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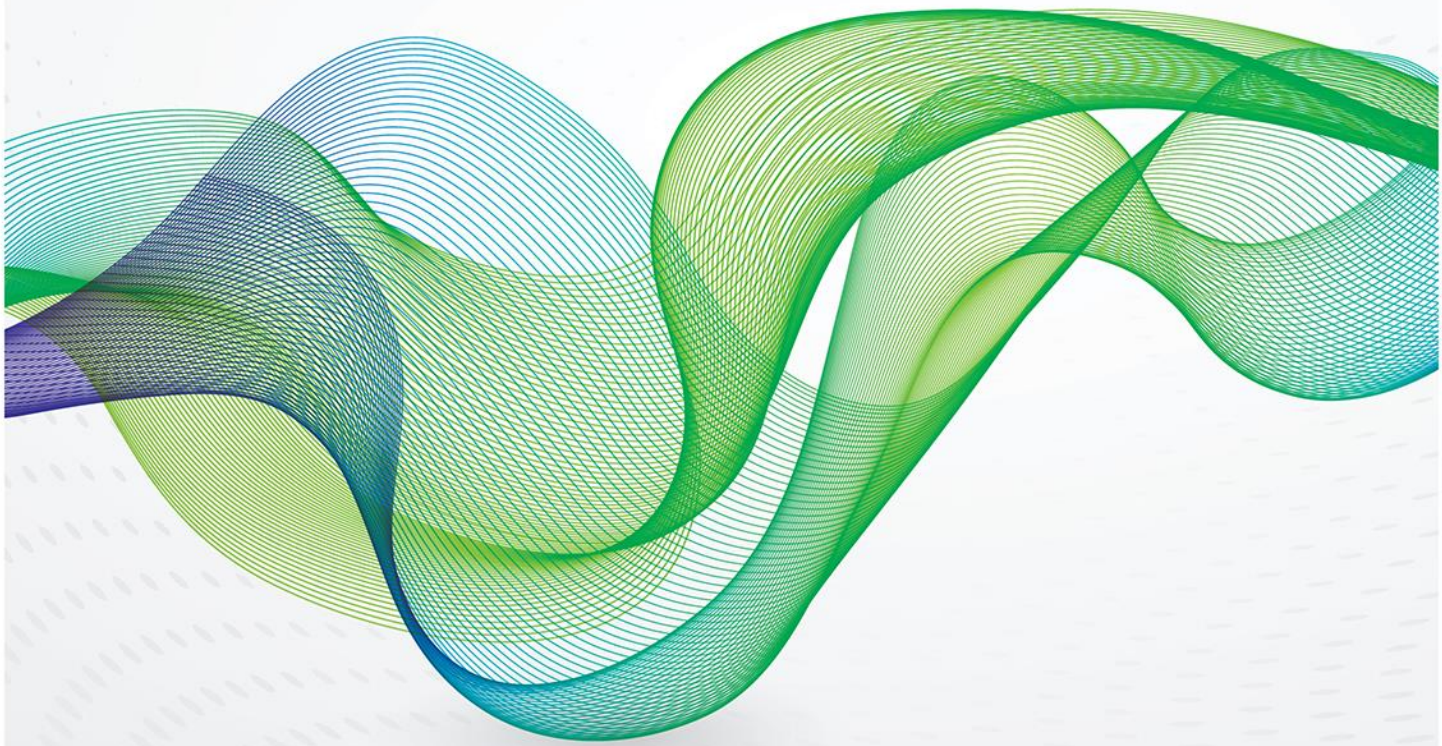
The Dynamics of the Revenue Maximization–Market Share Trade-Off: Saudi Arabia's Oil Policy in the 2014–2015 Price Fall



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Abstract

A key objective of this paper is to analyze the behavior of Saudi Arabia during the 2014-15 price fall in the light of the rise of US shale supply, the cohesion within OPEC, and the structural features of Saudi Arabia's domestic economy and energy sector. Applying a simple analytical framework which formalizes the trade-offs facing Saudi Arabia in its output decisions, we show that under uncertainty it is better for the Kingdom to assume US shale oil supply is elastic, and not to cut output. We further argue that as Saudi Arabia learns more about this new source of supply, its policy will adapt accordingly. Saudi Arabia's oil policy could change as the trade-off between revenue maximization and market share evolves, and as new information arrives in the oil market. This will keep the market second-guessing, continuing to shape market expectations and influence market outcomes.

Keywords: revenue maximization, market share, OPEC, Saudi Arabia, US shale, volatility, oil

JEL classification: D43, D81, Q02, Q41, Q48

1. Introduction

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,[1] Saudi Arabia's role in the oil market has always come under close scrutiny. This is not only due to its predominant position in world crude oil reserves, production and trade, but also due to the fact it is the only country with an official policy of maintaining spare capacity, which can be utilized within a relatively short period of time.

OPEC's decision not to cut output in November 2014, spearheaded by Saudi Arabia, 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 on the short and long run dynamics of the oil market? Has the role of the 'swing producer' shifted from Saudi Arabia to the US shale producers? [2]

OPEC's decision 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 with a lower oil price, or that it even favours a low price policy in the current context, in order to achieve wider geopolitical objectives (Fattouh, 2015). But such an explanation is problematic. Since the oil embargo in 1973, Saudi Arabia has not explicitly used oil as a political tool.[3] Additionally, such explanations ignore some basic features relating to the Saudi economy and its almost complete reliance on oil revenues – despite decades of effort to diversify the economic base (Cherif and Hasanov, 2014; Aissaoui, 2013). Furthermore, 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 to its rulers; this in turn shapes key economic objectives and consequently, government spending decisions.[4] Therefore, the policy objective of revenue maximization will always rank highly in the Kingdom's oil output decisions.

However, Saudi Arabia also holds one of the world's largest proven oil reserve base, with a reserve-to-production ratio of more than 63 years and therefore, securing long-term demand for its oil is another key policy objective that should be balanced against short-term revenue maximization. The Kingdom also produces a wide variety of crude grades – ranging from the super-light to the super-heavy – catering for a range of refineries.[5] Given this production and export profile, a presence in important markets such as the USA, Europe, and Asia is also necessary to secure outlets for its crude.

Characteristics of the Kingdom's domestic economy also figure prominently in its policy objectives – domestic demand for oil has increased rapidly over the last few decades, concomitant with a rise in the energy intensity of GDP. In order to meet this rising demand (which includes higher demand from its new domestic refineries), whilst maintaining exports above a certain level, Saudi Arabia has been increasing its drilling activity and 'calibrating' its oil sector to maintain crude production at a level above 10 million b/d. Whilst the Kingdom can adjust its production, the cost of adjustment has become higher, and the range which its output is able to fluctuate within has become narrower. Consequently, Saudi Arabia's investment and output policy ideally needs to be geared towards both optimizing the size of its spare capacity and meeting domestic demand.[6]

Given the above background, a key objective of this paper is to analyze the behavior of Saudi Arabia during the latest price cycle, in the light of the transformations in global crude oil markets, the

[1] See Fattouh (2011) for a review of the evolution of the pricing system.
[2] For instance, The Economist (2015) asserts that 'American shale firms are now the oil market's swing producers'.
[3] 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.
[4] We explore these further in section 3.2.
[5] In 2014, Saudi Arabia produced around 9.5 million b/d and exported close to 7 million b/d of crude oil.
[6] Lower than optimal spare capacity could reduce the Kingdom's ability to calm oil markets in case of disruption, whereas higher than optimal spare capacity could put downward pressure on oil prices and affect the rate of return on its investment.

cohesion within OPEC, and the structural features of its domestic economy and energy sector. In the next section we discuss previous literature on the behavior of Saudi Arabia. In section three we present a simple analytical framework to formalize the trade-offs facing Saudi Arabia in its output decisions, and in section four we apply the framework to the latest oil price cycle. Section five concludes.

2. Literature and Context

There have been numerous attempts to formalize the behavior of Saudi Arabia within OPEC, with no consensus over whether the weight of evidence points to any particular explanatory model. Early models have postulated that Saudi Arabia approaches the trade-off between revenue maximization and market share from the point of view of a 'wealth-maximising rational monopolist'. In a framework where resources are exhaustible, 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 producers 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).

Saudi Arabia's predominant position in the world oil market has led many studies to model it as the 'dominant producer' within OPEC, with the remaining producers (both OPEC and non- OPEC) acting as the competitive fringe.[7] As a dominant producer, Saudi Arabia sets its output in anticipation of the reaction of the fringe and maximizes its profits based on the residual demand. Despite this prevalent view, 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'.

Other studies model Saudi Arabia within OPEC as part of a group of countries with different oil reserve bases and divergent political, social, and economic systems. To account for this heterogeneity some models split all 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. It finds that countries with low discount rates and high reserve bases such as Saudi Arabia will choose a lower price path than the price pushers.[8]

Despite this behavioral heterogeneity, all oil exporting countries are aware of the fact that in the face of an oil price fall caused by *ex ante* excess supplies, co-operation on cutting output is the most effective way to reverse the price decline and clear the excess supplies. Seeking market share in an over-supplied market often results in sharp falls in the oil price and oil revenues (Mabro, 1998). Given that oil demand is highly inelastic in the short-term, the demand will not rise enough to absorb the surplus production. As the supply curve is also inelastic in the short-term, production will not fall promptly as once costs are sunk, producers will continue to produce. Therefore, OPEC's attempt to increase supply in a falling market will result in accumulation of stocks and weaker prices and potentially lower revenues, as the increase in the volume of production does not compensate for the

[7] See Salant (1976) and Mabro (1991).

[8] In a similar vein, Hnyilicza and Pindyck (1976) divide OPEC into savers (countries with low discount rates) and spenders (countries with high discount rates) and analyze the interaction between these two groups using the theory of cooperative games.

decline in the oil price (Mabro, 1998). There is rarely a disagreement on the general nature of the trade-off between revenues and volume (or market share). The disagreement usually arises over which producers should shoulder the burden of the cut. The OPEC quota system has not been effective in resolving this fundamental issue. Many within OPEC would like to leave it to Saudi Arabia to shoulder most of the burden of the cut, while Saudi Arabia has made it clear, since 1986[9], that it is not willing to cut output unilaterally or assume the role of the swing producer, and any production cut should be shared with other producers, including non-OPEC producers. [10]

Within OPEC, the quota system remains the only mechanism to regulate output levels. But this mechanism rarely works, especially when the market is oversupplied (that is, when the quotas are mostly needed to balance the market). Even if there is agreement between OPEC members on the volume of the cut required to support prices, assigning quotas for individual countries has proven difficult in the past. Previous efforts to design a system of allocating quotas 'equitable to all members' and based on formulae that incorporates 'objective' criteria (such as the size of reserves, production capacity, historical production share, domestic oil consumption, production costs, dependency on oil exports, the size of the population, and external debt), have failed. But even if there is an agreement on such formulae to allocate individual quotas, OPEC does not have formal monitoring mechanisms in place, and hence, violations are usually not detected instantly (Kohl, 2002; Libecap & Smith 2004). These problems become more acute when the required cuts are large, as small OPEC members usually find it difficult to reduce their production on a pro-rata basis and hence are always dissatisfied with their allocated quotas.

Since OPEC does not have the formal enforcement mechanisms to punish member countries or to force them to abide by the agreed quotas, this has raised doubts over whether OPEC can collude to restrict output. But the empirical evidence suggests collusion can still occur in some instances. For instance, Geroski et al. (1987) find that collusion is rarely perfect and some producers may change their behavior in response to a rival's previous actions. Their empirical results show that varying-behavior models tend to outperform constant-conduct models. Similarly, Almoguera et al. (2011) find many switches between collusive and non-cooperative behavior in the period 1975–2004, indicating the ability to collude is not constant.

Griffin and Nielson (1994) find evidence that Saudi Arabia has in the past 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[11]. 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.

In fact, insights from game theory suggest that even in the absence of formal disciplinary mechanisms, collusion could still work if implicit threats force members to abide by the agreed quotas. Stigler (1964) argues that price wars often signal the collapse of collusion. In Porter (1983a, b) and

[9] See Mabro (2006) for a history of oil markets.

[10] With the continued decline in demand for its oil, OPEC's share in world oil production fell from 51 per cent in 1973 to 28 per cent in 1985, leading to a lack of internal cohesion. Saudi Arabia lost market share with every increase in the marker price and hence opposed price increases. Other OPEC members pushed for price increases – while at the same time pumping oil into the market in an attempt to boost revenues. OPEC's introduction of a formal quota system proved ineffective in preventing production from rising above quotas (in other words 'cheating') and it was becoming clear by the mid-1980s that OPEC 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, proving very costly.

[11] 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 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 their quotas and matches their cheating barrel for barrel, resulting in greater price variation than in the swing producer regime.

Green and Porter (1984), on the other hand, price wars represent the equilibrium outcome of a dynamic non-cooperative game. Price wars can be the solution to the problems of imperfect information and imperfect enforcement mechanisms that plague OPEC. They are also credible means of communicating and signalling to other countries – hence price wars can be strategic in nature.[12] But this mechanism to force collusion implies sharp adjustment in revenues from time to time, as prices may have to fall to very low levels to induce other producers to act collectively. This is complicated by the large differences in revenue needs, financial reserves, levels of debt, and production costs among OPEC members.

In such a context, in addition to filling the supply gap in face of disruptions, the size of spare capacity is an important determinant of the collusive outcome. In a rising market, when all producers (including Saudi Arabia) are producing at maximum capacity, OPEC becomes a 'price taker'. Saudi Arabia could decide to cut production to enhance its short-term revenues. But given high prices can impact oil demand growth and the state of the global economy, and hence longer-term revenues, Saudi Arabia often refrains from exercising such pricing power in a rising market. It has been willing to meet demand from its customers at the going price (in other words, act as quantity adjuster). In a falling market when spare capacity is rising, the sustainability of collusive outcomes would depend on the one-shot deviation gains by individual producers, the losses of future collusive profits, and the future cost of being punished. Haltwinger and Harrington (1991) for instance, 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, it is more difficult to sustain collusion when demand is falling. But the ability of Saudi Arabia to grow its production increases the cost of 'punishment'. Specifically, if Saudi Arabia decides to increase its production in a falling market, the gains from deviating from the collusive outcome for other producers will be smaller.

Against this broad context, in the sections that follow, we develop a simple analytical framework which formalises Saudi Arabia's decision-making process and role within OPEC, relative to the fundamental revenue maximization-market share trade off in the 2014-15 oil price cycle.

3. Analytical framework

In this section we propose a simple framework to explain Saudi Arabia's oil policy in response to a change in oil market conditions. The suggested model presents all possible scenarios, and the factors underlying the decision process for adopting a policy response. The model is then applied to the oil price fall of 2014-2015 as a case study.

The assumptions of our model are as follows:

i) The decision maker (Saudi Arabia) is an economically rational player.

ii) As an oil producer, Saudi Arabia seeks higher revenue than obtained from the competitive market (that is, second best maximization) rather than absolute maximization of revenue.

iii) As a market player it faces various trade-offs (not all objectives can be obtained simultaneously).

iv) There are uncertainties in the market (for example, the elasticity of supply of US shale oil).

v) Non-economic objectives are excluded from oil policy.

Assumption (ii) is based on the idea that the theoretical postulation of a revenue-maximising monopolist to explain Saudi Arabia's economic behavior has proven invalid based on empirical

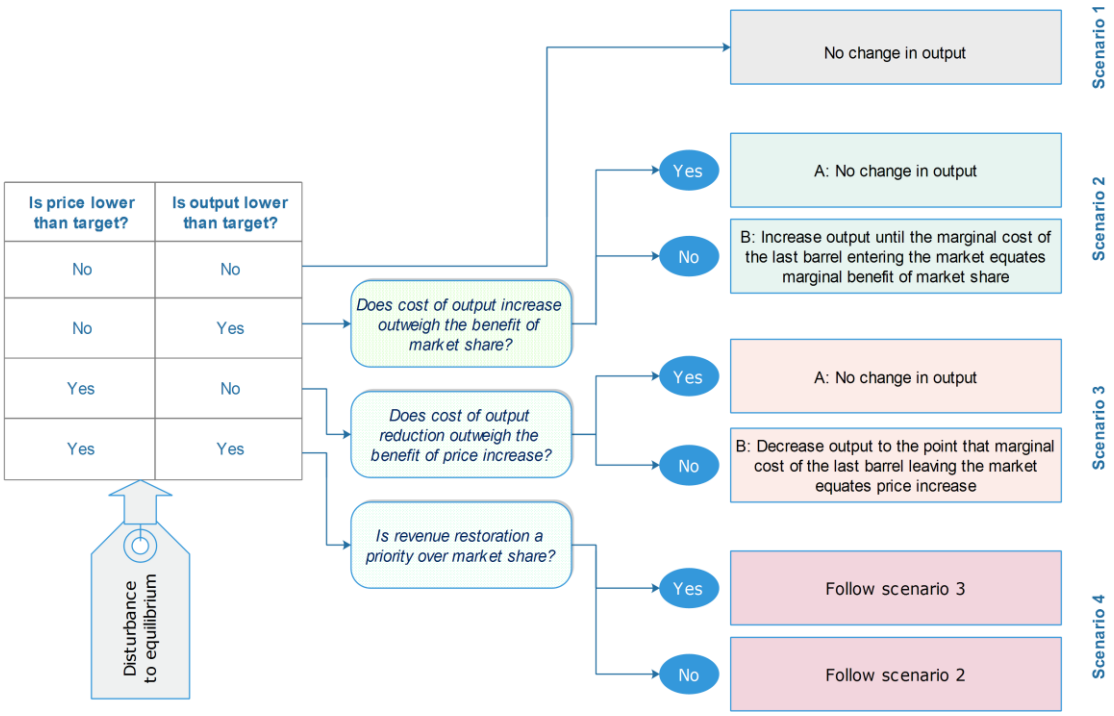
[12] For instance, in 1998, Saudi Arabia responded to Venezuela's increase in production and rapid capacity expansion by increasing its own output. In this situation, Saudi Arabia played the role of the discipliner – succeeding in getting other producers to cut output after prices fell to very low levels.

evidence (Mabro, 1991). As for assumption (v), since the oil embargo in 1973, there is little evidence the Kingdom uses oil as a political weapon (Fattouh and Sen, 2015).

Saudi Arabia aims to secure a target revenue, a target market share and to optimize the size of its spare capacity. As the policy instruments available to the Kingdom are limited, all three targets are achieved through modifying output (and investment, which affects output in the longer term). The degree of market share is correlated with the size of spare capacity; thus we can reduce the ultimate policy objectives to revenue and output levels. A shock which leads to a significant shift in the oil price and/or output level triggers a response from the Kingdom.

Our proposed framework rationalizes the response mechanism in the face of market disequilibrium due to shocks. Figure 1 presents the possible effects of a market shock on output and revenues, the trade-off facing the Kingdom, and finally, the response under each scenario. As seen from Figure 1, any oil market disequilibrium can fall into one of the four different scenarios presented. However, a response is not required in all scenarios. As explained later, sometimes a response is not necessary because the objective variables do not deviate from the targets (for example, scenario 1) and in certain cases a response is not economical (for example, scenario 2.A).

Figure 1: Structure of framework



Source: Authors

3.1 Possible scenarios

Scenario 1: within target variations

Scenario 1 refers to 'normal' fluctuations in the oil market. The price of oil can be affected by various factors and is subject to a number of shocks. However, as long as these fluctuations are within the specified targets, they do not trigger any action from oil producing countries including Saudi Arabia. For instance, the Brent price was fairly stable from 2010 until mid-June 2014 at above $100. The narrow price variations around the target price were perceived as 'normal' or 'desirable' by oil producing countries including Saudi Arabia. This is mainly because a stable market would benefit oil

producing countries in various ways. For instance, it helps support government spending plans, stabilizes the national income and enables governments to plan for the future through the creation of wealth funds.

Scenario 2: output drop

This case refers to the situation where Saudi Arabia's output level falls as it is substituted by other producers, but prices are such that the Kingdom's oil revenue remains within the target. This may happen when an oil producer that has been long out of the market, returns. A war for regaining market share may lead to a drop in the Kingdom's output level. Therefore it is unclear whether Saudi Arabia should increase its output in order to restore the target output level, but at the cost of losing revenues due to the new market equilibrium with lower oil prices.

Scenario 3: price fall

This is the most common type of shock hitting the oil market where the oil price plunges and consequently revenue falls short of the target, while the output level of Saudi Arabia remains within the target. This can happen for several reasons. For example, when a new source of supply enters the market and adds to existing supplies, under the condition that demand in oil consuming countries is stagnant, or the growth in oil demand is not big enough to absorb all the surplus production. Then the question of whether Saudi Arabia should cut back its output – in order to influence the price and consequently restore its revenue – depends on the cost of losing market share versus the benefits of restoring revenue.

Scenario 4: price-output fall

This is the worst-case scenario from a producer's perspective, where both the market share and revenue fall below the target level. This can be the result of a significant shock to both demand and supply. Alternatively, it can happen due to an unsuccessful attempt to restore market share or the price under scenarios 2 and 3.

3.2 The nature of trade-off

The important feature of the above scenarios (except scenario one) is the trade-off between the increase in output (or increase market share) and revenue maximization. This situation can be interpreted in various forms such as a trade-off between short-term objectives (maximising revenue) and long-term goals (securing demand for oil through market share and hence maximizing long-term revenues). Along the same lines it can be translated as a trade-off between static efficiency (ensuring present time viability) and dynamic efficiency (ensuring future viability). The key point is that it entails a compromise, as the two aforementioned objectives become mutually exclusive when the market deviates from the stable condition. The opportunity cost of gaining market share is losing revenue, and the opportunity cost of maximising revenue is losing market share. In this section we further explain the factors that affect the fundamental trade-off, including determinants of market share value, output level constraints, and the revenue requirement of Saudi Arabia. We also briefly discuss the role of demand and capacity surplus in the context of the aforementioned trade off.

3.2.1 The value of market share and production adjustment constraints

Traditionally, there has been a debate among economists about the intrinsic value of the market share as an objective of the firm (Jacobson, 1988). This question is of paramount importance for planning and market strategies of oil producing countries, because the cost of gaining or maintaining market share is only justifiable if such policy proves to be profitable in the long run.

The value of market share is widely attributed to its positive impact on the firm's long run profitability. This raises the question of how higher market share leads to more profitability in the long-term. Classical studies often provide three explanations for this (Jacobson, 1988). The first is related to economies of scale and scope. Larger producers are able to utilize various tangible and intangible assets and accomplish tasks more efficiently. As the market share increases, so do the cumulative sales and experience through which larger firms can gain cost advantage over smaller ones.

Additionally, economies of scale and scope can act as a barrier to the entry of smaller producers into the market. This is because the cost advantage can be such that operation below a certain level of output becomes unprofitable. The second explanation pertains to market power. The size and importance of larger producers enables them to bargain more effectively and exert market power, increasing their profitability. The third explanation is related to product and management quality. In this view, a larger market share is the sign of competent management and a reliable supplier.

The neo-classical economics account of the ways in which market share affects long run profitability cannot be the main reason behind the interest in the market share for oil, a strategic commodity with distinct features[13]. Thus, a key issue is how the relationship between market share and long run profitability works for the oil producers. In the context of Saudi Arabia, at least three paths can be envisioned. First, the interest in market share comes from a long-term view of revenue maximization. With more than 267 billion barrels of proved reserves, Saudi Arabia holds 18 percent of world oil reserves. The Kingdom, thus, needs to secure demand for its massive reserves, if its oil industry is going to remain profitable in the long run. This, in turn, implies a proportionate market share via presence in key markets around the world. The second channel is through influencing the behavior of competitors within OPEC. The high production level and official policy of maintaining spare capacity has given Saudi Arabia the status of *de facto* leader of OPEC. When there is significant disharmony or non-compliance among fellow OPEC members, Saudi Arabia can discipline the members by expanding its market share and thus reducing everyone's profit margin. This can bring all members to the table for unanimous decision making with a positive impact on their profit (for example, a production cut by all members). The third way can be through market share as a deterrent strategy for the elimination of emergent competitors. If a new source of supply to the market is likely to be a threat to the Kingdom's long run profitability, Saudi Arabia's dominance in production and trade can make the new rival business unprofitable and ultimately force it out of the market. Also consistent with this strategy, Saudi Arabia can abandon its role as market stabilizer in an over-supplied market, inducing more price volatility and sharper price movements. Increased volatility, together with the perception that prices could fluctuate within a wide range, may cause investors to reassess the risks in new energy projects; increasing the value of the option to wait (Dixit and Pindyck, 2014) and discouraging investment in new oil projects.

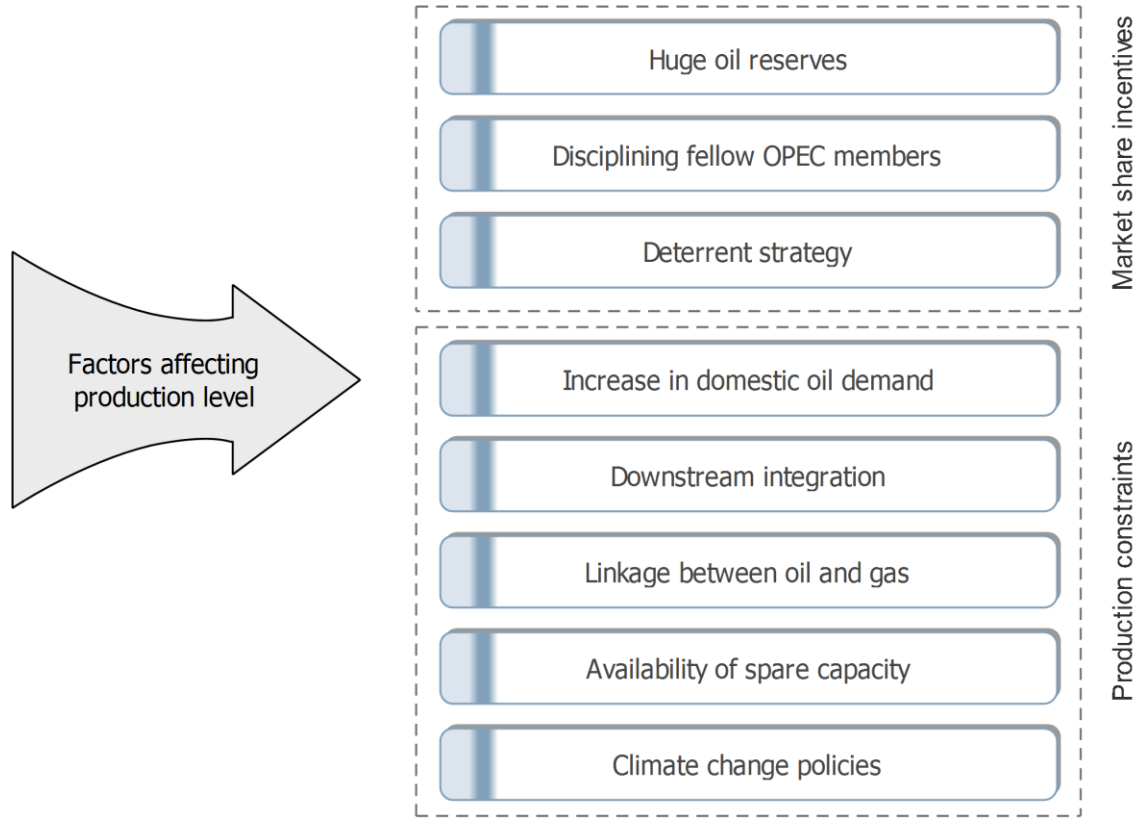
However, there are other factors that affect Saudi production, apart from the economic value of market share. In fact, irrespective of the relationship between market share and long term profitability, Saudi Arabia's output level is bound by various factors. As is illustrated in Figure 2, these constraining factors are: an increase in domestic demand, linkages between oil and gas, downstream integration, and availability of spare capacity. Over the last few decades, domestic demand for oil has rocketed from 607 thousand b/d in 1980 to 3.185 million b/d in 2014 (BP, 2015). At the same time, the Kingdom's economy has become more energy intensive due to demand from industries, availability of huge subsidies for fossil fuels, and inefficient consumption (Fattouh and El-Katiri, 2013). Additionally, the bulk of gas produced in Saudi Arabia is of the associated type and many industries such as petrochemicals rely heavily on ethane. Furthermore, in the last two years Saudi Arabia has added two new refineries with capacity of 400 thousand b/d respectively and is preparing for a third refinery of equivalent capacity to come online in 2018. Downstream integration is being pursued with the aim of capturing greater value from the supply chain, as well as achieving broader objectives of diversification and job creation. This suggests Saudi Arabia's oil production cannot fall below a certain level due to internal constraints.

While the aforementioned constraints determine the lower threshold for production, the size of spare capacity affects both the lower and upper bound for the Kingdom's oil production[14]. Saudi Arabia steers its output and investment policy towards an optimum spare capacity, as well as meeting

[13] The neo-classical explanation of the nature of relationship between market share and profitability might be of secondary importance at best. In fact when the target market share is achieved the oil producer automatically benefits from those results.
[14] The Kingdom's current spare capacity is estimated at 1.5 to 2 million b/d (Fattouh and Sen, 2015).

domestic demand. A higher than optimal spare capacity can depress oil prices and trim down the Kingdom's revenue base. A lower than optimal spare capacity, on the other hand, causes the Kingdom to lose its control over the oil market, with the risk of higher and volatile oil prices leading to demand destruction.

Figure 2: Oil production level constraints



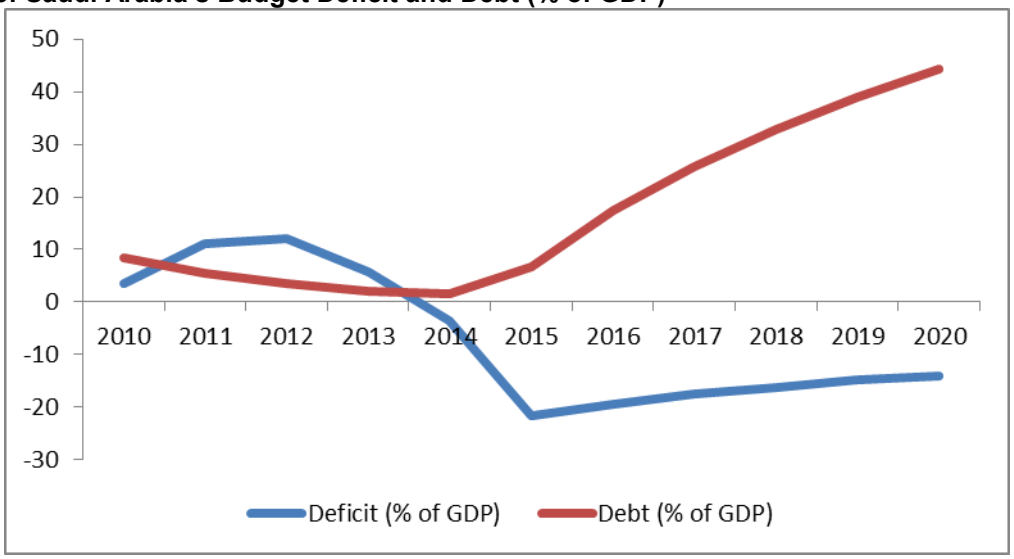
Source: Authors

3.2.2 Kingdom revenue requirement

Saudi Arabia obtains more than 90% of its fiscal revenue from oil (IMF, 2015). According to its Ministry of Finance, the government aims at a sustainable and strong economy by focusing on development of infrastructures, education, health and social security services, municipality services, water management services, roads and highways, science and technology and e-government (Ministry of Finance, 2015). Over the past several decades, oil revenue has supported a significant increase in the standard of living in the Kingdom.

Given the contribution of the non-oil sector to the government's revenues is negligible, and the level of product import of various kinds is large, revenue from oil exports is of paramount importance for Saudi Arabia. The lack of economic diversification and reliance on oil revenues expose the Kingdom's economy to oil market shocks. The recent sharp fall in the oil price underlines the challenges facing Saudi Arabia in maintaining long run fiscal stability, given the share of the public sector in its economy and the rapid increase in current and capital government expenditure. For the first time since 2009, Saudi Arabia had run a budget deficit in 2014, with estimates for the deficit to reach more than 20% of GDP in 2015. Although Saudi Arabia has been drawing down on its foreign reserves, the debt to GDP ratio is still projected to reach around 44% of GDP by 2020 (see Figure 3). Therefore, as with any other oil exporter, Saudi Arabia has revenue constraints, and this can affect its decision on the direction of the trade-off between market share and revenue.

Figure 3: Saudi Arabia's Budget Deficit and Debt (% of GDP)



Notes: 2010-2014 Actual; 2015-2020 Projections

Source: IMF, World Economic Outlook, October 2015

3.2.3 The role of demand (tight versus weak market) and surplus capacity

The status of the market, as well as oil producers' available spare capacity, has crucial implications for the direction of the trade-off facing oil producing countries, including Saudi Arabia. An increase in oil demand leads to a tight market and all producers operate at their full capacity. This situation leaves Saudi Arabia as the only country with the power to restrain price increases through ramping up production, as it is the only oil producer with an official policy of holding spare capacity. Additionally, in a tight market Saudi Arabia can easily place upward pressure on the oil price by cutting output. A revenue restoration objective in a tight market, therefore, is likely to be an achievable strategy. Yet a significant price increase may accelerate the long-term demand and supply responses, with implications for the Kingdom's long-term revenues.

On the other hand, a sudden decrease in demand puts downward pressure on prices. Supply outside OPEC would adjust to low prices, but given that the supply curve is highly inelastic, the supply response is not immediate, causing a build-up of inventories overground (storage) or underground (spare capacity). In such a market, OPEC producers have the choice of either cutting supplies or keeping production unchanged. Saudi Arabia's response will be shaped by other producers' decisions. If other OPEC producers continue to produce at maximum capacity, Saudi Arabia can either cut or ramp up production. Cuts in supply will help support prices, but the impact on Saudi Arabia's revenues will depend on whether the revenues lost as a result of lower production outweigh the gains in revenues from higher prices.

In the case that other OPEC producers have spare capacity, a production cut by Saudi Arabia may not have any effect on the oil price if this is substituted by other OPEC members. In the past, OPEC's producers have behaved like non-OPEC and tend to produce at maximum capacity, but the potential return of producers such as Iran or Libya can be incorporated in this framework. These countries can be thought of as having spare capacity that can be utilized in a short period of time. In this case, it is unclear whether Saudi Arabia should increase its output in order to restore the target output level, but at the cost of losing revenues due to the new market equilibrium with lower oil prices. The answer to this question depends on the benefits of restoring market share versus the cost of an increase in output. If the cost of ramping up production outweighs the benefits of market share, then the adjustment of output is not economical. Otherwise, Saudi Arabia should increase its output until the marginal cost of the last barrel put into the market equates the marginal benefit of market share.

3.2.4 Event-specific factors and uncertainties

The aforementioned factors such as the intrinsic value of market share, production level constraints, revenue requirements of the Kingdom and the role of demand and surplus capacity always play a role irrespective of the type of oil shock. However, every price cycle has its own features and this one is no different.

The advent of US shale oil in the most recent oil price collapse is a specific factor. The global financial crisis in 2008 and its impact on the oil market was also a specific factor. The characteristics of these factors play an important role in the short-term oil policy of the Kingdom. The lack of information and experience about the nature of event specific factors introduces considerable uncertainties in various dimensions. For instance, whether the effects of specific factors on oil market crises are of a transitory or permanent nature can be a source of uncertainty. The effect of the global financial crisis on the oil market was mainly perceived as a transitory factor. But the question is whether the same can be said about the emergence of unconventional oil.

The effect of uncertainties becomes even more pronounced when related to a critical piece of information needed for policy response. For example, an important dimension of uncertainty regarding unconventional oil in general and US shale oil in particular, as an event-specific factor, pertains to its elasticity. The shale oil supply curve can be of any form, with different implications for Saudi Arabia's policy response. To illustrate the extent of uncertainties facing the incumbent oil producers, in Table 1 we present qualitatively some possible ranges for the short-term elasticity of shale oil supply, leaving out the extreme cases (i.e., perfectly elastic, perfectly inelastic and unitary elastic)[15].

Table 1 presents four different categories of shale oil elasticity, their definition and their impact on the direction of the trade-off when Saudi Arabia and the US shale oil producers are both swing producers. As seen from the table, when shale oil is relatively elastic, an output cut by Saudi Arabia does not affect the oil price, simply because the resulting supply shortage will be substituted by increased tight oil production. Thus, any production cut, in this case, is probably doomed to failure.[16] The same applies when there is asymmetric elasticity in the form of shale being inelastic when the oil price declines and elastic when it rises. The only way in which Saudi Arabia can effectively cut its output is when shale oil is relatively inelastic, or when it has an asymmetric elasticity in the opposite direction of the aforementioned case. These all highlight the role of event-specific factors and associated risks that the Kingdom faces when it devises a response policy to an oil market shock.

[15] In practice the possible values for elasticity are infinite. The qualitative summary presented here is only for an illustration of the uncertainties facing Saudi Arabia. It is based on the classical interpretation of quantitative values of elasticity. Furthermore, elasticity is rarely constant along the entire supply curve and changes in supply in response to price changes, depend on which point of the supply curve the elasticity is being measured at.

[16] In a recent speech, the Saudi Oil Minister Ali Al-Naimi expressed his concerns of such a scenario stating that 'the experience of the first half of the 1980s was still in our minds. At the time, we cut our production several times. Some OPEC countries followed our lead, and the aim was to reach a specific price that we thought was achievable. It didn't work. In the end, we lost our customers and the price. The Kingdom's production dwindled from over 10 mb/d in 1980 to less than 3 mb/d in 1985. The price fell from over $40 per barrel to less than $10. We are not willing to make the same mistake again'. See https://en-maktoob.news.yahoo.com/full-text-saudi-oil-ministers-speech-riyadh-084034690--business.html

Table 1: Uncertainties in shale oil's elasticity of supply and its impact on the trade off

Short run elasticity	Definition	Implications for trade-off
Relatively elastic	Proportionate change in shale oil supply is *higher* than proportionate change in oil prices.	An output cut by SA is not likely to influence the oil price as the Kingdom cut will be substituted by shale oil.
Relatively inelastic	Proportionate change in shale oil supply is *lower* than proportionate change in oil prices.	An output cut by SA is likely to influence the oil price as it will not be substituted.
Asymmetric elasticity (1)	Shale oil is relatively *elastic when oil price goes down* and relatively *inelastic when oil price increases.*	An output cut by SA is likely to influence the oil price as it will not be substituted.
Asymmetric elasticity (2)	Shale oil is relatively *inelastic when oil price goes down* and relatively *elastic when oil price increases.*	An output cut by SA is not likely to influence the oil price as the Kingdom's cut will be substituted by shale oil.

4. Applying the framework: 2014-15 oil price drop

The proposed framework is applied to the oil market crisis of 2014-15. This most recent oil price drop coincides with scenario 3 explained in Section 3.1. As in previous oil price falls, there are a myriad of factors, including common and specific, which shape Saudi Arabia's output policy. The common factors are those related to revenue requirement, market share and production constraints. The specific factor is the advent of shale oil. It is evident these factors are not all equally weighted. A factor that has a greater impact on the loss or gain resulting from a particular decision is more important in the decision making process.

The short run strategy in the face of uncertainties and a new source of supply can be explained through a simple strategic game as presented in Table 2. The game has two players: Saudi Arabia and the rest of OPEC. It is divided into two identical simultaneous games in order to account for the effect of US shale oil, as the event-specific factor, and its associated uncertainty. This uncertainty pertains to supply curve elasticity, which is assumed to be either elastic or inelastic. Furthermore, we assume the market is falling (as was the case in 2014) meaning supply is growing faster than demand and existing spare capacity is rising – other suppliers are producing at a rate below their maximum capacity and thus can ramp up production in the short run.

The payoffs of the game, which depend on the strategies taken by players, are the gains or losses that producers make compared to the case of inaction (i.e., no change in output). The ranking of payoffs is such that C<B<A. A: is the highest payoff which players can obtain if they unanimously cut

their output without any possibility of substitution (-A is the highest level of loss that players make when they lose both their market share and revenue).[17] B is a modest gain players make from a successful production cut of other players (-B is a moderate loss to due to a production cut in presence of falling market and possibility of substitution). C is the lowest gain players make from the successful production cut of its own (-C is the lowest loss due to production cut in presence of a falling market and substitution).

Table 2: Optimum strategy in the short run (falling market)

	Elastic US supply (game 1)			Inelastic US supply (game 2)	
	Other-OPEC members cut output	Other-OPEC members do not change output		Other-OPEC members cut output	Other-OPEC members do not change output
SA cuts output	-C, -C	-A, 0	SA cuts output	A, A	C, B
SA does not change output	0, -A	0, 0	SA does not change output	B, C	0, 0

As seen from the table, when shale oil supply curve is highly inelastic (game 2) there is a strictly dominant strategy for the Kingdom. In the short-term, Saudi Arabia benefits from an output cut irrespective of the behavior of other players. There is also a dominant strategy for other suppliers: cutting output leaves them a level of gain higher than inaction, no matter what Saudi Arabia does. Therefore, under game (2), there is a single optimal strategy profile – Saudi Arabia should opt for an output cut with or without coordination from other members.

In similar manner, when shale oil supply curve is highly elastic (game 1) there is a dominant strategy both for Saudi Arabia and other players. Saudi Arabia would be better off not changing its output, irrespective of the behavior of other players. The same applies to other players. Thus, the game has a single optimal strategy: no player changes its output level because it loses both its market share and revenue.

The problem is at the time of decision there is no information available to the players regarding the elasticity of shale oil supply curve. Put another way, there is no way for the players, including Saudi Arabia, to find out which game they are in *a priori*. In fact, whether they are in game (1) or (2) will only be revealed after the players have implemented their strategy. If the players knew in advance which game they are in, then the problem would be simple. This is because each player can play their optimal strategy and, due to presence of a unique equilibrium under both games, an efficient outcome would be achieved. However, due to uncertainty the players are exposed to significant risk because four different possibilities exist:

[17] This assumes that Saudi Arabia's decision to cut output will have an immediate impact on price and hence on revenues. In practice, there may be lags between the time an announcement of a cut is made and the time the price responds to such news. This would depend on market conditions and whether market participants consider the announcement of a cut as credible signal or 'cheap talk'. Furthermore, it is not always clear how the market will initially react to the announcement of an output cut (see for instance, Fattouh, 2008). This could add a further layer of uncertainty to the game. For simplicity, we assume that the output cut will be successful in raising the price.

i.) Saudi Arabia might be in game (1) and plays as if it is in game (1)

ii.) Saudi Arabia might be in game (1) but plays as if it is in game (2)

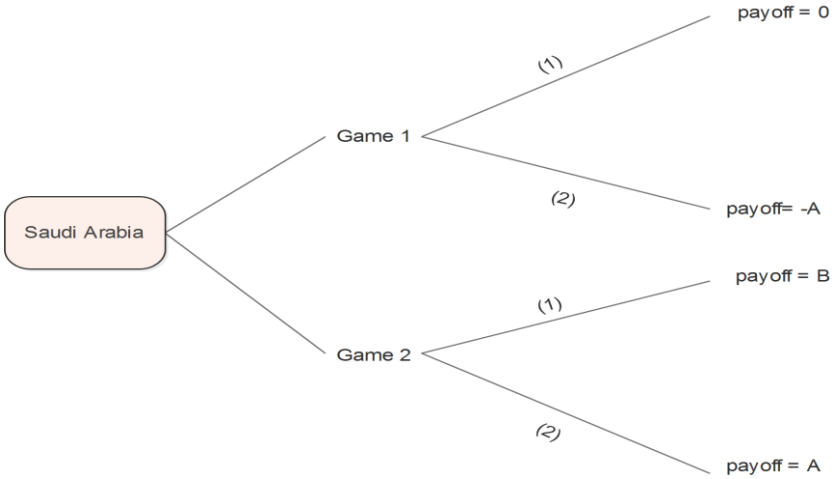
iii.) Saudi Arabia might be in game (2) but plays as if it is in game (1)

iv.) Saudi Arabia might be in game (2) and plays as if it is in game (2)

In order to show how the decision is made under uncertainty, we depict the tree diagram of the game in Figure 4. It is clear from the diagram that if Saudi Arabia is in game (1) (elastic shale oil supply) and plays the optimal strategy of game one (no change in the output) the payoff would be zero. However, if Saudi Arabia plays the optimal strategy of game (2) (cutting output assuming inelastic shale oil supply) while in fact it is in game (1), the Kingdom incurs the biggest loss which is -A (losing both market share and revenue). Similarly, if Saudi Arabia is in game (2) and plays as if it is in game (1), the Kingdom makes a moderate gain B. But if Saudi Arabia plays as it is in game (2) the payoff is highest which is A.

Taking all four different possibilities into account, we can calculate the expected payoff of playing optimal strategy of game (1) in presence of full uncertainty about the game as: *Exp[P(game1)]= 0.5 (0) +0.5 (B) =0.5B.* Likewise the expected payoff of playing the optimal strategy of game (2) under uncertainty is: *Exp[P(game2)]=0.5(A) +0.5(-A) =0*. As the expected payoff of playing the optimal strategy of game (1) is strictly higher than the expected payoff of playing the optimal strategy of game (2), it is always better for Saudi Arabia to assume that it is in game (1) as long as there is no information available *a priori*. In other words, under uncertainty it is always safer for the Kingdom to assume that shale oil supply is elastic. As we saw in game (1) the optimal strategy under elastic shale oil is “no change in output”. This might be one of the reasons Saudi Arabia did not agree with a production cut in OPEC meeting in November 2014. This situation exists until the oil market transmits new information regarding the uncertainty to which the Kingdom can react and adjust its strategy accordingly.

Figure 4: Tree diagram of the whole game in presence of uncertainty induced by US shale oil



For example, in hindsight, the current downward phase of the cycle has revealed some interesting features regarding US tight oil production worth highlighting:

- The US tight oil industry is highly responsive to low oil prices as reflected in the sharp fall in the number of rigs and the large cuts in capital expenditure announced by the US shale producers;
- But the relationship between the fall in the number of rigs and the fall in production is not linear and is affected by factors such as efficiency gains, the ability of shale producers to renegotiate contracts with service providers, and high grading (i.e. shifting rigs into more productive areas or sweet spots). During the downturn, US shale producers have shown the ability to achieve strong

efficiency gains, lower the cost of services, and retreat to their core assets. This meant despite the fall in the oil price, production continued to rise initially;

- Nevertheless, given the high decline rates of tight oil wells, the fall in the number of rigs has ultimately resulted in slower output growth as declines from existing wells outweigh the supply growth from new wells, but this occurred with a lag of several months, which added another layer of uncertainty;
- 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 rollover existing debts and extend new lines of credit. 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. But this could change if there is a shift in the financial market's perception about the risk investing in US shale.

However, these observations only pertain to the downside phase of the cycle. As we saw from our simple game, a key uncertainty remains as to how fast 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 divergent views regarding the strength of the 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, the availability of finance, 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 downward phase of the cycle, US tight oil supply will respond to higher oil prices, but with substantial lags. The lagged response will be determined by factors such as the speed at which rigs could be redeployed, the increase in the 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 bring back laid-off workers.

In short, with the advent of US shale, OPEC and Saudi Arabia have entered uncharted 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 in the form of decision under uncertainty.

5. Conclusion

Given its highly undiversified economic base, maximizing revenues will always rank highly in Saudi Arabia's output decision. However, this objective needs to be balanced against another 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 behavior of other producers. Our analytical framework categorized the determinants of the trade-off into 'common factors' and 'event specific' factors. We argue that the advent of US shale has made the calculus of the trade-off more uncertain, complicating Saudi Arabia's output decision. However, using a simple game, we show that under uncertainty, it is always safer for the Kingdom to assume shale oil supply is elastic and not to cut output. But as Saudi Arabia learns more about this new source of supply, its policy will adapt accordingly. The fact Saudi Arabia's oil policy could change, as new information arrives in the market and as the trade-off between revenue maximization and market share evolves, will keep the market second-guessing. It will continue to shape market expectations and influence market outcomes.

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