THE OXFORD INSTITUTE FOR ENERGY STUDIES

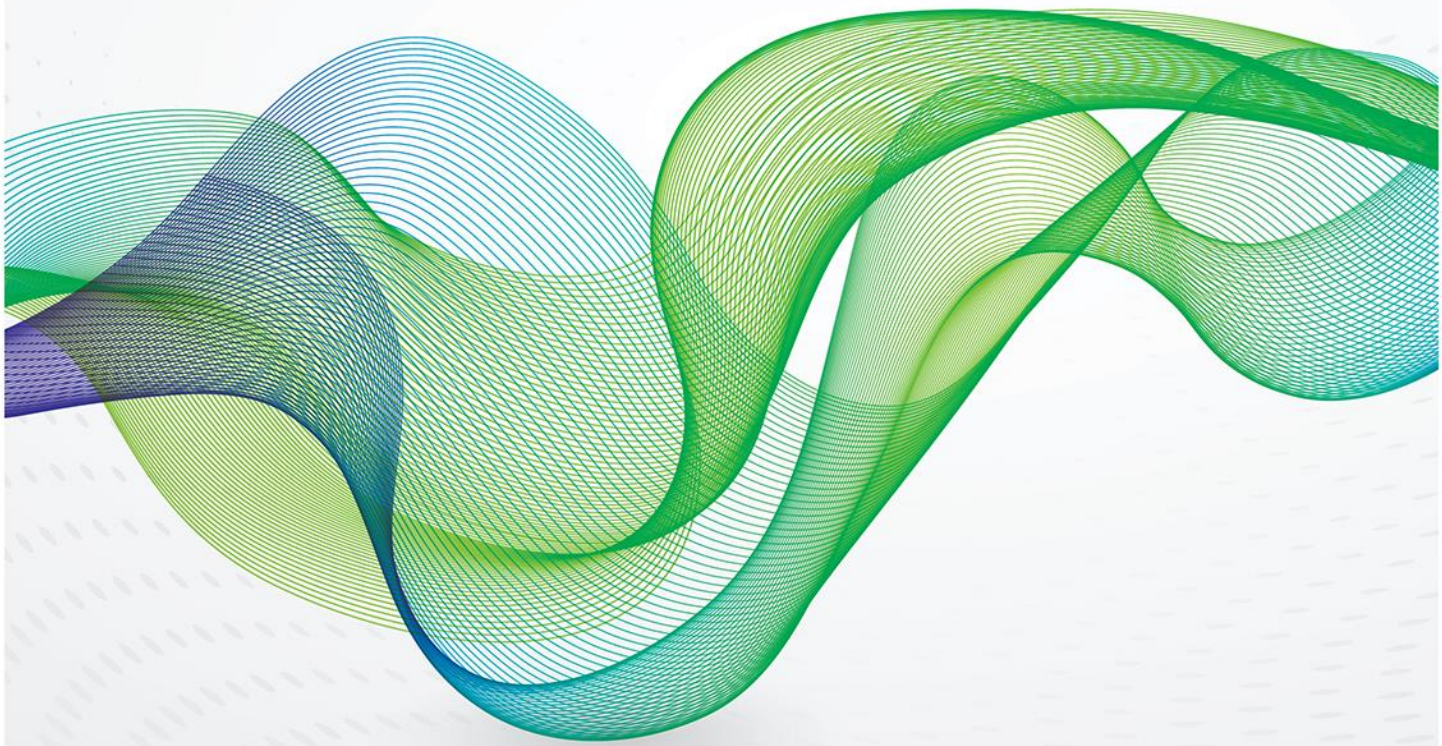
A RECOGNIZED INDEPENDENT CENTRE OF THE UNIVERSITY OF OXFORD

UNIVERSITY OF OXFORD

June 2015

Saudi Arabia Oil Policy:

More than Meets the Eye?



OIES PAPER: MEP 13

Bassam Fattouh and Anupama Sen

ISBN 978-1-78467-032-0

Contents

Figures

Acknowledgements

We would like to thank Ali Aissaoui, Giacomo Luciani, Adnan Shihab-Eldin, John Gault and Amrita Sen for their valuable comments. All remaining errors are ours. We would also like to thank the Kuwait Foundation for the Advancement of Sciences (KFAS) for the research grant.

I. Introduction

The sharp drop in the oil price between June 2014 and January 2015 turned the world's attention to Saudi Arabia's role in the oil market and the determinants of its oil output policy. Initial hopes that Saudi Arabia would come to 'rescue' and 'balance' the market and put a floor under the oil price were, once the kingdom had spearheaded OPEC's decision in November 2014 not to cut output, replaced by stories of 'price wars', 'conspiracy theories', and 'grand design strategies and games' aimed at pushing prices down to achieve some wider geopolitical objectives.[1] This raised a set of fundamental questions: has there been a shift in Saudi Arabia's oil policy? And if the answer is yes, what are the implications of this shift in policy on the short and long run dynamics of the oil market? Has the role of 'swing producer' shifted from Saudi Arabia to the US shale producers?[2] Is OPEC still relevant in the 'new oil order'?[3]

A key objective of this paper is to analyse the behaviour of Saudi Arabia during the latest price cycle, bearing in mind the transformations in global crude oil markets, the changes within OPEC, and the structural features of the kingdom's domestic economy and its energy sector. Given Saudi Arabia's multiple objectives and its limited number of policy tools, the kingdom always faces a trade-off when it comes to its oil output policy. Shaped by changing market conditions, lack of internal cohesion within OPEC, non-cooperation from non-OPEC producers, and the advent of US shale, which introduced many uncertainties with respect to the supply response, the trade-off for Saudi Arabia in the current market context has favoured market share over short-term oil revenue maximization. But Saudi Arabia's conduct is not constant and tends to vary over time;[4] it is therefore premature to exclude the possibility of a reversal in policy if market conditions change or other players show willingness to cooperate on an output cut (though the rapid rise in domestic demand and integration down the energy value chain has limited Saudi Arabia's flexibility and increased the cost of adjusting its crude production both on the upside and the downside). While Saudi Arabia faces the revenue maximization–market share trade-off in the short term, its oil policy is also shaped by long-term considerations such as its investment in the oil sector and the availability of spare capacity, diversification of its economic base, and climate change and energy security policies that affect the long-term demand for Saudi oil and the share of oil in the global energy mix.

[1] For a summary of these views, see Fattouh (2015).

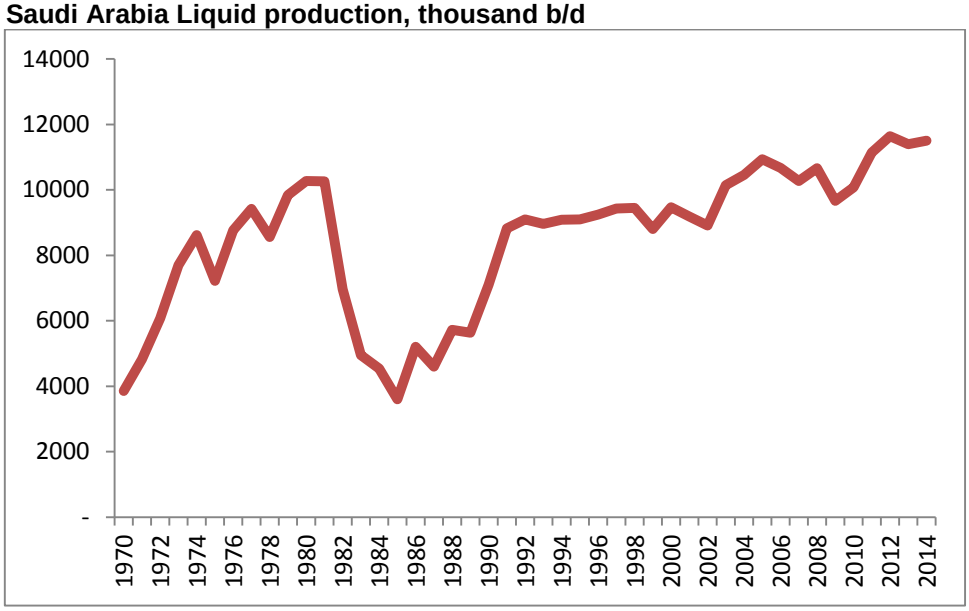
[2] For instance, The Economist (2015) asserts that 'American shale firms are now the oil market's swing producers'.

[3] In 2015, Goldman Sachs published a report entitled 'The New Oil Order: Making Sense of an Industry's Transformation' where it sees the oil market 'moving into an environment that reinforces commodity prices to be lower not higher'. Available at: www.goldmansachs.com/our-thinking/outlook/the-new-oil-order/#overview.

[4] Empirical evidence is consistent with the varying conduct hypothesis. Geroski et al. (1987) find that collusion is rarely perfect and some producers may change their behaviour in response to a rival's previous actions. Their empirical results show that varying-behaviour models tend to out-perform constant-conduct models. Similarly, Almoguera et al. (2011) find many switches between collusive and non-cooperative behaviour in the period 1975–2004, indicating that the ability to collude is not static. These empirical results indicate that changes in oil prices can be explained not only in terms of shifts in oil market balances, but also by changes in the conduct of market players.

Since the position taken by OPEC in controlling the pricing system in 1973 and the abandonment of the administered pricing system in the mid 1980s,[5] Saudi Arabia's role in the oil market has come under close scrutiny. This should come as no surprise. Saudi Arabia holds the second largest oil reserve base in the world; it accounts for a large share of global oil production and crude oil trade; and it is the only country that has an official policy of maintaining spare capacity that can be utilized within a relatively short period of time. Moreover, its production is negatively correlated with that of other OPEC producers and has been highly volatile, despite the fact that Saudi Arabia did not experience the political shocks and outages affecting neighbouring countries such as Iran and Iraq (Nakov and Nuño, 2013; see Figure 1). Given these features, many studies have modelled Saudi Arabia as the 'dominant producer' within OPEC, with the remaining producers (both OPEC and non-OPEC) acting as a competitive fringe.[6] As a dominant producer, Saudi Arabia sets its output in anticipation of the reaction of this fringe and maximizes its profits based on the residual demand.

Figure 1: Saudi Arabia Liquid production, thousand b/d



Source: BP (2015). Includes NGLs.

Despite this prevalent view of Saudi Arabia in the literature, the empirical evidence has not been supportive of the 'dominant producer' model. Smith (2005) finds no evidence in support of a dominant producer and concludes that if Saudi Arabia

> ... has assumed the role of Stackelberg leader, dominant firm, or swing producer, it must not have been pursued with enough vigor and continuity, either before or after the quota system was adopted, to have left a discernible pattern in the data.

[5] For a review of the evolution of the pricing system, see Fattouh (2011a).

[6] See for instance, Salant (1976) and Mabro (1991).

Mabro (1998), who has been a strong proponent of the dominant producer model, acknowledges that against all expectations, from 1992 to the first half of 1997, Saudi Arabia performed the role of a 'fixed volume supplier' that does not vary output according to changes in oil demand.

Rather than acting as a dominant producer, Griffin and Nielson (1994) find evidence that Saudi Arabia opted for a tit-for-tat strategy that punishes members for producing above their quotas and rewards them for compliance. They identify three strategies for Saudi Arabia: the Cournot strategy, the swing producer, and the tit-for-tat strategy.[7] As long as Saudi Arabia earns more than Cournot profits, it will be willing to tolerate deviations from the quota and at times may act as a swing producer to earn profits in excess of the Cournot equilibrium level. However, if cheating becomes flagrant, Saudi Arabia will punish the cheaters by increasing its output until every producer gets Cournot profits. Some have argued that such behaviour is also needed to enforce discipline within OPEC. In contrast to Stigler (1964) – who considers a price war to be a signal of the collapse of collusion – insights from game theory suggest that in the absence of a formal disciplinary mechanism[8], collusion could still work if implicit threats force members to abide by the agreed quotas. In Porter (1983a; 1983b) and Green and Porter (1984), price wars represent the equilibrium outcome of a dynamic non-cooperative game and are the solution to the problems of imperfect information that plague OPEC. They are also a credible means of communicating and signalling to other players – hence price wars can be strategic in nature.[9]

Saudi Arabia's recent decision not to adjust its output to balance the market and to seek market share instead, however, cast doubts on some of the widely held views regarding the kingdom's role in the oil market and on the suitability of the existing theoretical frameworks in explaining Saudi Arabia's output policy. For instance, some argue that Saudi Arabia has abandoned the role of swing producer in favour of US shale producers. Others argue that the kingdom no longer has the ability to enforce

[7] In the standard Cournot strategy, each producer takes the output of the other producers as given and equates the marginal cost with the marginal revenue. In Griffin and Nelson (1994), the Cournot equilibrium sets the floor for the level of profits that Saudi Arabia can achieve if other strategies fail. In the swing producer regime, Saudi Arabia adjusts its production in response to other OPEC members producing above their quotas (i.e. cheating), and hence one would expect to see stable prices in this regime. In the tit-for-tat strategy, Saudi Arabia punishes other OPEC members for producing above the quota and matches their cheating barrel by barrel, resulting in greater price variation than in the swing producer regime.

[8] OPEC has neither a formal monitoring system nor disciplinary mechanisms in place. Violations are therefore not usually detected instantly; even if they are, OPEC is unable to punish, and thus to force, member countries into abiding by the agreed quotas (Kohl, 2002; Libecap and Smith, 2004). These problems become more acute when the required cuts are significant. Widespread cheating and lack of monitoring and disciplinary mechanisms have raised doubts as to whether OPEC is able to cooperate in restricting output, leading some to conclude that the oil market can be best described as 'competitive' (Verleger, 1987).

[9] For instance, in 1998 Saudi Arabia responded to Venezuela's increase in production and rapid capacity expansion by increasing its own output. In a way, Saudi Arabia played the role of the discipliner – succeeding in getting other producers to cut output after prices fell to very low levels. But maintaining discipline in this way is costly and the benefits are not always clear. Furthermore, it may take a long time to forge such an agreement on output cut (Lajous 2015).

discipline within OPEC and thus the organization as a whole has become irrelevant to oil market outcomes.[10]

II. Saudi Arabia's oil policy and the trade-offs

Saudi Arabia's oil policy should not be analysed in isolation of the evolution of global oil market dynamics. It is also fundamentally rooted and shaped by some salient features of its political, economic, and social systems. The key factors that have a direct influence on the kingdom's policy are:

- **High dependency on oil revenues**. Despite various attempts to diversify its economy, Saudi Arabia remains highly dependent on oil revenues (Cherif and Hasanov, 2014; Aissaoui, 2013). Its government continues to play a key a role in the kingdom's development path while government spending, fuelled by oil revenues, remains the main engine behind the growth of its local economy, including the non-oil private sector. Given the central role played by oil in the Saudi economy, the policy objective of maximizing oil revenues will always rank high in any oil output decision.
- **Massive oil reserve base that will be exhausted over many decades**. According to the *BP Statistical Review of World Energy 2015* (BP (2015), Saudi Arabia holds around 267 billion barrels of proven reserves, with a reserve-to-production (R/P) ratio of more than 63 years. Therefore, securing long-term demand for its oil is a key policy objective that should be balanced against other objectives such as higher revenues and higher oil prices. Demand reduction – resulting from high and volatile oil prices and/or oil substitution policies driven by energy security and climate change concerns – constitutes a long-term challenge, especially while Saudi Arabia's continuing attempts to diversify its economic base remain unsuccessful.
- **Saudi Arabia's dominance in oil production and trade**. In 2014, Saudi Arabia produced around 9.5 million b/d and exported close to 7 million b/d of crude oil.[11] The kingdom also produces a wide variety of grades – ranging from the super-light to the super-heavy – and hence can satisfy demand from a wide range of refineries. Given this production and export profile, a presence in key markets such as the USA, Europe, and Asia is important to secure outlets for its crude.
- **Rapid increase in domestic demand**. Over the last few decades, Saudi Arabia's liquid consumption has been growing fast, increasing more than fivefold from 607 thousand b/d in 1980 to 3.185 million b/d in 2014 (BP, 2015) and its GDP growth has become increasingly energy intensive. This can be explained by a number of factors which include: improvements in living standards, diversification into energy intensive industry, and the existence of low and subsidized

[10] See Obaid (2014).

[11] See Saudi Aramco (2014).

fuel, gas, and electricity prices that encourage wasteful consumption (Fattouh and El-Katiri, 2013). The kingdom has also been extending the energy value chain by investing in new refineries and integrating them with petrochemical plants. Satisfying the demand from these new refineries (at least the domestic ones) and its energy intensive industries will affect the kingdom's export capacity, in the absence of investment in new productive capacity. In order to meet the rapid rise in domestic demand while maintaining exports above a certain level, Saudi Arabia has been increasing its drilling activity and ramping its production – 'calibrating' its energy sector to maintain crude production at a level above 10 million b/d. While Saudi Arabia can still adjust its production, the cost of adjustment has become higher and the range within which its output is able to fluctuate has become narrower.

- **The links between oil and gas.** Historically, the bulk of natural gas produced in the kingdom has been of the associated type. Furthermore, key sectors such as petrochemicals still rely very heavily on ethane. This constrains the ability of Saudi Arabia to cuts its production below a certain level, as any cut in crude production will affect the supply of natural gas to the domestic market. This factor is likely to become less important over time, as the share of non-associated gas continues to increase, and as petrochemicals increase their reliance on liquid feedstock such as naphtha (Fattouh, 2011b). But in the short to the medium term, any decision to cut oil output must take account of the potential impact on domestic gas supplies.
- **The availability of spare capacity**. Saudi Arabia is one of the few producers with ample spare capacity that can be used effectively to balance the market in a relatively short period of time. Furthermore, Saudi Arabia is the only country that has an official policy to maintain spare capacity. Therefore, investment and output policy should be geared towards both optimizing the size of its spare capacity (currently estimated at between 1.5 to 2 million b/d) and meeting domestic demand, which has been growing at a fast rate. Neither a very small nor a very large amount of idle capacity is desirable. On the one hand, low spare capacity reduces the ability of Saudi Arabia to calm oil markets in case of disruption. On the other hand, large spare capacity puts downward pressure on oil prices and affects the rate of return on its investment.
- **Political and internal stability.** Being at the heart of a politically unstable region, especially in the aftermath of the Arab uprisings, the objective of maintaining Saudi Arabia's internal stability is of paramount importance. This shapes key economic policies such as the government's spending decisions[12], the pace of economic reforms (including the reform of energy prices), and the kingdom's regional and international relations.

[12] Saudi Arabia has historically overseen large welfare progarmmes, channeling oil and gas revenues into social security, health, education, and the provision of public employment. The kingdom has responded to the upsurge in political turmoil across the region by further increasing social spending. In addition, Saudi Arabia has increased its financial support for some of its ailing strategic partners in the region such as Egypt and Bahrain.

Given these multiple objectives, some of which are short term while others are long term, and also given the limited number of tools available to policy makers (essentially: adjusting output and signalling to the market in the short term, and determining the pace of investment in its energy sector in the long term), Saudi Arabia faces trade-offs with regards to its oil output decisions. One key trade-off is between the objective of revenue maximization vis-à-vis that of maintaining market share and production volumes above a certain level. This trade-off is shaped both by external oil market conditions, cohesion within OPEC, and internal country dynamics. Early models of OPEC approached this trade-off from the point of view of a 'wealth-maximizing rational monopolist'. For instance, the price path of a rationalist monopolist will be higher than the competitive price path, as the monopolist takes advantage of the relatively lower price elasticity in the earlier periods to restrict output and charge a higher price. But at some stage, the monopoly price will fall below the competitive price. This allows the producer to achieve sufficiently large gains to offset the costs associated with cartelization (Pindyck, 1978). However, as noted by Mabro (1991), in practice,

> ... the revenue maximization objective which theory postulates and core producers would dearly like to achieve is not credible. [Instead, producers have to] become content with a second best: to obtain through the pricing policy more revenues than would have accrued under a competitive market structure. This more may be much better than nothing but is likely to be very different from the optimum. (Mabro, 1991).

It is in this context of 'second best', trade-offs, imperfect information, and wide uncertainty introduced by a new source of supply, that this paper attempts to explain the behaviour of Saudi Arabia in the current price cycle.

III. Saudi Arabia's oil policy over the 2014–2015 price cycle

The 2014–2015 oil price cycle has generated much speculation about the drivers of Saudi Arabia's oil policy. Some explanations are based on the premise that Saudi Arabia is not concerned about a lower oil price, or that it even favours a low price policy in the current context, in order to achieve wider geopolitical objectives. One view that has gained some traction is that Saudi Arabia is driving the price down in order to put pressure on the oil export-dependent Russian and Iranian economies. But such an explanation is problematic. Since the oil embargo in 1973, Saudi Arabia has not used oil as a political tool;[13] in recent years it has taken pride in the fact that decisions related to production and investment in the oil sector have been based solely on commercial considerations, independent of any US influence. Furthermore, one should question the effectiveness of oil as a political weapon and whether a squeeze on the oil revenues of either Russia or Iran could induce a radical (or even a slight) shift in the foreign policies of these countries. But more importantly, such explanations ignore some basic features relating to the Saudi economy. As mentioned previously, Saudi Arabia's dependence on oil revenues remains high, while its spending commitments at both the domestic and

[13] There are milder versions of this view. For instance, some argue that while Saudi Arabia no longer uses oil as a political weapon, the kingdom subtly wields it as an instrument of foreign policy to enhance its political influence.

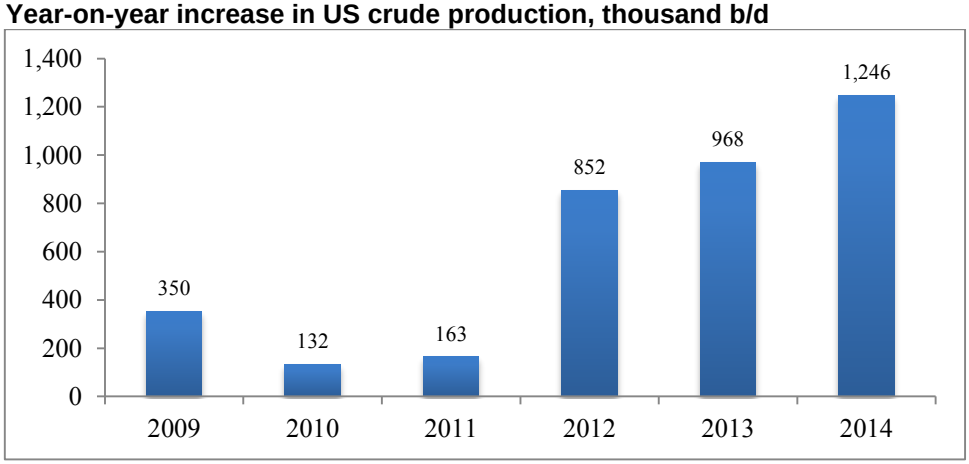
regional level continue to rise, especially in the aftermath of the Arab uprisings. Therefore, a policy of deliberately pushing prices down would cause self-harm.

In fact, just before oil prices started falling, Mr Ali-Naimi, the Saudi oil minister, declared in May 2014 that:

> One hundred dollars is a fair price for everybody – consumers, producers, oil companies.[14]

However, at this relatively high and stable 'fair price', strong supply and demand responses were becoming more visible. On the supply side, US production was increasing at a phenomenal rate, with 1.2 million b/d of crude oil (including lease condensate) being added in 2014 (see Figure 2). On the demand side, between 2011 and 2014, global growth in oil demand continued being revised downwards, reflecting weaker economic prospects and higher oil prices. In June 2014, the IEA projected a global oil demand growth of 1.4 million b/d for 2014. By December, the IEA had lowered its projection by more than half for 2014.

Figure 2: Year-on-year increase in US crude production, thousand b/d



Source: EIA

Despite the increased visibility of these demand and supply responses, the last few years have seen no proactive Saudi oil policy aimed at bringing prices down. Instead, as shown by the Saudi oil minister's comments reported above, Saudi Arabia validated the $100 oil price environment by signalling the fairness of such a price to the market. This reflects a clear asymmetry in oil policy response: prices need to rise to extremely high levels (levels that could threaten demand growth and the health of the global economy) to provoke a proactive Saudi response. One demonstration of this was seen in the first half of 2008 when prices hit close to $150, and then again in early 2012, when oil prices increased sharply as concerns over US-Israeli attacks on Iran intensified.[15] It is interesting to

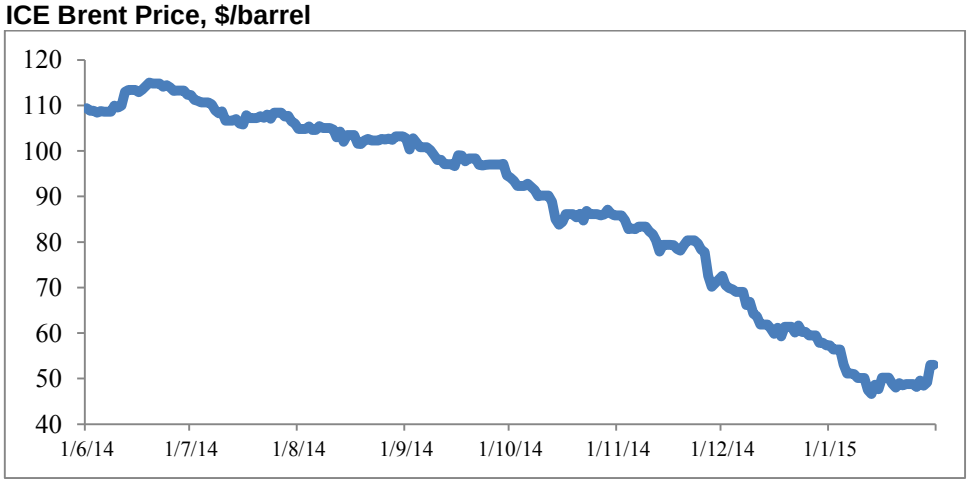
[14] Reuters, 'Saudi Arabia, OPEC would cover for any Ukraine-related oil shortage – Naimi', 12 May 2014.
[15] In an unusual event, the Saudi Oil Minister Mr Ali Al-Naimi wrote an editorial in March 2012 arguing that 'high international oil prices are bad news. Bad for Europe, bad for the US, bad for emerging economies and bad for the world's poorest nations. A

note that during these episodes of sharply rising prices, Saudi Arabia communicates its 'concerns' without any coordination with OPEC, reflecting both the difficulty of getting other OPEC members on board in a rising market and the fact that the other OPEC countries are producing at maximum capacity and hence have no power to influence the market.[16]

(i) The loss of a feedback mechanism and implications for the oil market

As oil prices started falling from June 2014, the world's attention turned to OPEC and its dominant player Saudi Arabia. Expectations that Saudi Arabia would come to 'rescue' and 'balance' the market by adjusting its output shaped market expectations and provided some support for the oil price. Although oil prices continued to fall from their peak in June 2014, the initial decline was moderate and the Brent price was still trading at $100/barrel at the beginning of September 2014 (see Figure 3). OPEC's decision not to cut output in its November meeting, in favour of leaving it to the market to find the new equilibrium price, resulted in the revision of market expectations about a key feedback mechanism in a falling market; this affected sentiment, causing a sharp decline in the oil price. Between 26 November 2014 (the day before the OPEC meeting) and mid January 2015, the Brent price fell by more than $30 per barrel.

Figure 3: ICE Brent Price, $/barrel



Source: Reuters

period of prolonged high prices is bad for all oil producing nations, including Saudi Arabia, and they are bad news for the energy industry more widely' and that Saudi Arabia 'would like to see a lower price. It would like to see a fair and reasonable price that will not hurt the global economic recovery, especially in emerging and developing countries'. See Naimi (2012).

[16] This is to be expected, as OPEC consists of a group of countries with different oil reserve bases and divergent political, social, and economic systems. To account for this fact, some models split OPEC members into subgroups based on their time preference and endowment. For instance, Eckbo (1976) splits OPEC into three groups: hard core, the price pushers, and the expansionist fringe. He finds that countries with low discount rates and high reserve bases will choose a lower price path than the price pushers. In similar vein, Hnyilicza and Pindyck (1976) divide OPEC into savers (countries with low discount rates) and spenders (countries with high discount rates) and analyse the interaction between these two groups using the theory of cooperative games.

While lower prices help stimulate oil demand and potentially slow the pace of oil supply growth (including leading to some projects being delayed or postponed), these effects tend to take time to filter through to oil market balances. Cuts by OPEC (and supply disruptions) still constitute the quickest and most effective mechanism that feeds through directly to oil market balances. On the downside, market perception of the loss of 'OPEC feedback' has a range of implications for oil market dynamics. If there is no quick mechanism to balance an oversupplied market, the market can only balance through demand and supply adjustments in response to changes in oil prices. Given the low short-run price elasticity of supply and demand, the adjustment is not immediate; supply continues to exceed demand, causing inventories to build up and putting downward pressure on oil prices. The high degree of uncertainty, together with different market expectations about timing and magnitude of supply and demand responses, can also induce volatility. Oil prices can thus become more prone to undershooting if the market overestimates the size of the over-supply and/or if there are concerns that the available on-land and floating storage facilities are not big enough to absorb all the extra crude coming into the market.

The decision to 'leave it to the market' also has long-term implications for the investment environment. The fact that prices could, in the future, fluctuate widely implies that the perception of risk in investing in oil projects has changed. In addition to the high oil price environment,[17] the stability of price within a narrow range between 2011 and mid 2014, and the implicit expectation that OPEC would put a floor on the oil price (and in effect guarantee the rate of return on investment in new energy projects) encouraged investment in new projects and the entry of new players into the market. Increased volatility, together with the perception that prices could fluctuate within a wide range, can cause investors (including national and international companies) to reassess the risks in new energy projects, discouraging overall investment and increasing the value of the option to wait. Thus, from Saudi Arabia's perspective, price volatility can accelerate the investment and supply response. However, higher volatility and sharper swings in oil prices also accelerate demand responses and have adverse impact on the domestic economy given its heavy reliance on oil revenues.

(ii) Saudi Arabia does not swing alone

All oil exporting countries are aware of the fact that in the face of a fall in the oil price caused by *ex ante* excess supplies, co-operation on the output front is the most effective way to reverse the price decline. There is rarely disagreement on this general principle, but disagreements usually arise over which countries should shoulder the burden of the cut. It has long been the case that non-OPEC countries leave it to OPEC to implement cuts. In turn, many within OPEC would like to leave it to Saudi Arabia to shoulder the burden (Mabro, 1998).

[17] The rapid increase in the oil price between 2003 and mid 2008, the quick recovery of the oil price following the 2008 financial crisis, together with technological innovation, encouraged investment and the entry of new sources of supply (such as shale) into the market.

The expectation that Saudi Arabia would balance the market on its own is somehow surprising, as the kingdom has made it very clear on many occasions that it will not cut output unilaterally. As Mabro (1998) notes:

> Saudi Arabia's willingness to cut output on its own to influence the course of oil prices could not be taken for granted.

In fact, following the price collapse in 1985, nobody should realistically expect Saudi Arabia to act as the sole 'swing producer'. Between 1973 and 1985, OPEC exercised the ultimate pricing power by setting the marker price, but in doing so it had to live with variable volumes of production. With the continued decline in demand for its oil, OPEC saw its share in the world's oil production fall from 51 per cent in 1973 to 28 per cent in 1985. Under this pressure, disagreements within OPEC began to surface. Saudi Arabia lost market share with every increase in the marker price and hence opposed price increases. Other OPEC members pushed for large price increases – while at the same time putting additional oil in the market in an attempt to boost revenues. OPEC's introduction of a formal quota system proved to be ineffective in preventing production from rising above quotas (in other words 'cheating') and it was becoming clear by the mid-1980s that the organization was losing its power to set the oil price. Saudi Arabia's attempts to defend the marker price resulted in a huge loss of market share: the demand for Saudi oil declined from 10.2 million b/d in 1980 to 3.6 million b/d in 1985. This decline in production volumes and loss of market share proved to be very costly for Saudi Arabia, which decided to abandon the administered pricing system in 1985, allowing the country to recover its lost share through the netback pricing system,[18] which provided oil companies with a guaranteed refining margin even if oil prices were to collapse. Under this system, refineries had the incentive to run at a high capacity, which led to an oversupply of petroleum products, forcing down the crude oil price. The price war that followed led to the collapse in crude oil prices.

In this current cycle, Saudi Arabia realized that key OPEC members (such as Iraq, Iran, and Venezuela) and non-OPEC producers (such as Russia and Mexico) were not willing or able to share the burden of the cut necessary for market stabilization. On the contrary, some producers (such as Iraq, Iran, and Russia) have indicated that they will continue to place more barrels in the market. Saudi Arabia thus opted to leave it to the price mechanism to clear excess supplies. For Saudi Arabia (as well as for other GCC producers such as the UAE and Kuwait), there was real concern that any cut in their production would have been offset by an increase in production from within and outside OPEC; this would have only a limited impact on prices, thereby defeating the purpose of cutting production. The ultimate nightmare for any exporter is a reduction in both its market share and its revenues.

[18] Netback pricing involved a general formula in which the price of crude oil was set equal to the *ex post* product realization minus refining and transport costs. A number of variables had to be defined in a complex contract. This included: the set of petroleum products that the refiner could produce from a barrel of oil, the refining costs, transportation costs, and the time lag between loading and delivery (Mabro, 1986).

Furthermore, Saudi Arabia has been facing tough competition in its key markets as a result of the shifts in crude oil and petroleum products trade flows caused by the increase in US oil production (Fattouh, 2014). Reductions in US imports have meant that many traditional exporters to the USA from West Africa and Latin America have had to find new markets, mainly in Asia. In order to maintain its market share in this, the fastest-growing region, Saudi Arabia has had to compete more aggressively in Asia – not only with producers from outside the region, but also from producers within the region (such as Iran, Iraq, and Kuwait) which are also targeting Asian markets.

Internal factors also played a role in the decision to 'leave it to the market'. Saudi Arabia is in a relatively better financial position to withstand lower short term prices than many other oil exporters. Over the last few years, the kingdom has accumulated large foreign assets of more than $700 billion (EIA, 2015) and its debt is quite small both in terms of absolute value and relative to GDP; its capacity to borrow from domestic banks and international financial markets is therefore large.

The advent of US shale has also generated a new set of challenges, making the calculus of the trade-off between increasing market share and maximizing revenue more difficult and highly uncertain. These uncertainties relate to a number of dimensions: the price elasticity of US tight oil supply; the breakeven cost below which production will start falling; and whether the growth slowdown would follow a linear or non-linear path. The key uncertainty is the degree of elasticity of the US tight oil supply curve, especially in a rising market. If the supply curve proves to be highly elastic, then this will put a cap on the oil price, as any increase in the price above a certain threshold would generate a strong supply feedback. In such a context, Saudi Arabia's actions to defend the oil price would have limited success; any cuts to its own production would be offset by an increase in US shale production, especially as US shale producers have the incentive to hedge their production at higher prices. An understanding of both the US shale supply response and the marginal cost of this new source of supply is of paramount importance for a key player such as Saudi Arabia.

(iii) The trade-off and US shale

Thus, shaped by changing market conditions, lack of internal cohesion within OPEC, and the advent of US shale (which has introduced many uncertainties to the supply response), the trade-off for Saudi Arabia in the current market context has favoured market share over short-term oil revenue maximization. In other words, while the structural features of the Saudi domestic economy imply that maximizing revenue remains a key objective, this should be balanced against the objective of maintaining volume above a certain threshold in order to avoid losing market share and being left with high idle capacity. Such consequences would be especially significant given the large investments that the kingdom has undertaken in its energy sector in the last few years. In 1985–1986, the relevant trade-off in the circumstances of the time favoured volume over price, after volumes went down to unacceptable levels. In 1998, the trade-off eventually favoured price over volume, given that the very

negative impact of abysmally low prices on revenues induced an agreement on collective cuts from both OPEC and non-OPEC producers.[19] From Saudi Arabia's perspective, keeping market share whatever the cost is not set in stone; its policy can change depending on market circumstances and the behaviour of other market players. The kingdom's oil policy is flexible and its preferred 'oil price' remains a moving target depending on oil market conditions. This explains why over the last few years the preferred price continued to drift upwards from $20, to $60, to $75, and most recently to $100.

While the current strategy of maintaining market share will entail the short-term pain of falling oil revenues, it may lead to a gain in market share in the longer-term, as production in high-cost non-OPEC producers starts to slow down in response to lower prices. Given that the costs incurred in the development of oil fields are sunk and given the low marginal cost of production, existing fields (including deep offshore) will continue to produce even in a low-price environment – in other words, the oil supply is relatively inelastic to changes in price. Deep cuts in capital budgets will eventually shrink the upcoming project pipeline start-ups, tightening up the growth of future supplies in the process, but their impact is not immediately felt on market balances. US tight oil, however, has introduced a new dynamic to the supply picture. Unlike conventional production, the investment cycle is shorter and US tight oil supply is by far more responsive to price movements. The recent fall in the oil price has resulted in a sharp decline in the number of rigs in the USA (falling by more than half in matter of months, see Figure 4). While US shale production did not respond immediately to the fall in the number of rigs, the high decline rates in tight oil wells imply that slowdown in production will occur within shorter lags, helping to shape market expectations. In fact, the current downward cycle has revealed some interesting features of US tight oil production that are worth highlighting:

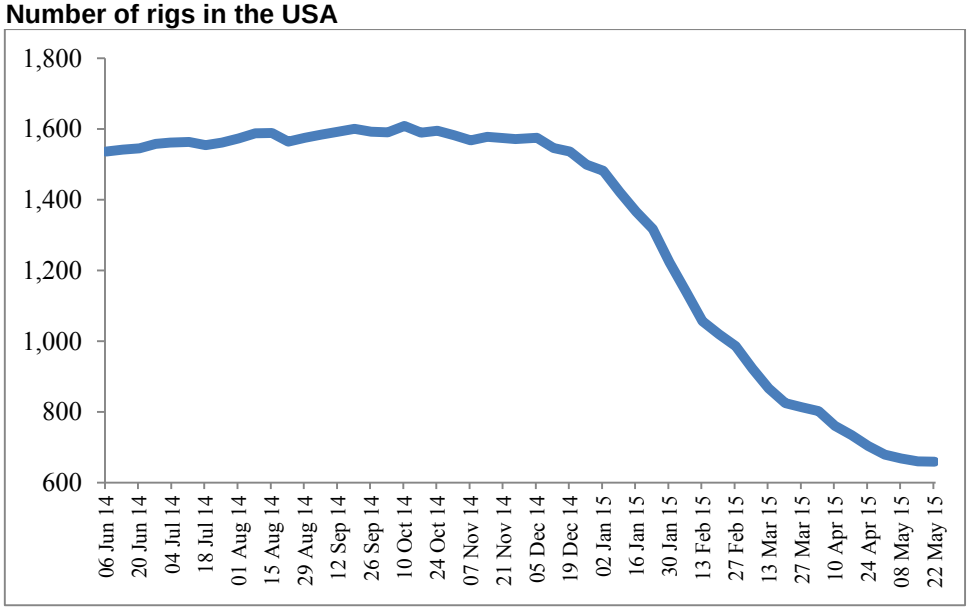
- The US tight oil industry is highly responsive to low oil prices; this is reflected in the sharp fall in the number of rigs and the large cuts in capital expenditure announced by the US shale producers.
- The relationship between the fall in the number of rigs and the fall in production is not linear; the distribution of oil rig productivity is highly skewed, with lower yielding rigs being shed first and remaining rigs being targeted towards the more productive 'sweet' spots.
- During the downturn, US shale producers have shown the ability to achieve strong efficiency gains and to renegotiate contracts with service providers; this implies that the break-even cost is highly variable and lower than initially expected.
- Unlike conventional fields, the decline rates in tight oil wells are very steep. Given the high decline rates of tight oil wells, the fall in the number of rigs will ultimately result in slower

[19] For more details, see Mabro (1998), Lajous (2015).

output growth as legacy declines from existing wells outweigh the supply growth from new wells, but this occurs with a lag of months.

- Given the high decline rates, the only way to increase production is to drill hundreds of new wells. This requires large increases in capital expenditure, which over the years have been financed by the accumulation of large amounts of debt by US shale producers. Therefore, in addition to production economics, US shale may be affected by other factors, including the cost of debt and the willingness of financial investors to roll-over existing debts and extend new lines of credit. US shale producers have proven to be more resilient than originally thought and despite weaker financial performance, financial investors continued to rollover credit to US shale companies; hence the disruptive impact from financial markets has not yet occurred.

Figure 4: Number of rigs in the USA



Source: Baker Hughes, Energy Aspects

Key uncertainties, however, remain over how quickly US tight oil production can respond to higher prices, and at what price level the decline in the rig count will be reversed. There are very divergent views regarding the strength of US supply feedback in a rising market. There are those who believe that the supply response would be quick and strong, putting a cap on the oil price. They point to a number of supporting factors such as: the availability of a large backlog of drilled but unfracked wells which can be brought into production fairly quickly, and the ability of shale producers to hedge their production at a higher oil price. In contrast, there are those who believe that (similar to the pattern followed in the downward phase of the cycle) US tight oil supply will respond to higher oil prices, but with substantial lags. The lagged response will be influenced by factors such as: the speed at which rigs can be redeployed, the increase in number of rigs needed to offset the decline rates, financial

investors' perception of risk and their willingness to extend new lines of credit, and the speed at which shale companies can rehire laid-off workers.

IV. Saudi Arabia's oil policy in the long term

While the trade-off between volume and revenue objectives will shape Saudi oil policy in the short term, long-term challenges will also be posed by the size of the kingdom's reserves, the high reliance on oil revenues, and the difficulty of diversifying the economy away from oil. In this context, three issues deserve special attention: investment (and hence the size of available spare capacity), diversification of the economy by integration down the energy supply chain, and climate change policies and their impact on long-term demand for Saudi oil.

(i) The investment and spare capacity question

In addition to its ability to adjust output, Saudi Arabia can decide on how fast to develop its reserves (thus affecting the size of future supplies coming to the market) given the large size of its reserve base, the relatively low cost of developing these reserves, and its stable investment environment. The fact that the cheapest reserves at the global level are not being developed first creates a market structure in which both low-cost producers and high-cost producers coexist, with implications for oil price behaviour. The oil price can clear within a wide range, depending on oil market conditions: the lower boundary of the range is set by the cost of production of the low-cost producer, whereas the upper boundary is set by the potential entry of substitutes and new supplies. When the market is characterized by excess demand (*ex ante*), potential substitutes and adjustments in demand cannot place a cap on the short-term price. Instead, in the absence of spare capacity, most of the adjustment is likely to occur through sharp increases in oil prices. Thus, when Saudi Arabia is producing at or close to its maximum capacity, it has little ability to influence the price. When the market is characterized by excess capacity, the oil price tends to move toward the lower boundary. Furthermore, in such a market, the ability to collude with other producers weakens[20] and thus prices can fall below the collusive outcome. Therefore, Saudi Arabia's decision to invest and increase capacity is linked to a key trade-off. On the one hand, idle capacity should not be so small that Saudi Arabia runs the risk of losing control of the market on the upside, with the risk of higher and more volatile prices causing demand destruction. On other hand, idle capacity should not be so large that it affects its revenues by putting downward pressure on the oil price.

In the current context of increased uncertainty, Saudi Arabia has no incentive to increase its oil productive capacity from the current level, and new investments will only be made to replace declines

[20] Haltwinger and Harrington (1991) find that under certain assumptions of constant and symmetrical marginal costs, a firm's incentives to deviate are stronger when future demand is falling: the value of the foregone collusive profits is smaller when demand is falling than when it is rising. Thus, according to their model, it is more difficult to sustain collusion when demand is falling.

in existing fields.[21] Factors such as policies aimed at reducing oil demand, and the potential of tight oil growth in the USA and other parts in the world, are generating a high degree of uncertainty regarding the 'call on Saudi crude', increasing the value of the 'option to wait' until some of the key uncertainties are resolved (Dixit and Pindyck, 1994). Given the rapid growth in its domestic demand especially during summer months (Fattouh, 2013) and the plethora of supply disruptions, there is the risk that Saudi Arabia's spare capacity would be eroded over time. On the other hand, the price environment provides the kingdom with an opportunity to reform its domestic energy subsidies, thus arresting the rapid growth in domestic demand to make more oil available for exports. However, there are as yet no signs that such a reform will occur any time soon, and the focus has been on enhancing energy efficiency instead. Saudi Arabia is also focusing on developing its gas reserves to increase the share of gas in the domestic economy in the longer term, also potentially freeing up oil for exports (Fattouh, 2011b).

While there is a wide belief that the US shale producers can replace Saudi Arabia as the swing supplier, recent evidence suggests that US shale response to price movements is subject to many lags and uncertainties and hence the adjustment is far from smooth. In a falling market, the number of rigs will fall but it will take many months before the impact is felt on production. In a rising market, the speed at which US shale output recovers is yet to be seen. Furthermore, unlike Saudi Arabia, the decision to increase or decrease US shale output is decentralized across many private producers with different production profiles, different balance sheets, and varying degrees of financial strength.[22]

(ii) Downstream integration and diversification

In recent years, Saudi Arabia has accelerated its efforts to capture more added value through vertical integration into refining and petrochemicals, adding two new refineries with capacity of 400,000 b/d each in the last two years, and having plans to build another 400,000 b/d refinery (expected to come on-stream by 2017). This will take the kingdom's total refining capacity to more than 3 million b/d by the end of this decade. Saudi Arabia has also been investing in refining assets in key markets in Asia.

In addition to satisfying its growing domestic demand, investment in refining is still considered by many policymakers to be a key step towards achieving the broader goals of diversification and job creation. This is not simply because refining creates added value by converting crude oil into refined products, but also because refining establishes the link between the upstream sector and

[21] In a 2013 interview, the Saudi Oil Minister, Mr Ali Al Naimi stated that the 'decision to increase capacity (completed in 2008) was made after thorough analysis of supply and demand factors, and clearly our decision was timely. Today, we do not see a case for further expansion of our production capacity. We expect additional supplies to come online from North America, Latin America and Iraq among others. Plus, and this is a vital point to keep in mind, there is no demand growth in OECD countries'.

[22] In addition, given the small reserve base of US shale, especially when compared to Saudi Arabia and OPEC, the US is not expected to play the role of the swing producer over the medium to long-term. For instance, in its Energy Outlook to 2035, BP expects US tight oil to continue to grow, but most of the growth will be concentrated in the period up to 2020. From the middle of the next decade onwards, tight oil supply growth is expected to slow down while the call on OPEC will start to rise.

petrochemicals;[23] this in turn provides opportunities for diversification and downstream integration into the full value chain, including the development of new industries.[24] Critics of this policy, however, suggest that such forward linkages reinforce, rather than mitigate, the kingdom's dependence on energy and given that these projects are highly capital intensive, they do not generate a large number of jobs (Aissaoui, 2013). Such a development strategy also encourages the emergence of very large vertically integrated state-owned companies, rather than the small and medium enterprises (SMEs) which represent a major source of job creation in many parts of the world.

Regardless of the arguments for and against diversification through downstream integration, the recent expansion in refining capacity will have important implications on global crude and oil petroleum products trade flows. In addition to crude markets, Saudi Arabia will also be competing in petroleum products and specialty product markets. These are intrinsically very different from crude oil markets, given the different specifications of the products and evolving regulations in international markets. This trend also involves a partial shift in the customer base from refiners to retailers. While refiners enjoy much greater flexibility and discretion in sourcing their crude, retailers are more likely to rely on a customary supplier, as long as conditions are competitive. Diversifying through downstream integration will also affect the allocation of crude between domestic refineries and export markets, which will affect the kingdom's position in the crude market. If Saudi Aramco tries to supply all the crude that is necessary to run their refineries to full capacity, this would imply that the volumes of crude available for export would be reduced, in the absence of new investment in productive capacity. The fact that joint refineries outside the kingdom can source crude from alternative sources provides the kingdom with some flexibility in its output policy.

(iii) Climate change policies and the long-term demand for oil: risks and potential responses

Government policies driven by energy security and climate change concerns, and geared towards substituting away from oil, pose a long-term challenge for Saudi Arabia. On the one hand, the physical impacts of climate change on the arid Gulf region are well recognized. Climate change is likely to lead to stresses on water supply, particularly reductions in deep aquifer recharge due to lower levels of rainfall and a rise in temperatures (Chowdhury et al., 2013). The region is further vulnerable to the indirect impacts of climate change – such as increased food insecurity and substantially higher food import bills. Water stresses and increases in surface temperatures are likely to impact upon the costs of production of hydrocarbons, as governments need to spend more on hydrocarbon installations to adapt to the changing climatic environment within which they operate.

[23] Saudi Arabia has a clear policy of establishing a leading position as one of the largest producers of petrochemicals and has earmarked $91 billion to be spent over the next 10 years to build new plants, expand existing ones, and integrate refineries with new or existing petrochemical units (*Saudi Gazette*, 23 December 2014).

[24] In addition to increasing feedstock availability, the use of refined products provides opportunities to produce more sophisticated petrochemical products that are needed to extend the value chain.

On the other hand, climate change mitigation measures – primarily those targeted at reducing global dependence on fossil fuels – also pose a risk, given the Saudi economy's stage and structure of industrialization, and its dependence upon oil revenues to support the country's development. Arguably, the potential impact of climate change measures on the demand for the kingdom's oil has more immediate relevance for its policymakers. From a fiscal point of view, as a large oil exporter, Saudi Arabia's ability to collect revenues is at stake; these revenues have kept and will continue to keep its economy running until such time as alternative industries have been developed.

From OPEC's perspective, taxes on petroleum products and oil substitution policies are seen as discriminatory, tending to dampen oil demand growth, and reducing the oil share in the energy mix in the long term. Taxes also raise a distributional issue since consuming countries can capture part of the rent – in most cases this part is larger than the share extracted by OPEC producers themselves – through taxation (Fattouh and van der Linde, 2011). Another central issue in this debate is that of 'unburnable carbon' – it has been estimated that if the probability of warming by 2 degrees or more is to be kept below 50 per cent, approximately 60–80 per cent of booked fossil fuels are unburnable (Collier and Venables, 2014). 'Unburnable carbon' has significant implications for resource-rich economies that are currently on a trajectory towards industrialization and economic development. Consequently, the issue has been explored through different angles in the economic literature. One line of argument postulates that countries that are highly dependent upon the burning of carbon to sustain their growth and/or economic development trajectories should receive some form of compensation for the adverse impacts of mandatory climate change mitigation measures that affect them. This relates not just to the principle of 'common but differentiated responsibilities' that has been actively propagated by country groupings such as the G77, but also to the more indirect economic impacts that will result from a reduction in demand for carbon-releasing fossil fuels, which form the backbone of these countries' export-based economies. Another, more nuanced, argument states that there are potentially large gains from a mechanism which selects for extraction only those reserves that maximize the net social benefit per unit of CO_2 emitted. This argues that coal is the predominant fuel that should remain unburnt as its emissions are 30–40 per cent higher than those of oil, and nearly twice those of natural gas; coal also generates lower economic rents and hence smaller losses if it is left in the ground (Collier and Venables, 2014).

A key policy issue is whether Saudi Arabia can mitigate the impact of climate change policies through its investment and output policy:

- Saudi Arabia can divert a larger part of the rent by raising oil prices today. Since the easiest oil demand is substituted first, the oil demand remaining is highly inelastic. This could allow Saudi Arabia to restrict its output and increase the oil price to take full advantage of the captive residual oil demand. High oil prices, however, accelerate the pace of demand reduction and may induce

consuming governments to pursue oil substitution policies more aggressively. They could also encourage supply growth in other parts of the world.

- Saudi Arabia could accelerate its investment pace and increase production to put downward pressure on the oil price in order to induce a rebound in global demand and drive out non-OPEC supply. However, there are doubts about the effectiveness of such a policy on increasing revenues. For instance, using simulation analysis, Loulou et al. (2008) show that OPEC would derive no advantage from flooding the oil market, even if all announced climate change policies were fully implemented, since its own net revenues would decrease in such an event. Simulation results also show that OPEC's profits would be lower in a world of effective climate change policies and that there is only limited scope for OPEC to defend its oil revenue by adopting a price strategy consistent with significant production restraint (Ghanem et al., 1999; Loulou et al., 2008).

Given the limited effectiveness of such investment and output policies, Saudi policymakers recognize that diversifying their economies and income sources should be a top priority. While Saudi Arabia is preparing for a future where energy demand is likely to shift towards renewables, there is still a strong belief that oil and gas will continue to play an important part in the global energy mix. OPEC's 2014 World Oil Outlook indicates that the world will need to find an additional 21 million b/d of crude over the next 25 years to meet global demand. Given the low cost of its reserves and its history as a reliable supplier, Saudi Arabia expects to play a key role in meeting this demand growth.[25]

V. Conclusions

This paper has discussed how Saudi Arabia's output policy has not been uniform over the years and how it has been shaped by many factors which include: changing oil market conditions, interaction with other OPEC producers, and internal country dynamics. Nevertheless, it is possible to discern some general trends, which can help explain Saudi Arabia's behaviour during past cycles and, more importantly, help anticipate its output policy in future cycles.

- Maximizing revenues will always rank high in the formation of Saudi Arabia's output decision, but this objective should be balanced against another objective of maintaining output above a certain level and maintaining its share in key markets. The trade-off between these two objectives tends to change over time depending on market conditions, the nature of the shock, and the behaviour

[25] Given that fossil fuels are expected to continue to play a role in the energy mix, Saudi Arabia has been supportive of carbon capture and storage (CCS) and considers the technology as an effective tool to minimize climate change. See for instance the speech by Saudi Oil Minister Ali Al-Naimi delivered at the UN Climate Summit in New York. Saudi Arabia has been investing in CCS technologies (for instance, Saudi Aramco is currently investing in the Uthmaniyah CO2- Enhanced Oil Recovery (EOR) Demonstration Project which will capture and store approximately 800,000 metric tons of CO2 per year from a natural gas production and processing facility), though such investments remain limited, and Saudi Arabia is yet to establish leadership in this area.

of other producers; hence Saudi Arabia's output policy is not constant. With the advent of US shale, Saudi Arabia has entered unchartered territory where it is still learning about a new source of supply and its responsiveness to price signals. This has made the calculus of the trade-off more uncertain. As Saudi Arabia learns more about this new source of supply, its policy will adapt accordingly. This highlights the importance of relying on dynamic models that allow for changes in Saudi Arabia's behaviour. Attempts to fit Saudi Arabia into one category have failed in the past and would most likely fail in the future, as its output policy is constantly evolving.

- The fact that Saudi Arabia's oil policy could be subject to change will keep the market second-guessing and will continue to shape market expectations and influence prices. This, however, will reduce its signalling power. For instance, in the past, Saudi Arabia has sent market signals about its preferred price or price range, but these were moving targets and most of the time they tended to validate the prevailing market conditions. Over time, such pricing signals will become less effective as the market will consider these moving price targets as 'cheap talk' (Fattouh, 2007).
- Saudi Arabia's behaviour has been asymmetric during price cycles. In the case of a disruption, or in a rapidly rising market, it is willing to fill the gap without any coordination with other OPEC members, but in a weak market, it is not willing to cut output unilaterally. In the current cycle, Saudi Arabia is not opposed to cuts to balance the market and support the oil price, but these cuts have to be implemented collectively with other producers both from within and outside OPEC (though Saudi Arabia is very well aware of the difficulties involved in reaching and implementing an agreement to cut output in the current cycle). The market should not expect Saudi Arabia to play the balancing role by itself. Furthermore, while the kingdom can still adjust its output, this has become more costly and its output is likely to fluctuate within a narrower range than was seen in previous cycles.
- Saudi Arabia will continue on its drive towards downstream integration, which is likely to affect its position in both crude and products markets in the longer term. As it starts exporting more refined and petrochemical products and less crude, Saudi Arabia will have to adapt its output policy and marketing strategies, as the nature of the competition in the two markets is very different. The kingdom will also have to optimize the supply of its crude to its own refineries and export markets, adding an additional constraint on its output policy and hence its ability to shape market expectations as a 'refiner'. Traditional tools as such as quotas in production will become ineffective as competition shifts to the products market.
- In the current cycle, there is a perception that OPEC (or Saudi) feedback has been lost (and for some observers it is a thing of the past). Perception of the loss of 'Saudi feedback' on the downside implies that oil prices are likely to become more prone to undershooting – sharp adjustments in oil prices may therefore become more frequent. Increased volatility, together with the perception that prices could fluctuate within a wide range, can cause investors to reassess the

risks in new energy projects, discouraging overall investment and increasing the value of the option to wait.

- Faced with a high degree of uncertainty, Saudi Arabia will be reluctant to invest in new capacity. Given the rapid rise in its domestic demand and the increased risk of disruptions in many parts of the world, the availability of spare capacity should not be taken for granted. This poses a key challenge for Saudi Arabia. Given the size of its reserve base, securing long-term demand for its oil is key for the sustainability of its economy. Higher and more volatile prices do affect demand patterns and hence Saudi Arabia has the incentive to maintain enough spare capacity to keep a lid on the oil price. Low spare capacity will also limit the kingdom's ability to use production policy to enforce discipline among producers if needed.[26] On the other hand, investing in idle capacity is costly and high spare capacity tends to be associated with weaker oil prices. Getting the balance right will prove very challenging in the current context. US shale producers will not be able to play the role of swing producer as effectively as Saudi Arabia, as their adjustment in falling and rising markets is far from smooth.
- While climate change policies aimed at substituting away from oil pose a threat to its long-term development strategy, there is a strong belief among Saudi policymakers that oil will continue to play a role in the world's energy mix and that Saudi oil will be competitive in a 'carbon constrained' world. There is a clear recognition of the fact that in the face of climate change policies, diversification of the kingdom's economic base and income sources remains the only viable long-term response.

[26] In addition to economic considerations, Saudi Arabia may also wish to maintain spare capacity for other reasons. As mentioned before, Saudi Arabia has an official policy to maintain spare capacity and is considered by many as the 'central bank' of the oil market, which has given it a special position in the global economic and political order. The 'value' or 'benefits' derived from maintaining such a position should also be taken into account.

References

Aissaoui (2013). 'Saudi Arabia's Economic Diversification: Progress in the Context of the GCC and Challenges', APICORP Economic Commentary, June 2013.

Almoguera, P., Douglas, C., and Herrera, A.M. (2011). 'Testing for the Cartel in OPEC: Non-cooperative Collusion or Just Non-cooperative?', *Oxford Review of Economic Policy*, **27** (1),144–68.

BP (2015). *BP Statistical Review of World Energy 2015*, available at: www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2015/bp-statistical-review-of-world-energy-2015-full-report.pdf.

Cherif, R. and Hasanov, F. (2014). 'Soaring of the Gulf Falcons: Diversification in the GCC Oil Exporters in Seven Propositions', IMF Working Paper WP/14/177, Washington D.C., International Monetary Fund.

Chowdhury, S., Al-Zahrani, A., and Abbas, A. (2013). 'Implications of climate change on crop water requirements in arid region: an example of Al-Jouf, Saudi Arabia', *Journal of King Saud University – Engineering Sciences*, Article-in-Press.

Collier, P. and Venables, A. J. (2014). 'Closing Coal: Economic and Moral Incentives', *Oxford Review of Economic Policy*, **30** (3), 492–512.

Dixit, A. and Pindyck, R. (1994). *Investment under Uncertainty*, Princeton: Princeton University Press.

Eckbo, P. L. (1976). *The Future of World Oil*, Cambridge, Mass., Ballinger Publishing Company.

EIA (2015). 'Saudi Arabia budget insulated from effects of lower oil prices', *Today in Energy*, 12 February 2015.

Fattouh, B. (2007). 'OPEC Pricing Power: The Need for a New Perspective', in D. Helm (ed.), *The New Energy Paradigm*, Oxford: Oxford University Press.

Fattouh, B. (2011a). 'An Anatomy of the Crude Oil Pricing System', Working Paper WPM40, Oxford Institute for Energy Studies.

Fattouh, B. (2011b). 'The Saudi Gas Sector and Its Role in Industrialization: Developments, Challenges and Options', in *Natural Gas Markets in the Middle East and North Africa*, Fattouh, B. and Stern, J. (eds), Oxford, Oxford University Press.

Fattouh B. (2013). 'Summer again: The swing in oil demand in Saudi Arabia', Oxford Energy Comment, Oxford Institute for Energy Studies, 29 July 2013.

Fattouh, B. (2014). 'The US Tight Oil Revolution and Its Impact on the Gulf Cooperation Countries – Beyond the Supply Shock', OIES Working Paper WPM54, Oxford Institute for Energy Studies.

Fattouh, B. (2015). 'The Image of GCC Oil Policy in the Western Media', Oxford Energy Comment, Oxford Institute for Energy Studies, 30 April 2015.

Fattouh, B. and El-Katiri, L. (2013). 'Energy subsidies in the Middle East and North Africa', *Energy Strategy Reviews*, 2 (1), 108–15.

Fattouh, B. and van der Linde, C. (2011). 'The International Energy Forum: Twenty Years of Producer–Consumer Dialogue in a Changing World', Riyadh International Energy Forum.

Geroski, P. A., Ulph, A. M., and Ulph, D. T. (1987). 'A Model of the Crude Oil Market in which Market Conduct Varies', *The Economic Journal*, **97** (Conference 1987), 77–86.

Ghanem, S., Lounnas, R., and Brennand, G. (1999). 'The impact of emissions trading on OPEC', *OPEC Review*, **23** (2), 79–112.

Green, E. and Porter, R. (1984). 'Noncooperative Collusion under Imperfect Price Information', *Econometrica*, **52** (1), 87–100.

Griffin, J. M. and Nielson, W. S. (1994). 'The 1985–1986 oil price collapse and afterwards: what does game theory add?', *Economic Inquiry*, **32** (4), 543–61.

Haltwinger, J. and Harrington, J. (1991). 'The Impact of Cyclical Demand Movements on Collusive Behavior', *RAND Journal of Economics*, **22** (1), 89–106.

Hnyilicza, E. and Pindyck. R. S. (1976). 'Pricing Policies for a Two-Part Exhaustible Resource Cartel: The Case of OPEC', *European Economic Review*, **8** (2), 139–54.

Kohl, W. L. (2002). 'OPEC behaviour, 1998–2001', *The Quarterly Review of Economics and Finance*, **42**(2), 209–33.

Lajous, A. (2015). 'The Mexican, Saudi and Venezuelan Connection: A Memoir', *Oxford Energy Forum*, **100**, 4–11.

Libecap, G. D. and Smith, J. L. (2004). 'Political Constraints on Government Cartelization: The Case of Oil Production Regulation in Texas and Saudi Arabia', in Peter Grossman (ed.), *How Cartels Endure and How They Fail: Studies of Industrial Collusion*, Cheltenham, UK: Edward Elgar Publishing Ltd.

Loulou, R., Labriet, M., Haurie, A., and Kanudia, A. (2008). 'OPEC Oil Pricing Strategies in a Climate Regime, a Two-Level Optimization Approach in an Integrated Assessment Model', Cahiers du GERAD, G-2008–71.

Mabro, R. (1986). 'Netback Pricing and the Oil Price Collapse of 1986', WPM10, Oxford Institute for Energy Studies.

Mabro, R. (1991). 'OPEC and the Price of Oil', *The Energy Journal*, **13** (2), 1–17.

Mabro, R. (1998). 'The Oil Price Crisis of 1998', Working Paper SP10, Oxford Institute for Energy Studies.

Nakov, A. and Nuño, G. (2013). 'Saudi Arabia and the Oil Market', *The Economic Journal*, **123** (573), 1333–62.

Naimi, A. (2012). 'Saudi Arabia will act to lower soaring oil prices', *Financial Times*, 28 March.

Obaid, N. (2014). 'Why OPEC is increasingly irrelevant', *Financial Times*, 17 December.

Pindyck, R.S. (1978). 'Gains to Producers from the Cartelization of Exhaustible Resources', *Review of Economics and Statistics*, **60** (2)**,** 238–51.

Porter, R.H. (1983a). 'A Study of Cartel Stability: The Joint Executive Committee, 1880–1886', *Bell Journal of Economics*, **14** (2), 301–14.

Porter, R.H. (1983b). 'Optimal Cartel Trigger Price Strategies', *Journal of Economic Theory*, **29** (2)**,** 313–18.

Saudi Aramco (2014). *Annual Review 2014*.

Salant, S. (1976). 'Exhaustible Resources and Industrial Structure: A Nash–Cournot Approach to the World Oil Market', *Journal of Political Economy*, **84** (5), 1079–93.

Smith, J. L. (2005). 'Inscrutable OPEC? Behavioral Tests of the Cartel Hypothesis', *The Energy Journal*, **26** (1), 51–82.

Stigler, G.J. (1964). 'A Theory of Oligopoly', *Journal of Political Economy*, 72 (1), 44–61.

The Economist (2015). ‘After OPEC’, 16–22 May.

Verleger, P.K. (1987). ‘The evaluation of oil as a commodity’, in Gordon, R., Jocoby, H., and Zimmerman, M. (eds), *Energy, Markets and Regulation: Essays in Honor of M. A. Adelman*, Cambridge, MA.: MIT Press.