event of an oil supply disruption (Nissen and Knapp 2005). According to its proponents, forward commercial storage or joint stockpiling would benefit the consuming country hosting the storage facility by enhancing its SPR availability, while it would signal the producing country’s standing as a ‘preferred and secure’ supplier of crude oil to its large NEA customers. It should be assumed that a joint stockpiling agreement would have a clause stipulating that the owner of the crude would maintain a certain level of crude in the tanks at any given time. Without such clause, the host country would face a real risk of finding empty storage tanks during an emergency.

As shown in Table 4, the first ME-NEA joint stockpiling deal was concluded in 2006 between Kuwait and South Korea, involving a 2 MMbbls joint crude oil stockpile at KNOC facilities in South Korea. In exchange for storing Kuwaiti oil and allowing KPC to trade from its depot, the host country receives a lease fee and may access those 2 MMbbls within 90 days of its requesting for supplies should an emergency occur (Korea Joongang Daily 2006). Since the deal was concluded in 2006, the two countries have been in talks about two more storage terminals under the same conditions (Al Arabiya 2013). Before its agreement with Kuwait, South Korea also agreed similar deals with other companies including Algeria’s Sonatrach, Norway’s Statoil, Chinaoil, Shell, Total and trading companies such as Glencore and Trafigura (Reuters 2009). All these agreements share the same basic principles: the exporting country or company remains the owner of the oil and can freely trade it in the region from the storage facility in exchange for giving South Korea pre-emptive purchase rights in an emergency (SHANA 2006). As part of its IJS project, which was launched back in 1999, South Korea reserves around 30 MMbbls of its total 146 MMbbls of storage capacity for leasing to oil producers, oil majors and oil trading companies, etc (Gulf News 2012).

Table 4. Joint oil stockpiling agreements between ME producers and Asian consumers.

Year of initial deal	Middle Eastern country	Asian country	Location of stockpile	Current volume (in MMbbls of stored crude oil)
2006	Kuwait	South Korea	n.a.	2
2009	UAE	Japan	Kiire	6.3
2010	Saudi Arabia	Japan	Okinawa	8.3
2012	UAE	South Korea	Yeosu	6
2016*	UAE	India	Mangalore	6
2016*	Iran	South Korea	Seosan	2

* Agreement yet to be finalized. Source: various media reports.

South Korea signed another joint oil stockpiling agreement with the UAE's ADNOC in 2012. The latter agreed to lease 6 million barrels of crude in South Korea's oil storage depot at Yeosu, which the country wants to develop as a regional oil hub. Unlike its stockpiling deal with Kuwait, South Korea agreed to forego leasing fees in exchange for participation rights in development of three oil fields in Abu Dhabi (Platts 2013). The agreement was reached as part of high levels talks between the South Korean president and the Crown Prince of Abu Dhabi. In 2013, Iraq also signed a joint oil stockpiling agreement with South Korea covering 4 MMbbls of crude. This, however, failed to materialize due to the exporting country's debt problems (Platts 2014). In 2016, following the lifting of sanctions, Iran and South Korea agreed to expand oil and gas cooperation, specifically mentioning joint stockpiling of Iranian oil in the NEA country (Koreanet 2016). It is believed that the future stockpile will comprise 2 MMbbls of crude and condensates, to be located in Seosan (Platts 2016).

Japan has concluded similar deals with ME producers. In 2009, JX Nippon and ADNOC agreed to establish a joint oil stockpile at the Kiire oil terminal in Kagoshima (JX Nippon 2009) The deal has been renewed twice, in 2012 and 2014, and total volumes stored by ADNOC in Kiire have grown to 6.3 MMbbls (RIM 2014). One year after the ADNOC agreement, Japan's JOGMEC reached a similar deal with Saudi Aramco (The National 2010). For providing 3.8 MMbbls free storage capacity to Saudi Aramco on the island of Okinawa, Japan receives priority to buy from that stockpile in the event of an oil supply emergency (METI 2010). This contract was subsequently extended. In 2013 storage capacity increased to 6.3 MMbbls, and to 8.3 MMbbls in 2016 (Saudi Aramco 2014; Reuters 2016). By storing oil in Okinawa, Saudi Aramco gains easier access to the greater East Asian market, China in particular. By 2010, Saudi Aramco had discontinued leasing storage capacity in the Caribbean amid slowing exports to the U.S. (Argus 2010).

Although China has not yet agreed to any joint oil stockpiling deals, it has been involved in negotiations for at least a decade. In 2006, for example, during Chinese president Hu Jintao's visit to Saudi Arabia a proposal was discussed for China to host Saudi crude oil in Chinese storage facilities in a joint stockpiling agreement (BBC, 2006). No agreement was reached and Saudi Aramco chose to stockpile its crude in Okinawa instead (Al-Tamimi 2014). During President Xi Jinping's 2016 visit to Riyadh, the topic of joint stockpiling between Saudi Arabia and China was again discussed and agreed upon in principle as part of the two countries' bilateral cooperation plans involving energy. There was no explicit public reference to joint stockpiling, but the authors were informed by a Chinese national oil company source that it was discussed. Iran, meanwhile, has effectively leased storage capacity at Dalian, China, since 2014, although it is not clear whether this also includes a clause stating that China can access the oil on a first-refusal basis (Reuters 2014). Due to western sanctions which led to a shortage of storage capacity, Iran used the port at Dalian to make deliveries into China and South Korea. Most of these exports consisted of surplus NGLs, condensates and heavy oil.

In 2016, ADNOC proposed storing oil in India's first strategic storage in Mangalore. Under the proposed agreement, ADNOC would occupy 6 MMbbls out of the storage facility's total capacity of 12 MMbbls. It is understood the agreement would operate on terms similar to the other joint stockpiling deals (Hindustan Times 2016). ADNOC would be able to commercially trade its crude from the storage and India would have preferential access to that oil at prevailing market prices in times of emergency. India is also considering inviting other exporting

ME NOCs such as Saudi Aramco, KPC and Qatar Petroleum to store oil in underground caverns in Visakhapatnam, Mangalore and Padur (First Post 2016; Energy Intelligence 2016). In order to achieve this, India will first need to liberalize its policy so that the oil-producing NOCs can export their oil from storage depots in India to third countries if it proves commercially profitable to do so. Export of crude oil stored in India is currently prohibited (Reuters 2016).

Commercial and strategic benefits for the Middle East

Joint stockpiling of crude oil in Asia can help ME exporters meet security of demand concerns by defending and/or gaining market share: it allows them to better compete against regional short-haul crudes, it can provide a low cost trading hub to serve other nearby markets and it gives customers in Asia a sense of 'credible commitment' to burnish the image of Gulf exporters as reliable crude suppliers of choice.

Competition with short-haul flows

ME exporters' market share in Asia is being challenged by non-traditional long- and short-haul flows of crude oil. Long-haul flows include imports from Latin America and West Africa that were reoriented from the Atlantic Basin, while Russia's ESPO crude provides Northeast Asian refiners with a nearby alternative. ESPO cargoes are attractive not only because they help Asian refiners to diversify from their heavy dependence on ME imports but also because they are:

- Only 2-4 days away in terms of sailing distance and can be delivered on board smaller Aframax (80,000 to 120,000 deadweight tons) tankers.
- Generally sold on a spot basis.
- Have less sulphur content and are therefore easier to refine by less complex refineries.
- Can be transported by rail to China-based refineries that do not have pipeline access (Bloomberg 2015; Energy Intelligence 2016).

Because of these characteristics, but predominantly because of its higher quality, ESPO crude usually fetches a significant premium over the Dubai benchmark.

The characteristics of Russian Pacific crude are proving especially attractive to Chinese customers, particularly to the smaller, independently operated refineries known as 'teapots'. Since July 2015, these teapot refineries have been granted licenses and quotas to import crude oil independently without having to buy their feedstock from China's NOCs (Wall Street Journal 2016). These refiners, which are now also allowed to export refined products, have been aggressively sourcing the most competitive barrels on spot markets. They collectively account for 1.2 MMbbls, or 15 percent of China's total crude imports. China's relaxation of import rules for independent refineries – as well as the expansion of the Skovorodino-Mohe pipeline into China – has contributed to Russia becoming China's largest import source, overtaking Saudi Arabia (Bloomberg 2015). In April 2016, Russia exported 1.17 MMbbls to China – up 52.4 percent year-on-year, while Saudi exports to China declined by 21.8 percent (Energy Intelligence 2016). ESPO crude will, however, most likely not be able to fundamentally challenge ME imports as baseload feedstock in Asia because of two handicaps: limited liquidity and a late release of shipping schedules (Reuters 2015). Rival ME and African crudes are usually sold two or three months before the loading date, while ESPO cargoes are sold only six weeks before the loading date, at a time when Asian refineries have already satisfied the bulk of their demand. Consequently, the number of ESPO buyers has fallen and deliveries are now mainly focused on China and Japan. Russia is actively seeking new term contract customers in the Far East (Platts 2016).

Joint stockpiling in Asia can be an effective way for ME exporters to better compete against these short-haul flows. Crude in leased storage facilities in Asia has the following competitive advantages:

Shorter voyage times

Cargoes from Saudi Aramco's leased storage at Okinawa in the East China Sea need only a fraction of the time to arrive in NEA refining centres, compared with their usual Gulf loading ports. As shown in Table 6, a VLCC traveling at a speed at 15 knots (nautical miles per hour) from Ras Tanura arrives in Qingdao in China, Yokohama in Japan and Yeosu in South Korea in 17 to 18 days. The same vessel can deliver a cargo from Okinawa to the same ports in China, Japan and Korea in 2-4 days, a significant reduction in travel time. It corresponds closely with Russian shipment times from Kozmino to NEA. Shorter voyage times obviously represent substantial savings in shipping and insurance costs for the customer. It should be noted, though, that shipping crude from Okinawa involves double handling costs, and cargoes sold ex-Okinawa will incorporate freight costs for moving the crude from the Arabian Gulf in the first place.

Table 5. Shipping distances between major ports, expressed in days.

	China (Qingdao)	Japan (Yokohama)	Korea (Yeosu)
Gulf			
Saudi Arabia (Ras Tanura)	17	18	17
Kuwait (Mina Al-Ahmadi)	17	19	17
UAE (Jebel Dhanna)	17	18	17
Iraq (Basrah)	18	19	18
Iran (Kharg Island)	17	18	17
Oman (Mina Al-Fahal)	16	17	16
Qatar (Halul Island)	17	18	17
West Africa			
Nigeria (Qua Iboe)	29	30	29
Angola (Cabinda)	27	28	27
Americas			
Venezuela (Puerto Miranda)	26	23	25
Ecuador (Balao)	24	22	23
Mexico (Salina Cruz)	21	18	20
FSU			
Russia (Kozmino)	3	3	2
Okinawa	2	2	1

Source: Sea Distances website. Based on a VLCC, speed of 15 knots, via shortest possible route.

Spot pricing

ME NOCs have been reported to have sold cargoes of crude intermittently on the spot market. This is a radical departure from the NOCs' preference for term contracts. These one-off sales are being experimented with by Gulf exporters because customers in the Far East are increasingly willing to purchase cargoes on the spot market. China's teapot refineries, located mainly in the Shandong province, represent commercial entities which are new to the global oil market and which view spot purchases as a way to 'test' the market values of crudes and compare the reliability of competing exporters. Gulf NOCs can most easily reach these new customers by selling them spot cargoes from their joint storage facilities in Asia. Saudi Aramco, for example, sold a cargo of crude from its Okinawa storage depot to a Chinese independent refiner, Chambroad Petrochemical, on a spot basis in 2016 (Platts 2016). Saudi Aramco reportedly priced this cargo on a FOB Okinawa basis instead of quoting an official selling price. Saudi Aramco is reported to have sold the cargo at a discount to the Dubai benchmark rather than at a 'prompt' premium (Forbes 2016). The Saudi NOC had sold spot from Okinawa before, in 2012, when it shipped a cargo to Japanese refiner Cosmo Oil (Reuters 2012). A discussion of spot price discovery in NEA is provided in section 5.

Volume flexibility

Oil from a leased storage depot can be delivered in smaller or customized quantities on smaller vessels, which suits many refining centers and ports in Asia that only have limited offload capacity. Saudi Aramco's cargo to Chambroad Petrochemical, for example, consisted of 730,000 bbls loaded on an Aframax sized tanker (Platts 2016). Standard sized VLCCs (over 180,000 dwt) traveling the route between the Gulf and Asia usually ship fixed volumes of 2 MMbbls. This volume (Aframax) and contract flexibility is more suited to the needs of financially-constrained, smaller refiners in Asia. Arabian crude is now better able to directly compete with ESPO deliveries, as the latter are also usually shipped in smaller lots.

Creation of low-cost trading hubs

Crude oil from leased storage in a particular country is not necessarily sold by the seller to the host country. Instead the storage depot can act as a trading hub, with cargoes being sold to a wide variety of customers in the region. Okinawa can act as Saudi Aramco's 'mini Ras Tanura', conveniently located in the NEA region. ADNOC can use Kiire in the same way, as an Asian satellite of its main loading terminals in the Arabian Gulf. Tankers loading from joint stockpiling tanks mainly sail to Asian countries, though Okinawa has in the past also been a source of oil cargoes heading to U.S. West Coast customers. Location is key, significantly reducing the exporters' trading risk. New players in the crude market, like the Chinese 'teapot' refiners, often have weaker credit profiles, which represents a clear risk to the exporter. If a spot contract is reneged upon, it would be easier for the seller to reach alternate customers with shorter voyages and in smaller cargo volumes (Platts 2016).

Apart from minimizing trading risk, joint stockpiling means the exporter incurs lower costs. This is because in most bilateral storage agreements the host country may cover the storage leasing costs, either fully or to a large extent. Japan, for example, is providing Saudi Aramco with free storage space at its Okinawa storage terminal in exchange for first drawing rights in times of emergency or unexpected supply shortages (Reuters 2013).

Japan likely agreed to this because that terminal was underutilized and represented a sunk cost. Storage capacity in Japan is generally available at competitive rates given the country's decreasing oil consumption and gradually declining refining capacity (The National 2010). Similarly, ADNOC does not pay to lease storage at the Kiire oil terminal (Reuters 2014), nor does South Korea charge the company a leasing fee in Yeosu, reportedly in exchange for participating rights in some of Abu Dhabi's oil fields (Platts 2013). Given the opacity of such reported 'quid pro quo' agreements, it would be difficult to calculate the effective storage lease costs without access to confidential commercial data.

Credible commitments

The ME region has traditionally been Asia's supplier of choice for reasons of relative proximity, reliability of term contracts and general crude quality, appropriate to many of the Asian refineries built with ME sour crude as their ideal slate. Consequently, Asian importers have for a long time been dependent for the greater part of their demand on Gulf crude. This is particularly true of Japan and South Korea, which source over 80 percent of their imports from the ME (EIA 2014). China is less dependent on ME crude as it has substantial domestic production and pipeline connectivity to Russia and Kazakhstan. Furthermore, its simpler refineries often require higher quality oil which comes predominantly from West Africa. As a result, Chinese crude imports are significantly more diversified than those of Japan and South Korea. China's current crude imports originate from: ME 52 percent; Africa 22 percent; former Soviet Union (FSU) 13 percent; and the Americas 11 percent (EIA 2014).

Stockpiling substantial volumes of ME crude near consuming centers in Asia can underscore the former region's long held image as a reliable supplier of crude oil to the world's fastest growing oil market. Committing assets close to the buyer can be seen as a risk-sharing strategy designed to safeguard commercial and strategic relationships. Joint stockpiling is a "credible commitment," in the words of economist Oliver Williamson (1983). By placing commercial oil in storage in Asia which can become part of the host country's SPR during an oil supply disruption, the ME suppliers are actively supporting alliances and promoting mutually beneficial exchanges with their NEA customers. As noted by Chatham House researcher John Mitchell, "It is in the interest of oil-exporting countries and companies to demonstrate their commitments to importing markets by contribution to arrangements for securing supply in the event of a disruption" (Mitchell 2014).

Commercial and strategic benefits for Northeast Asia

By making it attractive to Middle Eastern exporters to stockpile crude close to their main refining and distribution centres, Asian importers perceive benefits to their energy security and commercial objectives. For example, METI stated that the Aramco Okinawa joint stockpiling agreement "will fortify the relationship between Japan and the oil-producing country Saudi Arabia, as well as represent Japan's enhanced ability to respond to any emergency situation" (METI 2013). METI repeated at the signing of the joint stockpiling agreement with ADNOC that "this project contributes to enhancing the relationship between Japan and Abu Dhabi, on which Japan depends for about 23 percent of its imports of crude oil, and also strengthens Japan's ability to respond to crises" (METI 2014).

Security of supply and strategic petroleum reserves

A crucial part of any joint stockpiling agreement is that it allows the host country first or preferential access to the stored crude in the event of an oil supply disruption. By having a joint oil stockpiling agreement with a crude oil producer, the host country would save on capital costs by not having to pay upfront for oil to fill its SPR. (The hypothetical cost savings implicit in a joint oil stockpiling agreement are examined in section 4.) Such potential cost savings are an important reason why joint stockpiling deals are seen as an attractive supplement to the unilateral filling of a national SPR. This is especially the case in China, as its NOCs are reluctant to pay for SPR programs since their shareholders do not want to finance a public good at their expense. Building a national stockpile, it is argued by the NOCs, should be financed by the government. Currently, the NOCs are obliged by central planning authorities to ensure they hold a certain volume of oil in storage, beyond their own commercial requirements, as a complement to China's SPR (Energy Intelligence 2016; China SME 2016).

As joint oil stockpiling agreements are confidential to the parties involved, it is unclear on what terms oil can be bought by the host country on a first access basis. An 'emergency' is likely defined as an unexpected loss of crude supplies beyond a certain threshold (IEA 2014). If such a situation was to arise, it would have to be clear to both parties precisely what 'preferential access' means.

There is disagreement as to whether stored oil in a joint stockpile can officially be considered as part of the host country's SPR. This is not an issue for non-OECD Asian countries which determine their own stockpiling policies. For OECD member states Japan and South Korea, however, the IEA does not consider oil stored in joint stockpiles as part of their obligations to hold 90 days of net imports of oil in storage. Since 2014, METI has counted half of the crude stored by Saudi Aramco and ADNOC as part of the secondary SPR of Japan (Platts 2014). South Korea does not consider joint stockpiled crude as part of its national SPR.

De-risked barrels

Oil tankers delivering cargoes from the ME to Asia are exposed to transit risk, crossing the world's two most critical chokepoints: the Straits of Hormuz and the Straits of Malacca. The most vital shipping lane is the Straits of Hormuz, which connects the Arabian Gulf with the Arabian Sea via the Gulf of Oman. About 17 MMbbls are carried through this narrow sea lane each day, representing roughly 30 percent of all seaborne traded oil (EIA 2014). Of those 17 MMbbls, more than 85 percent goes to Asia (Tank World Expo 2016). More than 15 MMbbls of crude per day pass through the Straits of Malacca, which stretch between the Malay Peninsula and the Indonesian island of Sumatra, connecting the Indian and the Pacific Oceans. Both straits are vulnerable to threats including piracy, terrorist attacks, shipping accidents and geopolitical hostilities, all of which could result in a significant dislocation of global oil trade. Because of this, shipping rates between the Gulf and Asia often include additional insurance premiums. Stockpiled oil in Asia held by Gulf exporters can thus be seen as 'de-risked' barrels – an attractive feature for importers concerned about security of supply. Having an alternate storage location is also seen as important to ME exporters' energy security, especially for producers that cannot diversify away from the Straits of Hormuz as their sole transport route to world markets. This has been cited as a major reason for Kuwait's interest in joint stockpiling ventures in Asia (Reuters 2008).

Commercial objectives

Joint stockpiling allows Asian importers to achieve several commercial goals besides improving their perceived security of supply. The advantage of having ME crude oil stored nearby or within their own jurisdictions is the ability it confers to access cargoes at short notice due to unforeseen circumstances. This can help regional refineries optimize their crude slates when circumstances dictate. The existing joint oil stockpiling facilities in Japan and South Korea are within two to three days from NEA oil loading ports in China, South Korea, Japan and Taiwan. In terms of sailing time for crude oil carriers, this compares with the three weeks or so required to bring oil from the Gulf.

If unused for want of commercial bids by privately-held companies, government-owned storage tanks can be leased out free or at low marginal costs for SPR programs. Leasing charges have been waived by the host country in most joint oil stockpiling agreements. South Korea's KNOC has described the 'dynamic stockpiling' approach it uses to manage, with flexibility, South Korea's public oil stockpiles in order to reduce the expense associated with building and maintaining SPR stocks. Apart from earning storage fees – if not waived – from renting out spare storage space under the joint stockpiling program, KNOC also occasionally offers 'time swaps'. Invitations are sent to Korean refiners and sometimes to international oil purchasers to bid on a quantity of stockpiled oil, with the winning bidder having to return the oil within a stipulated time period and pay the bid premium. It is unclear whether these time swap exercises have been of net benefit to KNOC. While this innovative system may have "broadened the concept of strategic oil stockpiling by showing that stockpiled oil need not be dead oil" (Nieh 2006), the use of strategic oil stockpiles to engage in oil market transactions as a means of raising revenue to run SPR programs is not likely to be seen as operating strictly within the guidelines of the IEA's SPR 'best practice'.

Crude oil storage by ME NOCs in Asia could provide momentum to initiatives to develop oil trading hubs in the Far East. South Korea has invested the most in this policy objective, building up large storage capacities along its southern coast (Bloomberg 2016). With its deep water ports and expansive logistics infrastructure around Yeosu and Ulsan, the country is geographically and logistically well positioned to deliver cargoes further north, especially to the Chinese teapot refineries around Qingdao, and so become a NEA distribution centre. Japan's joint stockpiling depots are mostly used for supplying crude to China, South Korea and Taiwan rather than to Japan due to laws requiring intra-Japanese shipping to use Japanese ships. This makes shipping crude from Okinawa to other parts of Japan expensive – as with the Jones Act in the U.S. Asian oil companies have become more willing to buy crude oil on the spot market for a larger share of their total purchase portfolios, based on arbitrage and benchmark spread differences and the limits of their technical capabilities in refining different grades of crude oil. Storage capacity and ancillary port infrastructure in strategic locations are key to competitively sourcing their spot cargo import requirements.

Joint oil stockpiling agreements have been linked to Asian NOC acquisitions of equity stakes in ME upstream fields (Gulf News 2016). The storage agreement between Japan and Abu Dhabi was reported as part of a larger arrangement consistent with Japanese government objectives of extending Japan's upstream concessions in Abu Dhabi's ADMA block that were due to expire in 2018 (Platts 2014). When KNOC signed its storage deal with ADNOC in 2012, it agreed to forgo leasing fees in return for equity stakes in some Abu Dhabi oil fields (Bunker Ports News 2013). Indian oil companies are also said to be interested in stakes in the ADCO concessions. Discussions including the Indian government's proposed stockpiling agreement with ADNOC were reported in early 2016 (Gulf News 2016).

Northeast Asian SPR Cost Savings

The idea of saving costs in establishing SPRs is not new. Back in 1990 the U.S. Department of Energy asked Congress for authority to lease foreign oil to continue filling the U.S. SPR reserves (Lipmann 1990). This had been preceded by discussions between the U.S. Secretary of Energy and then Saudi oil minister Hisham Nazer. The proposal was not adopted due to a number of complicating factors such as applicable taxes and risk-sharing.

In this and the next section we outline the economics underlying the two dimensions of joint oil stockpiling: cost savings for host country SPR programs and commercial benefits for crude oil exporters. For ME producers, if the production, movement and international storage of crude oil is not additional to the OPEC quota, then working capital tied up in 'forward commercial storage' would be production cost plus freight. (That is, the supply of crude oil for storage is not counted against the OPEC quota, if any, or the exporting country's own target supply level, since a net increase of volume into markets would cause a fall in prices. This applies primarily to Saudi Arabia, which is large enough to unilaterally alter global supply levels – and for most of the past three decades only Saudi Arabia has had spare crude production capacity of any appreciable magnitude in any case. It should also be assumed that Saudi Aramco would not want to 'cannibalize' its own sales through gaining volumes on spot markets while losing sales in the long-term market which accounts for the vast majority of its crude oil sales.)

In an NOC's accounts, this production cost plus freight could be itemized as 'cost of doing business'. The working capital requirement for ME NOCs would be much lower than the carrying costs of the importing country if the importing country were to purchase the crude up front for its strategic reserves.

Table 6 illustrates the following two scenarios:

> A NEA country purchases ME crude for its SPR, then stores it until required under emergency or crisis conditions at an assumed cost of $41/bbl and cost of freight at $1/bbl. At a total cost of owning and transporting the crude of $42/bbl, its interest cost at 5 percent would be $2.10/bbl.

> A ME NOC retains title to crude oil stored in NEA and assures the host country the pre-emptive right to buy the oil at prevailing market price if an emergency situation is proclaimed. At a total production and freight cost of $6.00/bbl, its interest cost is only $0.30/bbl, or cheaper than the NEA interest cost incurred by $1.80/bbl.

In both cases, the construction and maintenance costs of the SPR oil storage facilities are borne by the host country. Buying the oil accounts for part of the largest share in the total cost of emergency oil stockpiles. The operating costs of storing crude oil vary widely, but estimates suggest $3/bbl per year in underground salt caverns as in the U.S. Gulf Coast SPR, $6-$9/bbl per year in land-based tanks with marine docking facilities and $9-$18/bbl/year in chartered very large crude carriers (VLCCs) (Shilling 2016). In mid-2016, for example, storage costs for chartered VLCCs ranged from $1.00-$1.20/bbl per month or $12–$14.50/bbl per year.

The comparison of the two scenarios in Table 6 is predicated upon the assumption that even though the ME NOC retains title to the oil until an agreed protocol of emergency proclamation is invoked, this is an acceptable substitute for the NEA host country's buying and storing its own crude oil under the joint oil stockpiling agreement. The economic rationale for the ME NOC in the second scenario again depends on the assumption of a link between the stored crude oil and the amount of crude purchased under the usual term contracts for crude oil exports.

Table 6. Indicative benefits of joint oil stockpiling between ME NOC and NEA NOC.

Costs **$/bbl**	**Scenario 1** **NEA buys SPR crude**	**Scenario 2** **ME stores and retains title to crude**	**Difference/Benefit**
Cost of Purchase/Production	41.00	5.00	36.00
Freight (ME–NEA)	1.00	1.00	0
Total cost of storing in NEA*	42.00	6.00	36.00
Interest cost @ 5%	-2.10	-0.30	1.80
Security premium (split benefit 50/50)		0.90	
Net gain	+2.10	+0.60	
For 15–30 MMbbl ($MM/yr)	31.5–63.0	9.0–18.0	

*Excluding costs of construction and maintenance of storage facilities. Source: KAPSARC analysis.

By storing its crude, the ME NOC would aim to both protect and increase its market share for term crude oil sales in the host country. In exchange for elimination of the considerable working capital requirement, the NEA country or NOC would expect to sign a term contract, on standard COSA terms, to lift ME crude with the crude oil purchasers in the host country, since the commercial objective of ME NOCs would be to maximize their long-term contracts under standard terms and formula prices.

It could also be the case that the location of the joint oil stockpiling facility, in close proximity to large consuming countries, allows the ME NOC to take advantage of the flexibility provided by effectively having short-haul crude to offer to both their term contract customers and to other crude oil refiners that are not term clients. From the point of view of the ME NOC, the consuming country could be expected to provide free storage. This is the case with the joint oil stockpile in Okinawa where Japan does not charge Saudi Aramco for leasing the storage. It should be noted that these storage facilities were reported as unused or 'idle' when Japan's first joint oil stockpiling deal with Saudi Aramco was announced. In an equal division of the carrying cost savings, the ME NOC could claim a further stockpiling 'security premium' to be paid by the host country. If it stored 15–30 MMbbl, it could gain $9-$18 million a year if it received 50 percent of the cost savings.

From the point of view of a large Asian net oil-importing country, if the storage of crude oil by the ME NOCs within their territory allows them to reduce the costs of the overall SPR program, then the economic rationale would favour Scenario 2 where the ME NOC retains title to the oil, since it could perform a function similar to SPR expenditures at a much lower cost. The host NEA country would save the $2.10/bbl carrying costs while retaining the essential SPR character of the oil stockpile. If 15–30 MMbbl were stored, the NEA country would save an estimated $31.5 million to $63 million a year.

The two scenarios compared are based on the assumption that the pre-emptive right to buy the ME NOC-owned crude oil under emergency conditions by the host country gives it the same benefits as owning its own crude oil and stored in its SPR, that is, they are substitutes. But in fact, from the host NEA country's point of view, the lack of title to the stored crude means that it faces price uncertainty since the price of the stored oil is only determined when it is lifted, which is at the prevailing market price. The pre-emptive right to purchase – declared after the host government invokes an oil supply disruption emergency – means that the right can be exercised only on payment of the market price at the time of lifting. If the NEA country were to own the oil, it would, as the owner, benefit from the uplift in crude oil prices resulting from the supply disruption event. Against the uncertain benefit of ownership, of course, is the onerous certain cost of carrying for the host country, amounting to over $2/bbl assuming a crude purchase price of just over $40/bbl, as illustrated in the example above.

The definition of the prevailing 'market price' during a supply disruption is fundamental in that there must be an agreed clause expressing a mutual understanding between the NEA country and the ME owner of the crude of what the market price is at the time of lifting. What is a fair assessment of the market price for a Saudi Aramco or an ADNOC crude oil cargo available for sale FOB Okinawa at relatively short notice? The most direct indicator would be the 'best alternative offer' that the crude oil owner can prove exists for the stored crude oil – i.e., if the owner has an open bid for its stored oil at hand – so that any government purchase on a pre-emptive basis would need to at least match this offer. Or there could be clauses in the joint oil stockpiling agreement that specify a particular formula reflecting the market price.

In a 2005 article published in industry journal Petroleum Intelligence Weekly, two oil analysts laid out a proposal for 'forward commercial storage' where OPEC producers utilize storage facilities located in consuming regions under the producer's commercial control, but with a call option sold to the consuming country as part of its SPR program (PIW 2005). A call option is defined as an agreement that gives the owner the right, but not the obligation, to buy a stock, bond, commodity or other asset at a specified price, within a specific time period, or at a specific time in the future. However, in the case of the joint oil stockpiling agreements, the option carrying the right to buy does not have a specified price; instead it states 'prevailing market prices'. The specified time period would be the period for which the lease is agreed in the joint oil stockpiling contract. (A U.S. option can be exercised at any time up to the termination of the contract, whereas a European option can only be exercised at the termination date.)

In normally operating liquid markets, the preferred option would carry a zero or negligible value, as anyone has the opportunity to buy the commodity at the market price so long as the buyer has credit lines and can charter a vessel that meets the crude seller's specifications for delivery at the specified port. A 'pre-emptive' right only grants the host country a preference in the case where it matches the best alternative bid. In the context of a supply disruption when panic buying and price spirals can occur – and have done, as during the 1970s price shocks – the pre-emptive right to buy at the prevailing market price, whatever it proves to be, can be problematic. When prices can spike wildly day to day or over hours and minutes, the agreement to supply oil in an emergency to the host government would need to be very precise as to the mode of price discovery. Any ambiguity could result in requirements to arbitrate or litigate, leading to potentially large losses for either or both parties to the agreement. Large economic losses can lead to a failure in commercial reputations with possible spillovers into diplomatic relations between the parties concerned.

In the event of a global crude supply disruption marked by panic buying and price spikes, the right of the government to invoke an official oil supply emergency and gain the preferential right to buy the crude in the joint oil stockpiling facilities in their jurisdiction could be valuable, even if only exercisable at the prevailing market price. If the government correctly predicts that a price spike is due to intensify, proclaiming an oil emergency and exercising the pre-emptive right to buy the stored crude oil would save it from even higher prices further into the oil disruption period. Of course, in the opposite case, if the government were to get it wrong, and what is expected to be a continued price spike ends up quickly being a reversal, then the government would stand to lose money having bought at what might later prove to be a peak.

As joint oil stockpiling agreements are commercial and confidential to the parties to the agreement, it is not clear whether the existing joint oil stockpiling agreements in Japan and South Korea oblige the host government to provide proof of loss of supply beyond a particular threshold in order to invoke an 'oil emergency'. However, the host NEA government would find it in its own interest to exercise an emergency call on the joint oil stockpiling only when required and demonstrably justifiable. The reputational damage of calling an unfounded oil supply emergency would militate against any strategic 'gaming' over the emergency proclamation. The latter would be a move that would damage any 'relational' or trust-based contract, such as a joint oil stockpiling agreement, where continued trust and good faith are critical (MacNeil 1988). Similarly, the risk of nationalization of crude oil stored in joint oil stockpiling facilities by the host government, while not trivial, could also be expected to be remote. Nonetheless, the expropriation risk of large-scale placement of assets by any government within another government's jurisdiction would be a factor for consideration by an oil producer seeking to participate in joint oil stockpiling agreements.

Middle East NOC Pricing Norms

Forward commercial storage in or near large consuming markets has provided crude oil exporters with logistical flexibility in terms of breaking bulk and proximity to final delivery points, and improved freight economics in their downstream integration ventures. Leased or owned storage facilities in Rotterdam, Latin America, the Caribbean and elsewhere have been an established feature of the downstream investment ventures in or near large oil-consuming markets by ME NOCs since the 1980s. Joint oil stockpiling agreements, however, are distinctive in that they are not part of a larger downstream integration program that would include investing in R&M assets. In that sense, joint oil stockpiling ventures for the ME NOC are a pure logistics play.

The surge in oil supplies that prompted the fall in oil prices in the second half of 2014 has prompted key Asian refiners to buy more of their crude on the spot market, so it can be delivered immediately rather than at some future date under the typical term contracts offered by ME crude sellers. As competition in Asian crude markets has intensified, and with a volatile trading environment, opportunistic buying of crude oil cargoes on spot markets has become more common. Even conservative Asian crude oil importers in Japan and South Korea, known for their priority to secure stable supplies under term contracts, are increasingly turning to spot markets to source greater volumes of crude oil. For example, Japan's JX Nippon Oil & Energy Corp. and South Korea's SK Innovation Co. are among the refiners aiming to enhance profits by purchasing more on the spot market while reducing what they buy under long-term contracts which typical charge higher prices during periods of crude oil glut (Bloomberg 2015). Short-term deals had previously accounted for about 10 percent of purchases by those countries' refiners; now they reportedly account for as much as a fifth to a quarter of total imports. It should be noted that all term contracts allow ME oil producers to "allocate" or control sales volumes as required for the country to fulfil its OPEC quota obligations. Thus, "stable supplies under term contracts" comes with the proviso that the ME supplier can reduce term contract volumes unilaterally if required by its OPEC quota policy.

Refiners in China and India have emerged as increasingly important buyers in the Asian crude oil market as both countries' crude oil imports grow rapidly. Their estimated combined daily net crude imports exceed 10 MMbbls, or some 3 MMbbl/d more than the U.S., the world's largest single crude oil importer. As China and India play an increasingly dominant role in Asia's crude oil market, a growing share of trading is done on a spot basis as "buyers prioritize cost and delivery flexibility over fixed shipment schedules" (Reuters 2016). In China, state-owned oil giants have been joined by nearly 20 independent refiners that have been granted crude oil import licenses and buy their crude oil supplies exclusively from spot markets. According to a managing director at Indian refiner Mangalore Refinery and Petrochemicals Ltd., "there's a perceptible shift from term contracts to spot purchases." Another source, with a Korean refiner, said, "It's become less important for us to secure stable volumes under term contracts because there is a lot of crude available…we now think in terms of profitability and that's why we're buying more spot crude this year" (Bloomberg 2015).

In this environment, the rationale for a ME NOC to participate in joint oil stockpiling would include gaining access to parts of the crude oil market that are not served by the larger Asian term contract crude oil buyers who have their own shipping arms to transport crude from the ME in VLCCs or ULCCs (ultra-large crude carriers over 250,000 dead weight tonnage). Illustrating this, a Saudi Aramco spot sale to an independent Chinese refiner with much weaker financial credit lines than the usual large Chinese NOCs that the company deals with was extensively reported by industry news sources. The 'break bulk' capability – where cargo is transported in smaller 'parcels' rather than in entire cargoes – offered by Japan's storage in Okinawa widens the range of refiners willing and able to buy crude oil. That is to say, it includes refiners with smaller receiving facilities that cannot handle direct ME imports, which are typically transported in very large or ultra-large crude carriers.

For the joint oil stockpiling agreement to be profitable for the crude oil seller, the price at which it would sell its stored crude oil in NEA should at least cover the FOB price of the crude oil at the port of loading in the Arabian Gulf, the cost of freight for moving the oil from the Gulf to storage in the joint oil stockpiling facility in NEA, any cost based on leased storage fees (if any) and handling charges due to the owner or operator of the oil storage facility. JOGMEC, the Japanese SPR manager, does not charge Saudi Arabia for using the Okinawa storage.

ME NOC crude oil sales to international buyers are long-term COSAs, usually 'evergreen' contracts renewable annually by mutual agreement between buyer and seller. The pricing formula generally has four components: point of sale, a market-related base price, an adjustment factor reflecting crude oil quality and the point of sale, and a timing mechanism that stipulates when the value of the formula is to be calculated (OUP 1997). Saudi Arabia, Kuwait, Iran, Qatar and Abu Dhabi are among Gulf oil producers using some form of formula prices for long-term contracts. Among the few Gulf crudes sold on the spot market – i.e., not based on term contracts with end-user and resale restrictions – are Oman and Dubai. For Asia-based buyers of Saudi crude, the FOB crude oil price is linked to the monthly average spot price of Oman and Dubai crude oils (O/D) during the month *t* in which the crude is loaded at a Saudi port for delivery to the Asian market. The Saudi sales invoice prices in crude oil sales agreements with Asia-based buyers are based on assessments provided by price reporting agency Platts, a division of Standard & Poors. Platts reports physical, not futures, prices. However, the Atlantic markets of Europe and North America have long had liquid exchange-traded crude oil futures prices in West Texas Intermediate (WTI) and Brent contracts. For sales to Europe, Brent futures serves as the reference price for Saudi and other GCC producers. For sales to the U.S., the Saudi reference price was not tied to the NYMEX exchange-traded WTI futures contract but rather a physical trade (or "cash") assessment by Platts, a price reporting agency (PRA). Platts cash assessments of WTI in the U.S. Gulf Coast served as the Saudi sales crude reference price until 2010 when it was replaced by an alternative PRA-assessed crude oil benchmark, the Argus Sour Crude Index (ASCI).

The base price for crude lifted at Ras Tanura or other Saudi ports is then adjusted by adding or subtracting an 'offset' or adjustment factor (see below). The ports of Ras Tanura and Ras al-Ju'aymah on the Persian Gulf handle most of Saudi Arabia's crude oil exports from the Gulf. The greater part of the remaining volumes are exported from the Yanbu terminal on the Red Sea.

$$AL_t = O/D_t + offset$$

The adjustment factor takes into account the quality differential between the given Saudi crude grade and the reference crude it is being priced off. The quality differential is measured as the difference in gross product worth (GPW) of the Saudi crude relative to the reference crude. The GPW measures the total value of all the refined product processed from the crude and determines its refining value. In Asia, refined product prices quoted at FOB Singapore are taken as the reference prices for calculating the GPW of the the crude oil.

The other two factors that determine the value of a commodity other than quality are its location and time of delivery. Since Arab Light (AL), Oman and Dubai crudes all originate in the Arabian Gulf, the freight differentials are marginal. Crude delivered from the Saudi port of Yanbu on the Red Sea would be an exception. And the time of delivery on FOB basis at an Arabian Gulf port is for the same month of lifting for all the three crudes.

In the case of Arab Light, if we take the example of cargoes loading in month *t*, which is December in Table 7, the offset for ALt is announced in the first week of *t--1* (November) as shown in the schematic in Table 8. At the time of the announcement of the December offset, the latest historical market data available is from month *t-2* (October). So, in determining the value of the offset for ALt, the GPW difference between AL and reference crude O/D is calculated for the most recently available data in month *t–2*.

In Asia, the crude oil spot market trades two months ahead of delivery into Asian destinations and Platts' quotes for front-month Dubai in December are for February deliveries of 500,000 bbl cargo sizes (Platts website). That is, when loading occurs in month *t* (December) the front month quotes for Oman and Dubai crudes are for *t+2* (February). It is during month *t-2* (October) that front month quotes for Oman and Dubai refer to the month of loading *t* (December) and third month quotes refer to month *t+2* (February).

Since December loading cargoes in the Arabian Gulf use the front month Platts quotes, which are for pricing February deliveries in Asia, the time structure of the reference crude prices impacts the invoice price for the crude sale. So that, if the price of the reference crude, Dubai, in the month when AL is loaded exceeds the two-month forward price, i.e., the Dubai front month quote, it loses by that amount of backwardation. (In backwardation, forward curve prices are lower than current spot prices.) Accordingly, a backwardation premium is added to reflect the value of December loading AL term contract FOB cargoes in the Arabian Gulf.

$$offset = (AL_{GPW(t-2)} - OD_{GPW(t-2)}) + (D_{M1(t-2)} - D_{M3(t-2)})$$

If a cargo from a joint oil stockpiling facility was sold to nearby refiners in NEA, it could be assumed that the ME NOC would try to sell it for at least as much as, adjusted for freight, it would have achieved if the cargo was sold FOB Arabian Gulf. In other words, it would want to achieve a price equal to, or higher than, what it would have sold for under the usual ME term contracts.

Table 7. Saudi Arab Light FOB Gulf official selling price.

Saudi Selling Price Formulae

Oct	Nov	Dec	Jan	Feb
t-2	t-1	t	t+1	t+2

Source: KAPSARC analysis.

Consider the case where an existing term customer needed oil at shorter notice than possible under the usual FOB nomination procedure for loading in the Arabian Gulf, which would take about three weeks or more to arrive at its NEA destination. A term contract customer facing the urgent need for a spot cargo due to unforeseen circumstances could request oil from a nearby joint oil stockpiling facility. For the crude seller, acceding to this request from a long-term contract client of good standing would be good business practice, provided that doing so does not cause the seller to realize a lower price than the normal FOB Arabian Gulf sale. Thus, if the crude oil seller received a request in December from a term client for a crude oil cargo for delivery in January, the crude oil seller could compare this to cargoes loaded in December in the Arabian Gulf and charge the same price, plus the cost of freight and loading/offloading and other applicable handling charges, and also plus the cost of storage at the joint oil stockpiling facility, if any.

Apart from significant exceptions such as Oman and the UAE, ME NOCs have typically avoided selling crude oil on spot markets, preferring long-term formula price contracts as the means of disposing of the bulk of their crude oil exports. However, they have occasionally sold crude oil on the Asian spot market. According to reports, Saudi Aramco sold its first cargo to Japanese refiner Cosmo Oil from the joint oil stockpiling facility in Okinawa in April 2012, for May delivery, on the spot market (Reuters 2012). In the post H2-2014 environment of low prices and intense competition in the Asian crude oil market, the pressure for the ME NOCs to protect market share has increasingly led to deals on spot markets with non-traditional customers. The recent Saudi Aramco sale of a spot cargo to a small, independent Chinese refiner sparked the attention of oil industry observers (Gloystein and Tan 2016). According to veteran oil observer Ed Morse of Citibank, "News that Saudi Arabia is selling a cargo on the spot market to Asia may mark the turning of a dramatic new chapter in the Saudi playbook…What is unusual is that the sale is spot rather than the initiation of a new term contract. Spot sales are about the only way the Kingdom can gain new market share in a world in which chunky buyers are interested in securing incremental purchases via spot rather than term arrangements" (Cho 2016).

From the point of view of the ME NOC, it might be assumed that the sales of crude oil ex-Okinawa, or some other NEA joint oil stockpiling facility, would take place so long as they do not lead to a revenue loss relative to what the crude seller would have realized had it sold the cargo FOB Arab Gulf under its usual term contract arrangements. In a tight crude oil market, the ME supplier would also look at adding a "prompt premium" to reflect similar premiums for other prompt crude oil cargoes available in the spot market. In addition, the sales of the spot cargo to new clients would be with the intention of converting at least some of the spot market buyers to 'regular customers' under conventional term contracts preferred by the ME NOCs.

From the point of view of a crude oil customer in NEA, the market price of the ME crude sold ex-Okinawa or some other joint oil stockpiling facility in Japan or Korea should be comparable to other similar crudes available in the region. A refiner in NEA would naturally assess the spot market for crude oil in the region and buy the most competitively priced crude oil, adjusted for its relative quality and freight cost. As the spot market for crude oil in Asia is active two months forward, if a NEA refiner was seeking to secure a prompt cargo from a nearby joint oil stockpiling facility one month ahead it would have to assess the month ahead market value of the reference crudes such as Dubai or Brent. As the front month Dubai crude contract is quoted for two months ahead, for any shorter period a NEA crude oil buyer would have to use quotes in the 'over-the-counter' (OTC) or derivatives market instead. The

Dubai swap contract, quoted for one month ahead, is often used to hedge typical medium or heavy sour crude from the ME and Russian Far East. Other spot crudes available to the NEA buyer from West Africa, Latin America and the U.S. West Coast are priced off Brent, the other global benchmark crude used for the world crude oil trade. A buyer of prompt crude in NEA would have to consider the quality and freight cost of crude cargoes on offer as well as the price of each relative to the two global benchmarks.

Dubai swaps are settled against the average of Platts' front month spot Dubai crude assessments. The cash-settled Dubai paper assessment reflects paper transactions of a minimum of 50,000 barrels. The relationship between Dubai swap and Brent prices is given by the following equivalences described in the table below, all reported for a time stamp of Singapore 4.30 p.m., i.e., Asia close. A NEA crude oil buyer seeking a cargo in December for a January loading from a nearby joint oil stockpiling facility would assess offers bearing in mind the price relationships in the table below. Whether the buyer hedges his purchases or not, these pricing relationships present the context in which offers for prompt delivery by crude sellers would be assessed. To assess the theoretical value of a January delivered physical cargo in December it would be necessary to start with ICE January Brent futures and go through a derivation process as outlined in Table 8.

It should be noted that the price of crude oil at any point in time in the NEA spot market is not necessarily higher than the opportunity cost facing ME NOCs which sell the vast majority of their crudes via term contracts on an FOB Arabian Gulf basis. In other words, the spot market price for any particular grade of crude oil prevailing at any particular time may be lower than the cost of crude oil of a similar grade bought under term contracts with the ME NOCs. In weak markets, the tendency is for spot prices to be lower than term contract prices and vice versa. This is the case even though formula prices for crude oil purchased under term contracts are typically referenced to spot crude prices, since term contract price movements lag spot price movements.

It should be noted that the volumes of crude oil stored under the various joint oil stockpiling agreements in South Korea and Japan are relatively small compared with total exports by the ME NOCs to the NEA region. For example, the 6.3 MMbbls stored by Saudi Aramco in Okinawa are dwarfed by the approximate 1.1 MMbbl/d imported by China from Saudi Arabia in the first half of 2016 (Chen 2016). However, storage throughput rates can work out to a full turnover once a month, or about 12 times the total storage capacity annually. For the Okinawa facility, for example, this throughput is 74.4 MMbbl a year, or over 200,000 bbl/d. Thus, the joint oil stockpiling facility utilized by Saudi Aramco could theoretically account for almost one-fifth of all Chinese imports from Saudi Arabia were it to sell all its cargoes from the Okinawa storage to China alone, with a full turnover once a month.

Table 8. Relationship between Dubai and Brent, swaps and physical contracts (Asia close).

ICE Jan. Brent Futures	+/-	ICE Jan. Brent EFP*	=	ICE Jan. Brent Physical
ICE Jan. Brent Physical	+/-	ICE Jan. Brent-Dubai EFS**	=	Jan. Dubai swap
Jan. Dubai swap	+/-	Dec./Jan. Dubai swap spread	=	Dec. Dubai swap

*Exchange of futures for physical; **Exchange of futures for swaps. Source: KAPSARC analysis.

Conclusion

The practice of oil exporting and importing countries jointly stockpiling crude oil in destination markets, first pioneered by South Korea and later adopted by Japan, has gained policy interest across other parts of Asia. Large non-OECD countries such as China and India, which are becoming increasingly dependent on growing volumes of imported crude, are currently negotiating joint oil stockpiling deals with various ME exporters. Joint oil stockpiling, although not currently recognized by the IEA as a form of SPR, could in fact prove a viable and mutually beneficial way for the non-OECD countries in Asia to meet at least a part of their SPR requirements. It is important to note the volume limitations to joint oil stockpiling: it is not likely that the ME oil exporters would want to store very large volumes of crude oil in destination markets in Asia over and above their own needs to provide prompt supplies on the spot crude oil market for their term customers' unplanned requirements and for 'strategic' spot sales to non-traditional customers to access niche markets. For the Asian crude oil importers, such bilateral agreements could be seen as an enhancement of their national SPR programs rather than as an alternative. They may also be seen as an alternative to IEA-coordinated stockpiling via multilateral agreement among the large non-OECD Asian oil importers: these countries can 'de-risk' at least a portion of their crude oil supplies by joint oil stockpiling if IEA coordination is not forthcoming.

Joint oil stockpiles can be classified as both commercial and strategic storage, providing the importing country with access to crude oil reserves in times of emergency without incurring the costs of buying crude oil outright for SPR purposes. Joint oil stockpiling agreements can also be a concrete step in furthering deeper economic relations between exporting and importing countries. Indeed, jointly stockpiling crude has often been discussed between the NOCs and between the energy and commerce ministries respectively of both ME producing regions and NEA consuming countries, as widely reported over the past several years.

ME exporters, by storing their oil closer to the large Asian demand centers, are better able to compete against short-haul crudes in the region. Stored ME crude oil in joint stockpiles offers the exporters a convenience yield given the close proximity of the storage facilities to the major NEA markets. Here, we use 'convenience yield' as defined by economist Nicholas Kaldor as: "a yield, qua stocks, by enabling a producer to lay hands on them the moment they are wanted and thus saving the cost and trouble of ordering frequent deliveries, or waiting for deliveries" (Kaldor 1939).

Taking into account the oil security concerns of NEA countries, ME oil stored in NEA locations offers buyers oil that has been 'de-risked', in that it has already transited the critical chokepoints of the Straits of Hormuz and Malacca. Joint stockpiling agreements offer crude oil sellers and buyers the flexibility to nominate smaller cargo sizes and permit break-bulk options. The joint stockpiling agreements have also offered the ME NOCs a platform for opportunistic access to spot markets, an important consideration in the current low oil price environment. The joint oil stockpiling agreements between ME producers and large Asian importers can be expected to become an important feature of the oil trading relationships between the two regions and could well prove to be a win-win formula.

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Appendix 1: The Economic Justification for SPRs

There is a large body of policy analysis and research into the role of buffer stocks for globally traded commodities such as rubber, tin, sugar and cocoa in the international trade literature from as far back as the 1950s and 60s. The broad consensus has been that commodity buffer stocks have been failures, and most of these stockpiling programs have now been discontinued. Many of them were attempts to 'stabilize' prices above some target level that producing countries felt necessary, but such producer cartels could not last, and political pressures and conflicting objectives led to the collapse of many (Verleger 1993; Jaffe and Soligo 2002).

However, oil stockpiling as a response to the oil shocks of the 1970s has proved a durable policy and most large economies now hold oil stocks, both of crude oil or refined petroleum products or both. The object of the oil SPRs that have been set up or are being actively built in the OECD countries, as well as many of the other large importing countries such as China and India, is to provide oil supplies in times of physical supply disruptions. Disruptions can occur as a result of: political embargoes as in the 1970s, production disruptions due to war or civil unrest in oil-producing regions, terrorist attacks on vital oil-related supply infrastructure and military or accidental disruptions to key chokepoints in sea lines of communications like the Straits of Hormuz or Malacca.

The first step toward forecasting the risk of future economic costs of oil supply disruptions has been to examine the historical record of significant oil supply disruptions. Though the past is no sure indicator of the future, it gives the analyst a sense of perspective as to the scale of past events and their historical patterns to help model the probabilities of future oil supply shocks.

Table A1 is a list of specific events up to Hurricane Katrina that led to significant oil supply disruptions. In terms of overall supply shortfall, the Suez Crisis (1956–57), the Yom Kippur War (1973-74), the Iranian revolution (1978–79) and the Iraqi invasion of Kuwait have been the most significant, accounting for between 7 percent to 12 percent of global output. The worst of these disruptions lasted from six to nine months.

A 1990 U.S. Department of Energy (DOE) interagency study estimated oil disruption probability distributions based on the historical frequency of disruptions of various sizes from 1951 to 1989. According to the study, the probability of a major disruption equal to or greater than 15 percent of world oil supply is 1 percent in any given year. A study by Taylor and Van Doren compiled a range of probability distributions of oil supply disruptions taken from a number of studies (as shown in table A2). The table summarizes the probabilities of large oil supply disruptions, defined here as exceeding 5 percent of global supply.

Table A1. World oil supply disruptions

Date of Oil Supply Disruption	Duration Months of Supply Disruption[1]	Average Gross Supply Shortfall (MBD)	World Production Prior to Disruption (MBD)[2]	Supply Shortfall[3] (%)
Nov. 1956-March. 1957 (Suez Crisis)	4	2	16.8	11.9

Dec. 1996-March 1967 (Syrian Transit Fee Dispute)	3	0.7	32.96	2.1
June 1967-Aug. 1967 (Six Day War)	2	2	35.39	5.7
May 1970-Jan. 1971 (Libyan Price Dispute)	8	1.3	45.89	2.8
Oct. 1973-March 1974 (Arab-Israeli War)	6	4.3	57.744	7.4
Nov. 1978-April 1979 (Iranian Revolution)	6	5.6	62.906	8.9
Oct. 1980-Jan. 1918 (Iran-Iraq War)	3	4.1	58.338	7.0
Aug. 1990-Jan. 1991 (Iraq Invasion of Kuwait)	5	4.3	60.487	7.1
June 2001-July. 2001 (Iraqi Oil Export Suspension)	2	2.1	67.551	3.1
Dec. 2002-March 2003 (Venezuela Labor Strike)	4	2.6	68.595	3.8
March 2003-Dec. 2003 (War in Iraq)	9	2.3	69.041	3.3
Aug. 2005-Sept. 2005 (Hurricane Katrina)	2	1.4[4]	73.572[5]	1.9

Source: KAPSARC analysis.

Table A2. Probability estimates of future major supply disruption of various studies.

Author/Institution	Date	Scenarios	Percentage Chance	Percentage Volume Lost Global Supply (5 percent>)
U.S. DOE	1979		10.0 5.0	10.0 20.0
Hogan	1981		30.0 20.0	5.0 10.0
Plummer	1981		20.0 10.0	5.0 16.8
Hogan	1983		20.0 10.0	10.0 20.0
Chao and Manne	1983		20.0 10.0	5.0 16.8
Leiby and Lee	1988	1 2 3 	10.0 5.5 0.3 10.6 1.0 14.0 6.0	7.0 10.0 17.0 8.5 17.0 8.5 25.0
EMF	1996		5.3 2.5	10> 15>

Source: KAPSARC analysis.

Oil supply disruptions do not correlate well with oil price shocks (see Figure A1). Some supply disruption events had little price effect, while others led to very large and long-lasting oil price increases, of which the 1970s price shocks and the Iraq-Kuwait war in 1990/91 were the most significant, right up to recent history.

While the historical data on the incidence of oil supply disruptions is clear, the interpretations of those events and their impact on the macroeconomic outcomes of net oil importers differs widely in the literature as well as in policy circles. Early legislation on strategic oil stockpiles, as in the IEA International Energy Program and the U.S. SPR, was based on 'physical shortage of supply', a concept of scarcity that is no longer applicable due to the profound transformation of the oil markets since the 1970s.

The oil industry used to be based mainly on global, vertically integrated, oligopolistic firms that controlled markets – including a series of global market share collusions – from upstream exploration and production to downstream oil refining and marketing, and had erected formidable barriers to entry against smaller upstart firms (Yergin 1991). Markets hardly existed as most flows from 'source rock to gas station' were transactions that were carried out within the huge globally integrated oil firms at transfer prices established by the company. Following the dislocations and nationalization of oil resources in the 1970s, global oil markets have become far more fungible and liquid, with a much larger role for market forces, and much more flexible as a result. By the 1980s, spot physical and derivative markets, including futures and swaps, helped establish competitive price signals for global trade in crude oils and refined oil products.

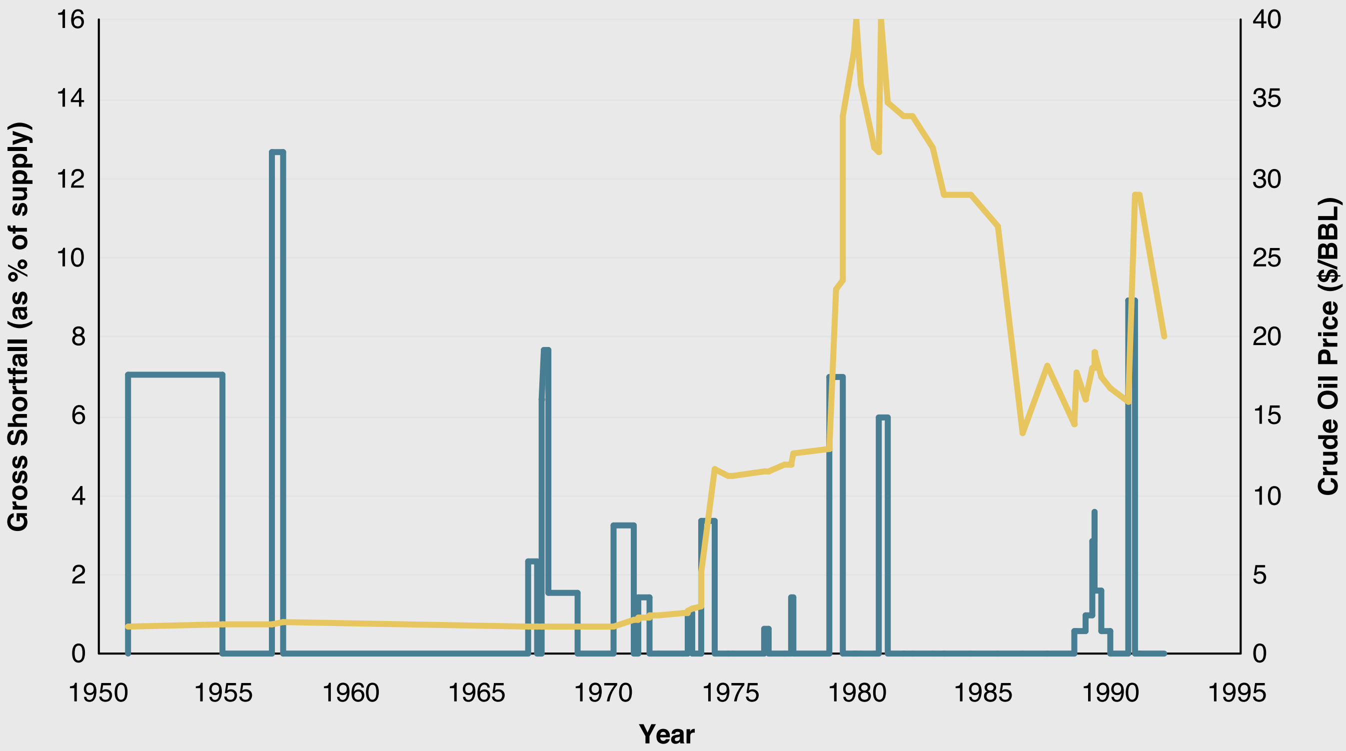

Figure 1. Historical Disruptions.

Source: Emergency Oil Stocks and APEC Energy Security, Interim Report 1999, Leiby and Bowman, Oak Ridge National Laboratory.

In this context, the obvious manifestation of 'physical oil shortages' is in the upward shift in prices. As Richard Gordon points out, "Basic economics indicates that no shortages will arise as long as prices are uncontrolled. The question is the price needed to eliminate the shortage" (Gordon 1992). In a fungible world market, countries cannot insulate themselves from markets: whether the importing country depends on ME oil or not is irrelevant, as any supply disruption anywhere will affect global prices for everyone. Willingness to pay world market prices for oil will secure all that a country needs except in the most dire emergency situation where all or most of the sources of oil imports suddenly become unavailable at once and where the global oil trade has completely collapsed. Absent such extreme scenarios, which would likely elicit a military response in any case, typical models of oil supply disruption study the costs of the macroeconomic impacts on GNP and on the balance of payments for net oil-importing countries as a result of upward oil price shocks.

Oil price shocks and their macroeconomic impacts

The apparent causal link between oil price shocks and subsequent economic recessions has led energy economists to focus on price shocks, rather than physical supply disruption measures and their economic impacts (Hamilton 1985). The models used to estimate the loss of potential economic output resulting from the increased economic scarcity of oil, together with costs arising from the economy's inability to adjust quickly to price shocks, have typically identified three components of economic cost: wealth transfer, loss of potential GDP and macroeconomic adjustment costs. These are direct costs. Mistaken responses of government to oil price shocks, such as price controls – as during the Carter administration – or inappropriate monetary policy leading to inflation, can add further substantial indirect economic costs.

The transfer of wealth to oil producers from the net oil-importing countries because of oil price shocks has been substantial. In nominal terms, prices quadrupled by 1974 to $12/bbl and doubled to $24 at the peak in 1981, which led to vast wealth transfers from the large net oil-importing countries to OPEC and other key producers. According to one estimate by the Oak Ridge National Laboratory of wealth transfers out of the U.S. during 1972–1991 due to monopoly prices – relative to an assumed competitive price – annual losses ranged from a low of $6 billion (in 1990 USD) in 1973 to $132 billion in 1980. Using a 5 percent annual discount rate, the present value is estimated at $1.9 trillion (Greene and Leiby 1993). This is a considerable sum. It should be noted, however, that the assumption of a competitive price to forecast what the baseline import costs 'would have been' as a counterfactual in order to derive wealth transfer estimates is subject to the reasonableness of the author's assumptions.

In 1984, Stanford University's Energy Modeling Forum (EMF) gathered the results of 14 economic models to forecast the effect of a sudden 50 percent oil price hike, sustained indefinitely, on GNP (as shown in table A3). These studies, however, do not divide the total loss of GNP growth into its two major components, the loss of potential GNP and the macroeconomic adjustment costs. The implied negative elasticities of GNP with respect to oil price in the EMF sample of 14 models range widely from 2 percent to almost 10 percent, but most are around the median estimate of 5.5 percent. The elasticity estimates are modeled on a 50 percent oil price shock occurring in 1983.

Table A3. Elasticity of GNP with respect to positive 50% oil price shock.

Model	Forecast elasticities of GNP with respect to oil price
LINK	-0.050
Wharton	-0.059
MACE	-0.043
Hubbard-Fry	-0.022
Chase	-0.050
Claremont	-0.072
MPS	-0.063
FRB MCM	-0.020
BEA	-0.069
DRI	-0.046
Hickman-Coen	-0.044
St. Louis	-0.057
Mork	-0.095
Michigan	-0.067
Average	-0.055

Source: Hickman, Huntington and Sweeney, 1987.

For most of the models, the maximum loss of GNP occurred in the year following the oil price shock, with macroeconomic adjustment costs declining in the following years as wages, prices, and capital adjust to the new price of oil. The average and median estimates of the loss in GNP over the period 1983–86 following a hypothetical 50 percent oil price shock in 1983 are shown in table A4. On average, the models predict a decline of -1.8 percent in the initial year, increasing to -2.7 percent by the second year and falling to -2.5 percent and -2.3 percent respectively in the third and fourth years of the price shock. The median estimates are very similar: -1.4 percent, -2.7 percent, -2.6 percent and -2.3 percent. Most of the models cited in the EMF study have similar transmission mechanisms that lead from oil price shocks to adverse macroeconomic performance. An upward oil price shock causes companies to increase their price markups, which in turn leads to lower aggregate spending and higher unemployment, i.e., to a recession. However, actual direct evidence as to the link between oil price shocks and economic performance is "surprisingly mixed." Hamilton (1983), for example, found that most recessions in the U.S. until 1980 were at least partly caused by oil price shocks. However, others suggest that the findings of this and other econometric studies were dominated by the two price shocks in the 1970s; at all other times oil prices were stable or falling. Other economists express caution in attaching importance to oil prices rather than other factors in explaining recessions. Bohi (1989) found that the impact of oil price shocks on production and employment was not significant, given the small share of energy costs in total production costs.

Much also depends on the elasticities of substitution among labour, capital and energy. The empirical literature on these elasticities is inconclusive (Bohi and Toman 1996). Other economists have offered alternative hypotheses to the recessions in the 1970s. In looking at the U.S., the U.K. and Japan, it was found that governments in those countries pursued

Table A4. 50 percent oil price shock on U.S. GNP in 1983.

	Percentage change in Real GNP			
	1983	**1984**	**1985**	**1986**
Average	-1.8	-2.7	-2.5	-2.3
Median	-1.4	-2.7	-2.6	-2.3

Source: Hickman, Huntington and Sweeney, 1987.

tighter macroeconomic policies after oil price shocks as an anti-inflationary strategy. Deflationary monetary policy, it is contended, led to the recession in these countries, not oil price shocks – even if the latter might have intensified recessionary outcomes. Thus, if oil price shocks were accommodated by loose (i.e., not anti-inflationary) monetary policy, that could have offset the fall in aggregate spending following the oil price shocks and hence avoided the recessions.

Risk and insurance

For oil reliant economies, the most direct and obvious direct energy security measure would be to require some level of bulk oil storage for both crude oil and refined products in case of fuel supply disruptions. At an intuitive level, the economic justification for holding oil stocks is straightforward: physical disruptions in oil supply can lead to severe price shocks – as they did in the 1970s – which adversely affects GDP and the balance of payments of net oil-importing countries. Since the demand for refined oil products is highly price inelastic in the short run, the negative effect of higher prices on the macro economy can be alleviated by a drawdown on strategic stocks during periods of supply disruption.

In this sense, establishing an SPR can be considered as a publicly funded insurance program to protect against the risk of supply disruptions, which lead to price shocks where the cost of administering the SPR is the value of the insurance premium. The question then emerges: is there a need for actual insurance against oil supply disruptions? And, if so, whether the government should provide this. The rationale for building and maintaining SPR programs is based on two conditions: the possible risk of oil supply disruptions and a deficiency in private sector norms of inventory behavior. The former is a necessary but not sufficient condition for SPR programs. In other words, the key issue is whether private agents will hold socially optimal level of stocks. There is a market failure argument for SPRs: holding oil stocks can yield macroeconomic social benefits upon release that are not captured by private inventory holders.

The value of private oil stocks equals the expected profits from arbitrage that can be earned by the private stockholder. The social value of publicly held SPRs, on the other hand, would be the expected cost savings from releasing oil stocks during a supply disruption. This includes two benefits: the benefit of reduced import payments – and hence a lower level of wealth transfer from net oil-importing to net oil-exporting countries – and the avoided macroeconomic costs, both lower potential GNP and macroeconomic adjustment costs, arising from economy wide dislocations caused by the oil price jump. Against these two benefits, the increase in oil prices during normal, i.e., non-disruptive, periods caused by the increase in oil demand so as to stock up on SPRs would be included as a cost.

A number of studies have been carried out on the optimal level of publicly funded SPRs, often cast as stochastic dynamic models that specify the risks of oil supply disturbances and calculate optimal stockpiling sizes under different market expectations. The U.S. government's first major energy policy study in the wake of the 1973 oil embargo proposed an optimal SPR size in the range of 1–2 billion bbls. As of June 2016, the U.S. SPR held 695 MMbbls. Later studies by Leiby and Lee of the Oak Ridge National Labs support SPR levels of 0.750–1 billion bbls. A study by Murphy, Toman and Weiss recommends an SPR of 1 billion bbls as justified, even after allowing for some crowding out effect of the SPR on private stocks, considering significant risks of supply disruption and macroeconomic effects on GDP and imports. However, not all studies are unambiguously in support of relatively large SPR levels. For example, the U.S. DOE argued in a 1990 report to Congress against a proposed increase of SPR from 600 MMbbls to 750 MMbbls in a reasonably wide range of scenarios. (U.S. DOE 1990) There have been other studies that call for the abolition of the U.S. SPR altogether, based on radically differing assumptions about the key parameters that drive optimal stockpiling models. (Taylor and Van Doren 2005)

Model assumptions

The optimal size of stockpiles differs according to the assumptions informing such models. Key assumptions include the probabilistic risk of oil supply disruptions, supply and demand elasticities, the expected macroeconomic costs from oil supply disruptions and the possible trade-offs between the SPR and private stockpiling. Those models that suggest to policymakers that very large stockpiles are optimal assume high risks of disruption, low short run elasticities on both demand and supply – especially non-OPEC supply – sides, large GDP and import price impacts from such disruptions and little or no adverse impact of SPRs on the level of private inventories held. It should also be noted that empirical estimates of costs and benefits differ widely as a function of the discount rates adopted. Thus, the U.S. DOE study finds that the gross benefits of an SPR expansion double when the discount rate is reduced from 10 percent to 5 percent, since estimates of future avoided macroeconomic costs of a supply shock are amplified with the lower rate. Given the wide differences in parameter values of key behavioral assumptions behind dynamic programing models of optimal SPRs, and the impossibility of objectively verifying the values of such critical parameters, Bohi and Toman argue that it is "impossible to make a credible judgement about the correct magnitude of the premium that should be attached to SPR" (Bohi and Toman 1996). Indeed, the very uncertainty "should engender great caution" in attempting to estimate the optimal level of SPR. In general, the authors conclude, the "energy security argument is a weak basis for supporting…larger strategic oil stocks."

About the Authors

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About the Project

Since the oil price shocks of the 1970s, the security of oil supply has been the main concern in academic and policy circles. The goal of this research project is to study the other side of the coin — the security of oil demand from the net-exporters perspective. How do large oil exporters trade off risk and rewards in ensuring security of demand? In the first phase of this research project, a comparative static model of global oil trade is developed to empirically measure the impacts of alternative crude oil market shares across segmented markets; to assess the strategic choice NOCs have in valuing alternative sales market portfolios in the context of the trade-off along the risk-reward frontier; and to compare IOC behavior as a benchmark for NOCs.

More specifically, this project will attempt to specify a parsimonious model of regionally segmented global oil trade calibrated to 2012 benchmark data which would allow comparative static exercises to simulate equilibrium impacts of alternative placement of term-contracted crude oil, including impacts on total revenues for crude oil producers. The model focuses on three fundamental variables that determine relative crude oil prices: transport costs, crude oil quality, and refinery flexibility.

In line with KAPSARC's overall objectives, the intent is to produce policy-relevant insights that help actors in the oil industry understand the consequences of decisions taken by large exporters.

The workshop series fits into the overall project by providing a continuing dialogue that raises key issues, provides feedback on current work, and sets future directions. The workshops are an open collaborative forum that enables the discussion of particular themes that feed into identified research questions.

Notes

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