An analysis on Saudi Arabia's crude oil production strategy

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“One-hundred dollars is a fair price

for everybody - consumers,

Producers, oil companies…

it is a fair price.”

Saudi oil minister Mr. Ali Naimi, May 2014

“If I reduce, what happens to my market share?

The price will go up and the Russians,

the Brazilians, US shale oil producers

will take my share.”.

Saudi oil minister Mr. Ali Naimi, December 2014

Ο Θεοδόσιος Περιφάνης βεβαιώνω ότι το έργο που εκπονήθηκε και παρουσιάζεται στην υποβαλλόμενη διπλωματική εργασία είναι αποκλειστικά ατομικό δικό μου. Όποιες πληροφορίες και υλικό που περιέχονται έχουν αντληθεί από άλλες πηγές, έχουν καταλλήλως αναφερθεί στην παρούσα διπλωματική εργασία. Επιπλέον τελώ εν γνώσει ότι σε περίπτωση διαπίστωσης ότι δεν συντρέχουν όσα βεβαιώνονται από μέρους μου, μου αφαιρείται ανά πάσα στιγμή αμέσως ο τίτλος.

(υπογραφή)

Acknowledgements

I would like to thank and express my deep appreciation to the following Professors:

Dr. Athanasios Dagoumas, Assistant Professor in Energy and Resource Economics at the University of Piraeus who was my thesis advisor. His support, with his valuable advices, experience and research guidance, not only helped, but made it possible for this thesis to be completed.

Dr. Michael Polemis, Assistant Professor in the Department of Economics at the University of Piraeus. His guidance and proposals on the econometric part of the thesis were more than valuable, since he proposed more than one methods to surpass any difficulties. This is testament of his deep knowledge on the area.

Dr. Nikolaos Farantouris, Professor at the International European Studies Department, University of Piraeus, holder of the Jean Monnet Chair on EU Law and Policies (Competition, Energy and Transport) and Director of the Master Programme in “Energy: Strategy, Law & Economics” at the Department of International & European Studies of the University of Piraeus. His energy and effort to establish a Master Programme with an international character should not only be appreciated but also supported.

Dr. Ioannis Paravantis, Associate Professor in the Department of International and European Studies of the University of Piraeus and Aggelos Kotios, Professor of International and European Economic and Development Relations and the Dean of School of Economics, Business and International Studies at University of Piraeus, whose advice and proposals for further topics to be addressed, I am looking forward.

Contents

Abstract

In accordance with OPEC's date, Saudi Arabia holds 18% of the proven reserves and is the largest crude oil exporter. In addition, the oil and gas sector contribute the 50% of the nation's GDP and the 85% of exports revenues[1]. The oil price volatility affects in great scale its economy, and as a consequence, the kingdom has a strong interest in the price levels. For Saudi Arabia, not only has been attributed the role of the price regulator but also that of the discipline enforcer among the OPEC members. The whole debate has come up again after the 170th OPEC meeting in Algeria on 28th of September 2016. It was there where the rebalancing of the oil market was agreed, and they decided for a production cap between 32,5 and 33 Mb/d.[2] OPEC members also decided to seek cooperation with other non-members producers. In this thesis, we examine the drivers and Saudi Arabia's behaviour during the last 2,5 years.

[1] Amy Myers Jaffe and Jareer Elass, SAUDI ARAMCO: National Flagship with Global Responsibilities, Rice University's Baker Institute for Public Policy, March 2007.
[2] OPEC, 170th (Extraordinary) Meeting of the OPEC Conference, http://www.opec.org/opec_web/en/press_room/3706.htm, (accessed 22/10/16).

Chapter 1: Introduction

1.1 Introduction

Saudi Arabia possesses 18 per cent of the world's proven petroleum reserves and ranks as the largest exporter of petroleum, according to the Annual Statistical Bulletin from the Organization of Oil Exporting Countries (OPEC, 2016a). The oil and gas sector accounts for about 50 per cent of its gross domestic product, and about 85 per cent of its export earnings. Following almost a decade of high crude oil prices, the main two Sovereignty Wealth Funds of the Saudi Arabia, namely the Saudi Arabia Monetary Agency Foreign Holdings and the Saudi Arabia Public Investment Fund, have increased sharply their revenues, leading to total reserves (including gold) of 734 billion US dollars in year 2013, according to the Sovereignty Wealth Fund Institute (SWFI, 2016). Considering that the evolution of Saudi Arabia's reserves has been increased over the last decade, with high oil prices, it derives that crude oil price strongly affects Saudi Arabia's earnings.

Therefore, Saudi Arabia has a strong interest to keep crude oil prices at high levels, even if this requires to decrease its own production. This is exactly the production model of the OPEC, where the participating oil exporting countries agree on their production rates and Saudi Arabia, as the largest producer, is acting as the swing producer, namely, readjusts its production compared to the fluctuations of the production from other countries and the evolution of global crude oil demand. However, the participating countries in the OPEC are deviating from their commitments, concerning their productions rates, due to internal problems of production or aiming at supporting their balances. This practically affects the production share of Saudi Arabia and therefore its profitability. This leads Saudi Arabia to doubts concerning performing its role as swing producer. Moreover, external -to OPEC- factors, such as the evolution of shale oil and gas in the USA, strongly affect the market share of all OPEC countries, challenging their profitability. This has led the OPEC countries, during the 170th (Extraordinary) Meeting of the OPEC Conference, to decide: "Based on the above observations and analysis, OPEC Member Countries have decided to conduct a serious and constructive dialogue with non-member producing countries, with the objective to stabilize the oil market and avoid the adverse impacts in the short- and medium-term." (OPEC, 2016b)

Therefore, it is of high interest to examine how Saudi Arabia is adjusting its crude oil production towards affecting the crude oil price and at what extent. This study aims at providing evidence on those questions, by developing an econometric model to estimate the crude oil production of Saudi Arabia, as related to critical factors such as crude oil stocks, price, other producers' production, demand, macro-economic factors and geopolitical concerns.

1.2 Literature Review

The main research question behind Saudi Arabia's behaviour is whether it behaves within the price-market share dilemma or not. Under this prism, Saudi Arabia, as a producer, has to choose between lower production, meaning higher price and market share, meaning lower price. Most researchers describe this trade-off between higher price and market share as if Saudi Arabia is a rational monopolist, attempting to maximise revenues. Since oil was perceived as a commodity in scarcity, a rational monopolist would put the hand on the pump, allowing low volumes to reach the market, at higher prices. This would maximize its earnings considering the low elasticity by demand side. The afore-mentioned will not continue for ever, and at some point, monopoly price will follow a declining course falling even lower than the competitive price. It is this price course, that Mabro (1991) highlights, and argues that producers cannot obtain the optimum, but they can only have increased revenues compared to what they would earn in competitive markets. This conclusion is in contradiction to what Pindyck (1978) argued, as under his theory monopolists were gaining enough to cover cartelization costs.

In addition to these theories, some researchers pose that other countries than Saudi Arabia also produce oil. Since oil is not produced by only one country, its revenues are realised by different economies and most significantly, they have different reserves. Two criteria were used to examine these divisions among producers. The first was endowment and the second was earnings time preference. Under this theory, countries are divided between price pushers, hard core, and expansionist fringe. Since Saudi Arabia has a lot of advantages like the largest reserves, ample spare capacity, and low-interest rates, it will prefer lower prices than what other countries would (other producers attempt to maximize wealth earlier (Eckbo 1976)).

But under the theory of industrial organization, a producer has again to choose between price and volume. This dilemma is in direct relation to the respective compensation a producer has when he sacrifices either price or volume earnings. If this is not the case, and a market share increase does not offset lower prices, then volume decline is the best countermeasure. Oil production is not immediately adjustable neither oil demand. As a result, both of their elasticities are inelastic in short run. If a producer tries to oversupply in a low or declining price environment, there will be no compensation resulting in revenue decline (Mabro 1998).

But the question remains. Who should cut the output and to what extent? Many believe that Saudi Arabia should be the first to cut production. On the contrary, Saudi Arabia has denounced the role of the swing producer and urges for collective agreements. In order to highlight this urgency, the kingdom requires the cooperation of non-OPEC countries. But even within OPEC, there is no agreement over volumes. Members tried numerous times to allocate volumes based on producers' characteristics but failed due to objections. In addition, even if countries agree over volumes, there is no monitoring and predesigned punishment for the violator. Even if members of OPEC realise that someone is cheating, this will be with a lag and not instantly. The inability to monitor and punish the cheater instantly were proved by Kohl (2002) and Libecap and Smith (2004).

Geroski et al. (1987) proved that there is no perfect collusion and as a matter of fact it is hard for optimum practices to be followed, especially since competitors' response is also a decision driver. Their finding was later strengthened by Almoguera et al. (2011) who find that producers waver between collusion and non-cooperation. All the afore-mentioned gave rise to the question over how Saudi Arabia reacts. Griffin and Nielson (1994) prove that Saudi Arabia is eager to accept profits if they are higher than Cournot level profits. But if cheating among members becomes prevalent, it will raise production to bring profits back to Cournot levels, punishing cheaters.

Moreover, it is Saudi Arabia's interest to avoid price wars. This is supported, by previous research, using game theory approaches. Stigler (1964) marks price wars as the prelude of collusion. Porter repeatedly recognized price wars as the result of a non-cooperation game - (Porter 1983 a, b), (Green and Porter 1984). When prices are high, each producer uses all his capacity. No one is willing to cut production as this would raise the prices for the rest, and would put demand under threat. If prices fall, then one should balance the tradeoff, between short-run revenues and others' reaction, to increase his market share. Since collusion is not easy for every period Haltwinger and Harrington (1991), find that a producer is more eager not to abide by output collusion when demand is falling. This is already known to the Saudi Administration, and this is the reason why ample capacity is kept. If a producer tries to increase output, Saudi Arabia increases its output in order to eliminate any temporary gains.

The above analysis highlights that although OPEC countries have resulted that agreeing on the production rates would keep oil prices at favorable levels, this is not actually happening. Therefore, the strategy of Saudi Arabia on its production rates, is uncertain, as decision making on that is being affected by several factors. This is the aim of the study, which has not been extensively examined in the literature, especially related to the latest development of the shale oil revolution. This adds further external -to OPEC- factors in the decision making of the production strategy of Saudi Arabia.

Chapter 2: Global outlook and market data-projections

2.1 Oil statistics

The year of 2015 was not a good year for oil prices as Brent averaged 52,39$/b, which was the lowest annual average since 2004, and a rapid decline from 2014's average by 46,56$/b.

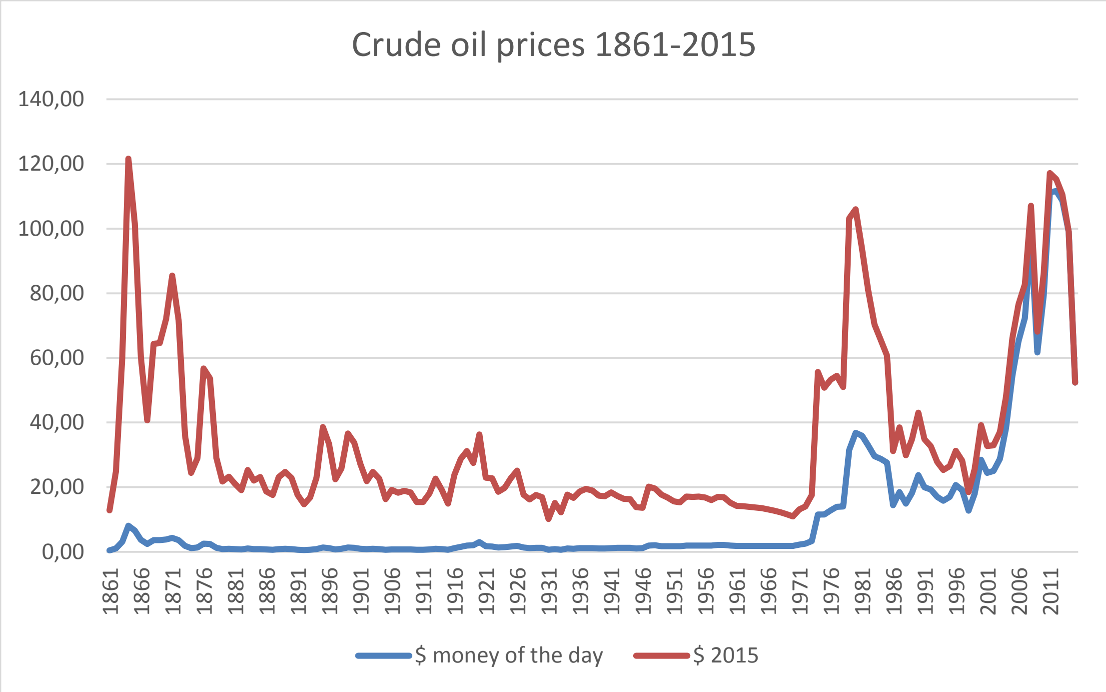

Figure 1 Crude Oil Prices 1861-2015

Source: BP Statistical Review of World Energy June 2016

The aforementioned decline came as a surprise, as global oil consumption increased by 1,9 million barrels per day or 1,9% positively compared to that of 2014. This strong increase is significant as the historical average is almost the half of it. To highlight global oil consumption increase it is useful to mention that the world increased its consumption by 1,1 Mb/d in 2014. The strong consumption came primarily from OECD countries which increased their consumption by 1,1%. OECD countries consumed 510.000 b/d more, reversing the average 1,1% decline in the last ten years. USA were the champion among the OECD countries which added 290.000 b/d and EU followed with 200.000 b/d. Again, both of them had increases (1,6% and 1,5% respectively) that surpassed the average of 1,1% of OECD countries. On the contrary Japan refrained from oil consumption by 3,9% or -160.000b/d.[3]

The pattern was also followed by Asian importers. China again increased its consumption by 770.000 b/d or 6,3% and India became the world's largest oil consumer by increasing its

[3] BP Statistical Review of World Energy June 2016

consumption 8,1% or 310.000 b/d. Non-OECD countries as a whole did not follow suit with their previous historical averages and they increased their consumption by only 1,4 Mb/d or 2,6%.[3]

What brought price down was an asymmetrical oil production increase for a second successive year. Global oil production increased by 2,8 Mb/d or 3,2% which was the highest since 2004. Countries such as Iraq and Saudi Arabia rose their production to historical high levels. Iraq added 750.000 b/d and Saudi Arabia other 510.000 b/d rising OPEC's production to 38,2 Mb/d. As a consequence, countries outside OPEC increased their production by 1,3 Mb/d which was a lower increase than that of previous year's. A country outside OPEC with significant role are USA which remained as world's largest oil producer by adding 1 Mb/d and had the highest production growth. Other countries followed suit as Brazil (+180.000 b/d), Russia (+140.000b/d) United Kingdom and Canada (+110.000 b/d each) covered oil disruptions by Mexico (-200.000 b/d) and Yemen (-100.000 b/d).[3]

2.2 Refining and trade

Crude runs were increased by 1 Mb/d in the OECD as high refining margins prevailed. The growth in Europe was the highest since 1986 (+740.000 b/d). On the contrary global refining capacity had its lowest increase since 1986 (450.000 b/d). This is justified by several closures in China, Taiwan and China which drove total Asian capacity to lower levels, something which had to happen since 1988.[3]

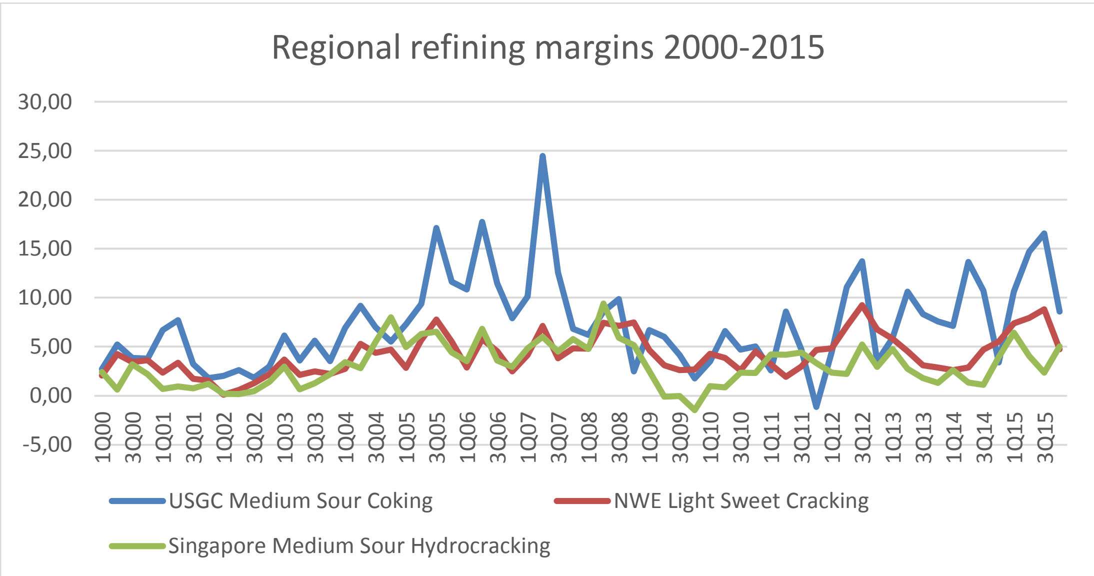

Figure 2 Regional refining margins 2000-2015

Note: The refining margins presented are benchmark margins for three major global refining centres: US Gulf Coast (USGC), North West Europe (NWE – Rotterdam) and Singapore. In each case, they are based on a single crude oil appropriate for that region and have optimized product yields based on a generic refinery configuration (cracking, hydrocracking or coking), again appropriate for that region. The margins are on a semi-variable basis, i.e. the margin after all variable costs and fixed energy cost.

Source: BP Statistical Review of World Energy June 2016

This was not enough to slow down global refinery utilisation which reached the 82,1% or increased by 1%, which was the highest during the last five years. Crude oil and its refined product trade was increased by 3 Mb/d or 5,2% compared to that of 2014 and were the highest increase since 1993. This kind of growth was justified by growing Middle East Exports (+550.000 b/d) when Europe imported 770.000b/d more, and China followed with +550.000 b/d. The USA was again the champion in refined product exports as they increased their volume by 470.000 b/d. As the highest oil and refined product producer, US narrowed their net oil imports to 4,8 Mb/d which was the lowest since 1985.[3]

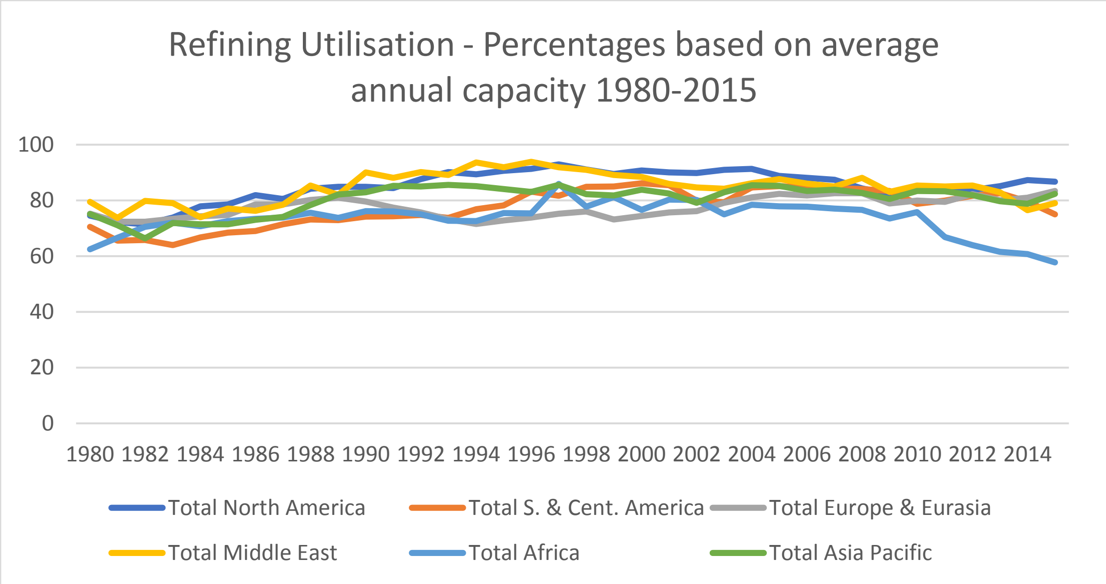

Figure 3 Refining Utilization

Source: BP Statistical Review of World Energy June 2016

2.3 Energy in connection with GDP and population

Oil demand is driven by economic advancement and global population. There are various scenarios for the decades to come and their analyses over the projected energy demand. We will follow the scenario to 2035 by BP, published in 2016 as it is one of the most valid and well established. In this scenario, the world population is increased by 1,5 billion people, and by 2035 the total population is 8,8 billion. For the same period world's GDP, more than doubles justified by population increase for the 20% of the increase and the rest by productivity gains. Global GDP increase stems again from China and India which account for half of it.

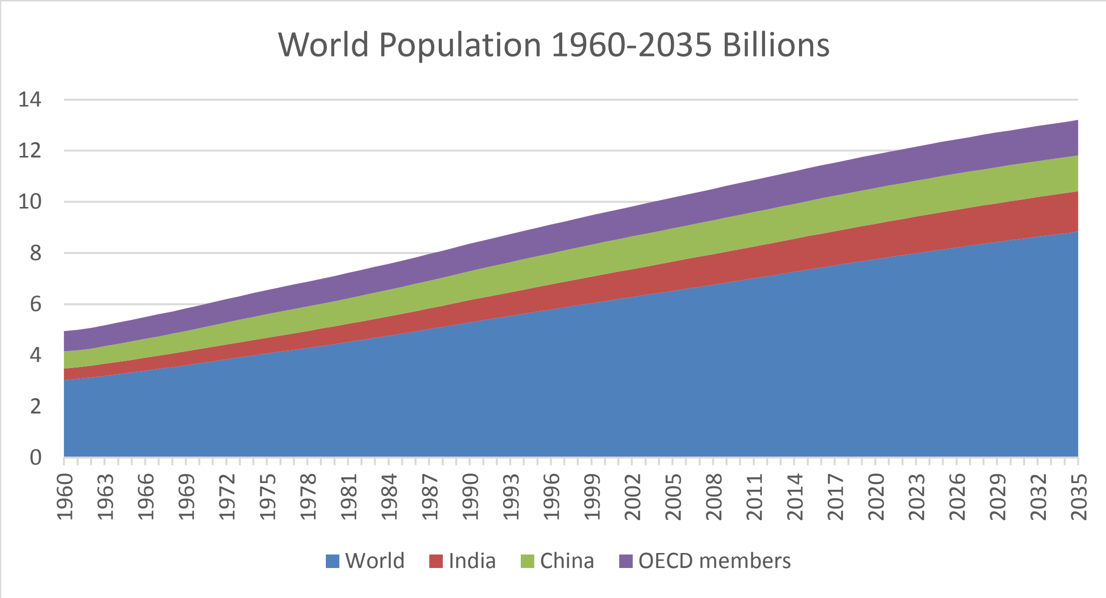

Figure 4 World Population projection Bns

Source: World Bank

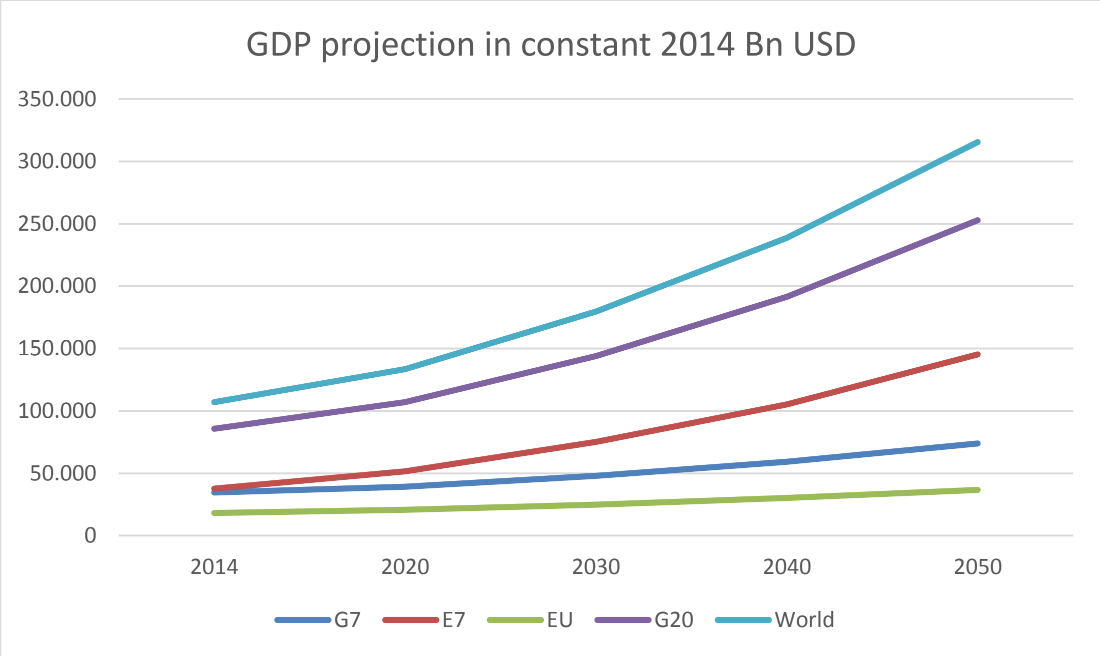

Figure 5 World GDP in constant 2014 Bns USD

Source: IMF World Economic Outlook database (October 2014) for 2014 estimates.

Global population will be increased mostly in Africa contributing 50% of the increase. On the contrary, Africa, will not contribute so much to the global GDP as only the 10% of the increase will come by it.

Population and GDP increase require more energy, and the global energy demand will follow suit, as by 2035 it will be increased by 34% to that of 2014. Developing countries will contribute to this increase as they will absorb mostly all of the increase. OECD countries do not require more energy and if this happens it will be to insignificant extent. Energy intensity lowers its pace. The annual energy growth falls from 2,3% for the period to 2000-2014 to 1,4%. In addition, global energy intensity is estimated to decrease by 2,1 per year for the period to 2035. This is the highest decrease in any 20-year period studied since 1965 and higher than the 1,5% per year which was the average declining rate for the last 20 years. Since China will have a declining energy intensity, global average will follow. OECD countries have a faster-declining rate of energy intensity in the last 20 years. Other major emerging countries will again follow, as they will turn their economies to industrialization, but this transformation will not be as energy intensive, as for the developed world in the previous years. The demand for energy in the future, even with declining energy intensity, will be strong enough. Even if the average energy intensity followed the previous course (decline by 0,9% per year), then the energy demand will increase by 71% and not 34% which is the base scenario

Fossil fuels remain the primary energy source and contribute 60% of the energy increase and 80% of total energy supply in 2035. Their persistence is remarkable as they now account for the 86% of the total energy supply. Oil will have a steady increase in this projection as it will grow by 0,9% per annum, although it will continue to lose share to natural gas. Combinedly the increase of oil and gas is identical to that of the previous 20 years.

The emission's growth rate is estimated to be halved to what it was in the last 20 years (0,9% to 2,1% per year). There is a carbon emission-energy consumption decoupling which will be pursued further more intensively, and falling energy intensity will help to that direction.[4]

2.4 Asian markets and demand drivers

As it is also noticed lately and after the 170th meeting of OPEC, the market rebalances. Low prices increase demand and supply cuts help to this direction. Liquid demand (oil biofuels and other will increase by 20Mb/d till 2035 reaching the total of 100 Mb/d. The vast majority of the increase comes from emerging economies as OECD ones continue to lower their demand by 5Mb/d. China and India, the main emerging economies account for over the 50% of the growth. China will not follow the previous path, and its energy demand will grow less per annum compared to the previous years (lower than 2% to 8% of the years from 2000). This is due to the economic slowdown; the economy will grow by 5% pa on average half of what was from 2000. China also moves from the construction-industrial sector to the service sector decreasing its energy intensity. Moreover, China is expanding its efforts towards more sustainable and efficient energy use.[4]

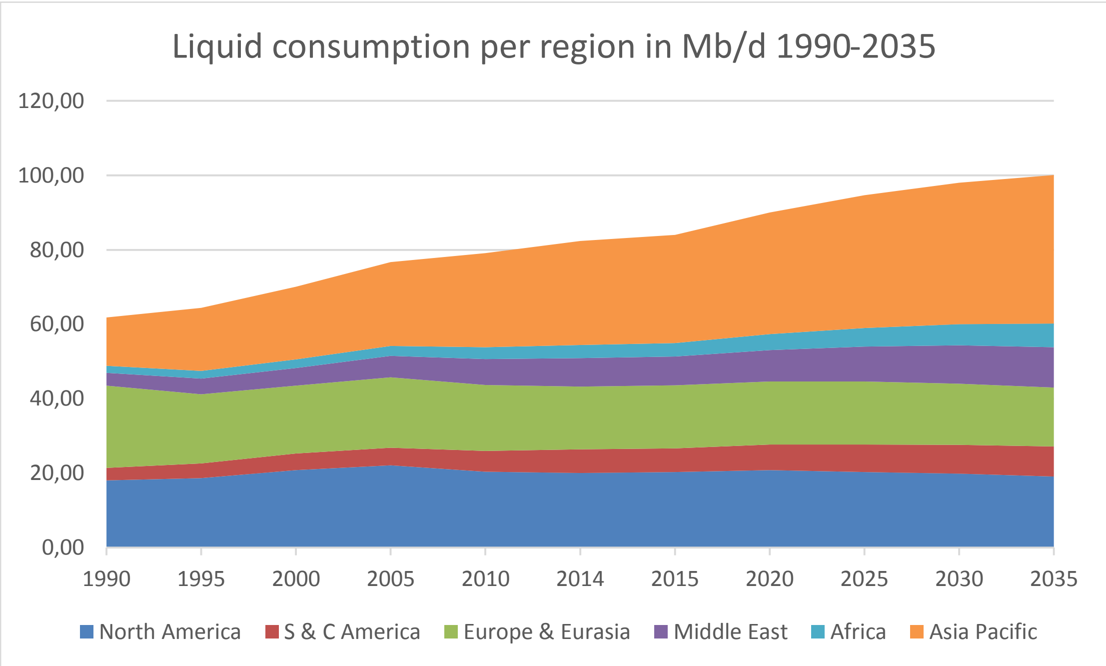

Figure 6 Liquid consumption per region

Source: BP 2016 Energy Outlook

[4] BP 2016 Energy outlook

Non-OPEC countries continue to augment their supply with 11 Mb/d. This growth comes from US shale, Brazilian Deepwater and oil sands of Canada. OPEC follows the increase in a lesser extent by only 7 Mb/d. Global liquids supply will be increased by 19 Mb/d, with non-OPEC countries to hold the majority of growth as USA shale, Brazilian Deepwater, and Canadian oil sands will contribute the 16 Mb/d of them. These three production resources will account for half of the non-OPEC production in 2035. OPEC will hold its market share of around 40% by increasing its supply by 7Mb/d reaching the 44Mb/d by 2035.

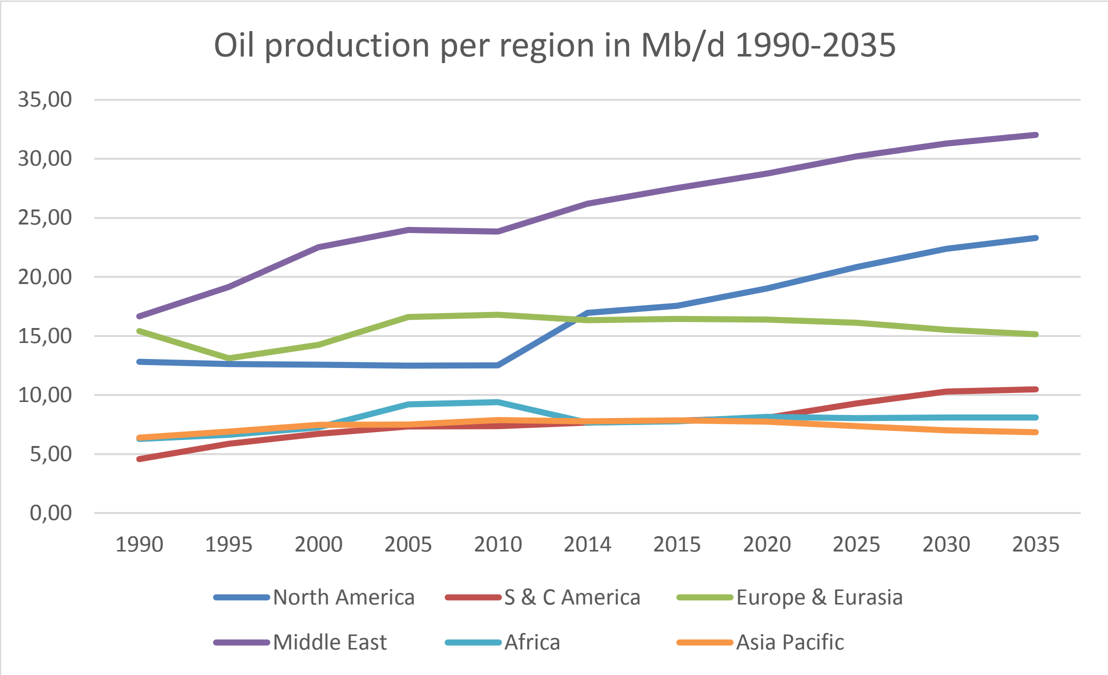

Figure 7 Oil production per region

Source: BP 2016 Energy Outlook

This sharp increase in America’s production leads to its import reductions in the continent and the ones net importers become exporters. Self-sufficiency is close, and the lift of oil exports in US oil in December of 2015 will result in the aforementioned reality. On the contrary, Asia will continue to depend on imports. All of the growth in global imports will head to Asia.

9Mb/d of the 19Mb/d of the increase in liquid supply will not require refining. Current refining capacity with added additions is more than enough to cover the growth in crude supplies in the next couples of years (10Mb/d). This global refining overcapacity will result in margin volatilities which will exit less efficient and distant refineries from the market.

The main use of liquid fuels is for transport and industry. Transport accounts for two-thirds of the increase. Emerging economies expand their vehicle fleet and fuel efficiency only slows down the growth in the post-2025 era. World’s vehicle fleet more than doubles to 2035 reaching the 2.4 billion. Oil dominates transport fuel by 88% in 2035. The share of non-oil fuel only increases from 7% to 12% by 2035. Petrochemical industry will be the second driver of oil demand growth. The industry used oil is approximately 40% non-combusted meaning unaffected by environmental policies.

This kind of boom is mostly projected in emerging economies. Non-OECD countries triple their fleet reaching 1,5 billion cars surpassing the OECD countries by 2020. Developed countries like USA and Japan are close to reaching their peak when it comes for their fleet. Efficiency will moderate this projection as a car in 2035 will travel 50 miles per gallon compare to the 30 miles per gallon today. Car efficiency advances in a rapid rate since it is increased by 2-3% per year compared to the 1,5% of the last decade.

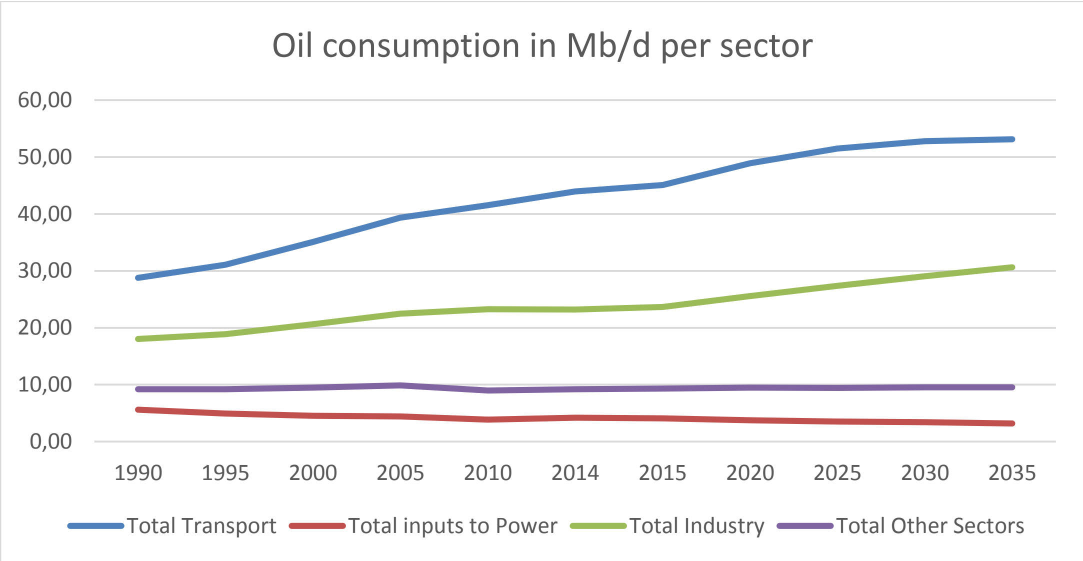

Figure 8 Oil consumption per sector

Source: BP 2016 Energy Outlook

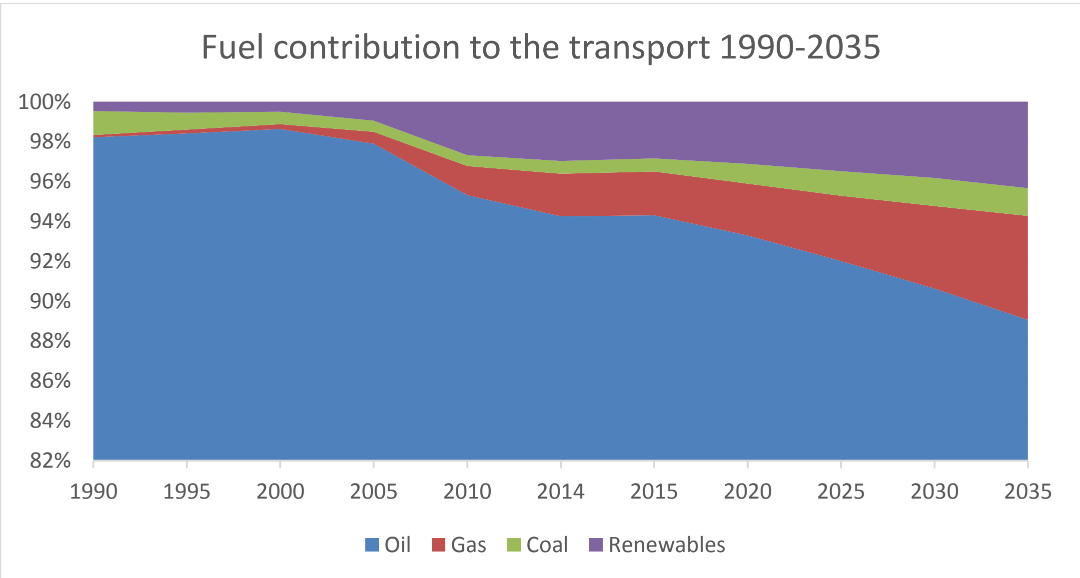

Figure 9 Fuel contribution to transport

Source: BP 2016 Energy Outlook

Chapter 3: Factors of oil significance over the Kingdom of Saudi Arabia

3.1 What makes oil so important for SA

Saudi Arabia is mostly dependable on crude oil production. As already mentioned its economy was primarily focused on exporting unprocessed crude (later we will discuss for the refining shift in SA). The kingdom is heavily financed by oil and the crown jewel, Saudi Aramco, is the greatest economic actor. Saudi Aramco supplies 10% of world demand and manages 25% of the world's oil reserves.[5] It does not own the reserves but has the exclusive prerogative of exploiting them.

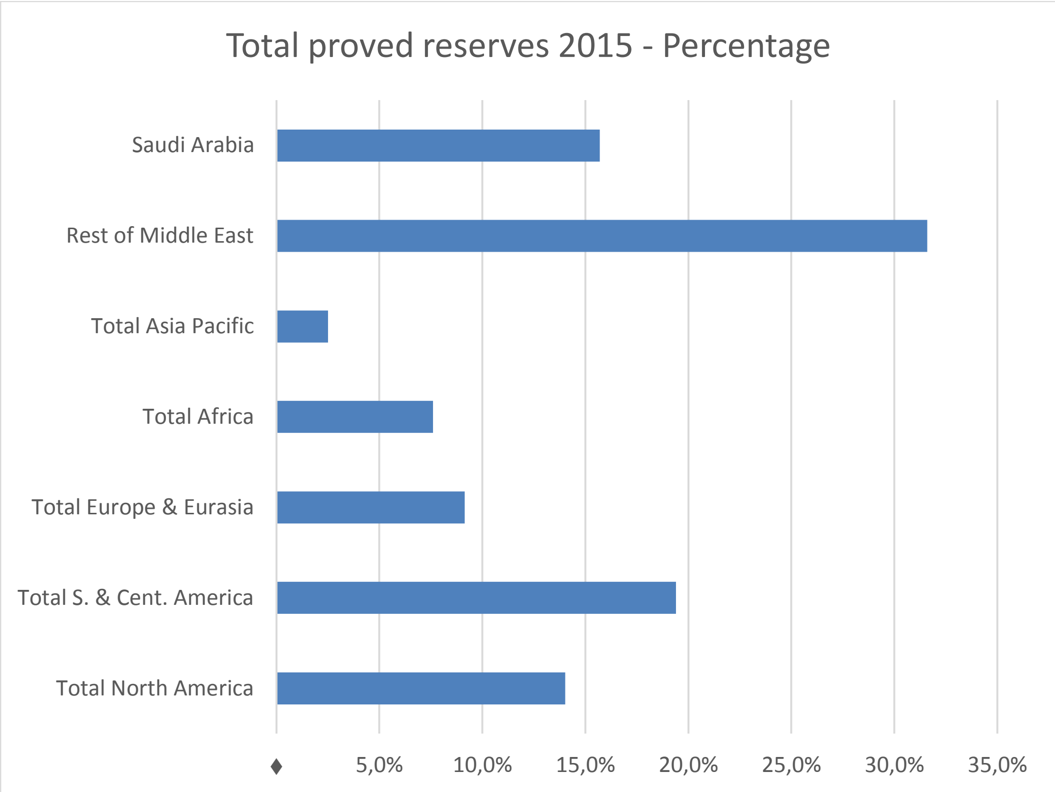

Figure 10 Distribution of total proved reserves - end of 2015

BP Statistical Review of World Energy June 2016

Its dependence is even more obvious when the state budget is examined. Oil sector participates by 40% in GDP. Crude exports account between 80% to 85% of export revenue. The oil revenue used by general government covers 70% to 80% of total budget.[5] Many believe that the last events of oil revenue decrease, deficits, and state budget balancing just present the suffering of the Dutch disease.

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[5] Amy Myers Jaffe and Jareer Elass, SAUDI ARAMCO: National Flagship with Global Responsibilities, Rice University's Baker Institute for Public Policy, March 2007.

One more reason which adds to the importance of oil to Saudi Arabia is the gigantic proven reserves. Saudi Arabia can continue to pump out oil for decades with the same pace. The proven reserves reach the emphatic quantity of 267 billion barrels. World demand can be sufficiently supplied not only for the years to come but for at least the next 63 years.[6] The reserve to production rate is considered among the highest, even if there are some doubts over its credibility. The magnitude of the reserves drove kingdom's preference for long-term contracts.[7]

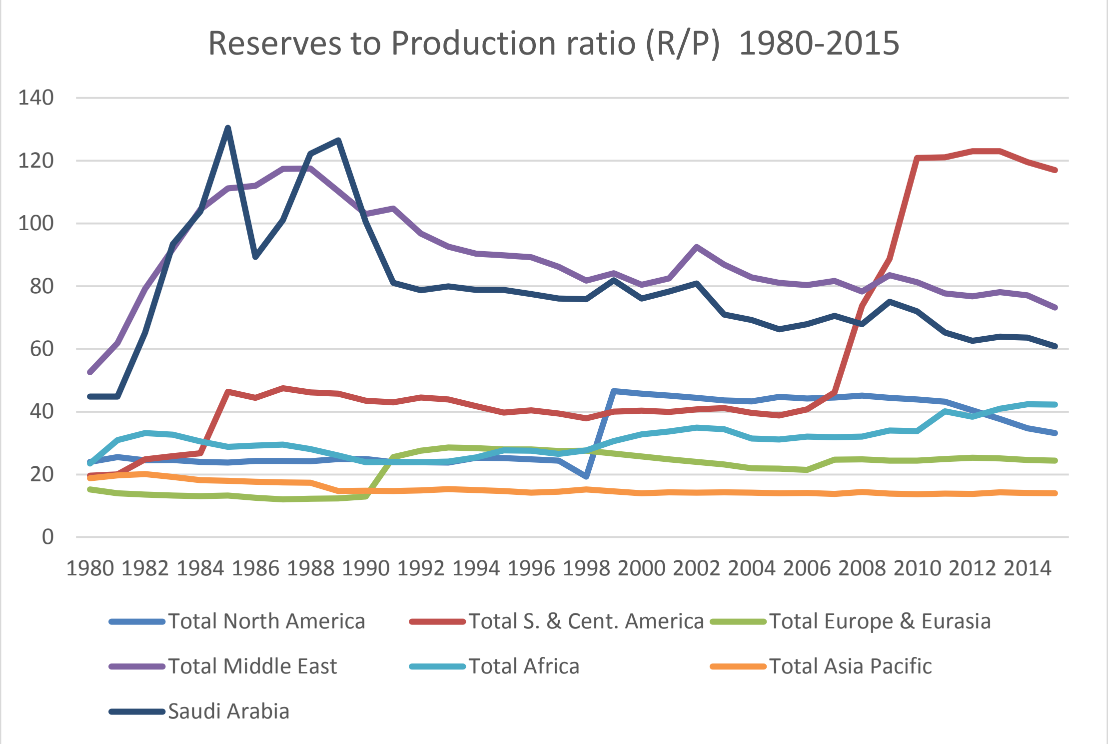

Figure 11 Reserves to Production ratio

BP Statistical Review of World Energy June 2016

Country's export volumes and reserves gave the initiative among the rest of the producers. Saudi Arabia's place is unchallenged as 9.5 Mb/d were produced and the 7 Mb/d of them were exported in 2014.[8] The variety of its oil quality is not homogenous supplying all the kind of refineries with different input specifications.

Saudi Arabia's oil production and reserves are only the first reasons to consider when examining the price levels, but an even more important factor is that the kingdom pursued and

[6] Bassam Fattouh and Anupama Sen, Saudi Arabia Oil Policy: More than Meets the Eye?, Oxford Institute for Energy Studies, OIES PAPER: MEP 13, June 2015.
[7] Beyond OPEC, Saudi Arabia's oil policy, The Economist, 14/5/2016, http://www.economist.com/news/finance-and-economics/21698695-kingdoms-new-oilman-chief-will-have-less-time-cartel-beyond-opec, (accessed 18/10/16).
[8] Bassam Fattouh and Anupama Sen, Saudi Arabia Oil Policy: More than Meets the Eye?, Oxford Institute for Energy Studies, OIES PAPER: MEP 13, June 2015.

succeeded to have a long-standing ample spare production capacity. For political rather economic reasons SA always holds spare capacity that gives the initiative to respond to any disruption event. It took only 90 days to replace the lost Iraqi and Kuwaiti production during the first Gulf War in 1990.[7] Their combined production was estimated at 3 Mb/d at that time. But spare capacity is always planned within desirable levels by the kingdom. Low levels of spare capacity remove the initiative of calming down the markets. When spare capacity is low, then it is impossible to take advantage of high prices caused by disruptions until they decline. Huge spare capacity would decrease the prices and as a repercussion investment return. So far there is no evidence that the kingdom will increase its spare capacity. New wells will only replace declining production reserves. Production and capacity probably will remain constant as uncertainties remain and the option of waiting for any favorable price change seems to cost less.

Chapter 4: Competitive forces

4.1 The US tight oil revolution

Much of the price decline was attributed to the US oil production increase. Shale oil was a game changer for many analysts across the world, and US producers' reactions were most anticipated in the industry. Saudi Arabia is well aware by this development and the battle for the market share began.

American unconventional oil production helped to balance disruptions in OPEC countries keeping prices stable for a series of years. The evolution from the small initial production of unconventional oil to flooding the US with oil is now considered as a revolution. Every OPEC meeting is discussed under the condition of how US producers will react.

Today, even Saudis consider US producers as the swing producers, a role long attributed to them. The justifications for this role change are many and complicated. Crude prices have been stable at high prices for quite a time. This was a temptation for US corporations to challenge Saudi oligopoly. Their attempts were mainly supported by Fed's response to the credit crunch. Quantitative easing and low-interest rates forced ample funds to exit financial markets and seek less risky opportunities. The momentum was ideal for new technologies to be tested in production scale. And there was a boom. The US in few years altered themselves from crude oil importers to producers, freeing up quantities for the rest of the world. Crude oil exported from West Africa and other parts of the world to the US such as Latin America and Saudi Arabia should find their way to more distant markets.

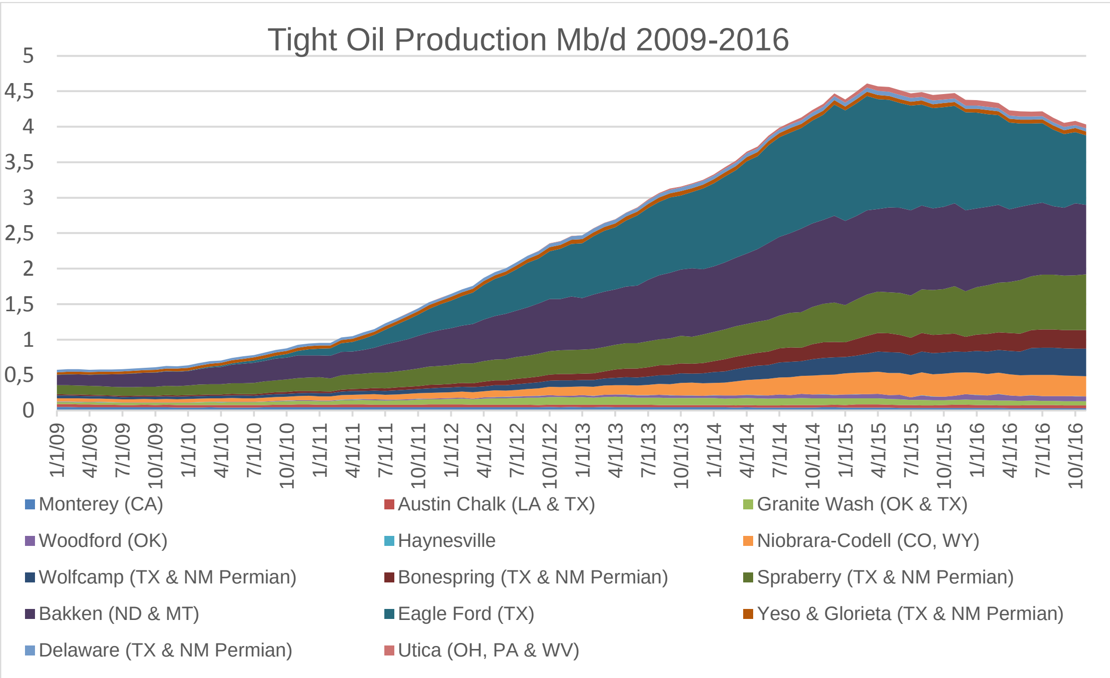

Figure 12 Tight Oil Production in major US basins

Source: EIA

The US should now find a way to export the overabundant commodity which for long was perceived as scarce. The ban on unprocessed exports and not on refined products gave the way out for the produced volumes. The US is the largest oil products exporter with 3.8 Mb/d in 2014. Remarkably, the most expensive distillates such as naphtha and gasoline tripled their exports rising at levels such as 0.5 Mb/d.[9] Projections for the US create an even more optimistic view as they are expected to be net exporters of light distillates by 2017. One development around the US market is the compromise achieved by Democrats and Republicans to lift the ban. On December 18th 2015, they reached an agreement to lift the crude export ban on an exchange to negotiate a five-year extent of tax credit to solar and wind power. This will complicate more the market as the American shale oil is light and sweet when domestic refineries distil more heavy and sour input. Exporting to Europe is expensive (3$) and not the best practice. Since only one year has passed it is quite early to predict how market dynamics will evolve.[10]

All the above could be described as a boon for US producers and refiners, but there is a downturn. OPEC refused to cut its production quotas when all the above was in the pipeline. Market dynamics pushed the oil price to very low levels, and US producers should adapt to the again changing environment.

US oil production is not assigned to any National Oil Company (NOC) but rather to several small private companies. The shift from high prices to low prices was very challenging for their balance sheets. They were mostly assisted by their size and technology.

US shale industry had the financial know-how and a mature market ready to supply hedging instruments to delay the impact of low prices on their earnings. Their future output was hedged. Technology played a second crucial role. Fracking emerged with new efficiencies lowering break even points.

[9] CIEP Clingendael International Energy Programme, Crude oil markets in 2015- The battle for market share, July 2015, KS-1518-WB16A.

[10] http://www.economist.com/news/finance-economics/21684531-light-sweet-compromise-puts-end-crude-market-distortions-america-lifts

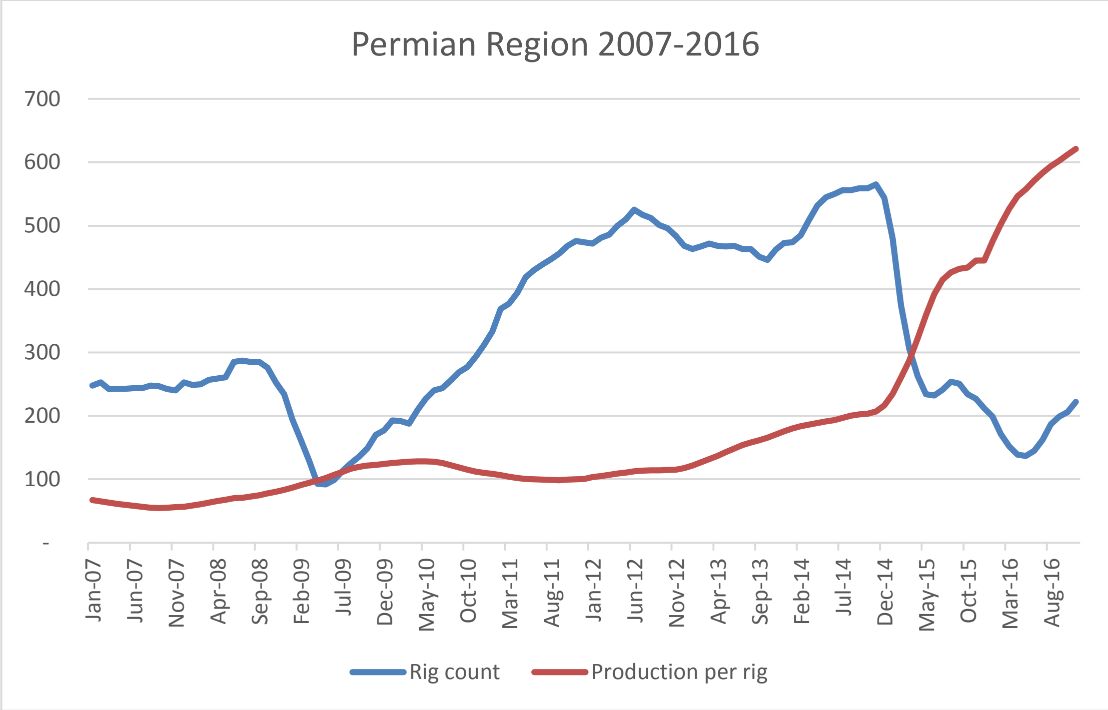

Figure 13 Number of Rigs and Production per Rig

Source: EIA

Fees also dropped for drilling operations making payback periods shorter, and production costs lower. The third countermeasure was cost reduction by increasing production in better basins while mothballing other less sweet spots. This is the reason why US production continued to increase until April 2015 (in February 2015 it reached 9.4 Mb/d) in a low-price environment and even when the number of rigs decreased.[9] The last but not least reaction was budget cutting either by postponing new investment or cost reductions. Apart from the less favorable prices, producers had to face their financiers' concerns over the extent of the credit lines they should provide.

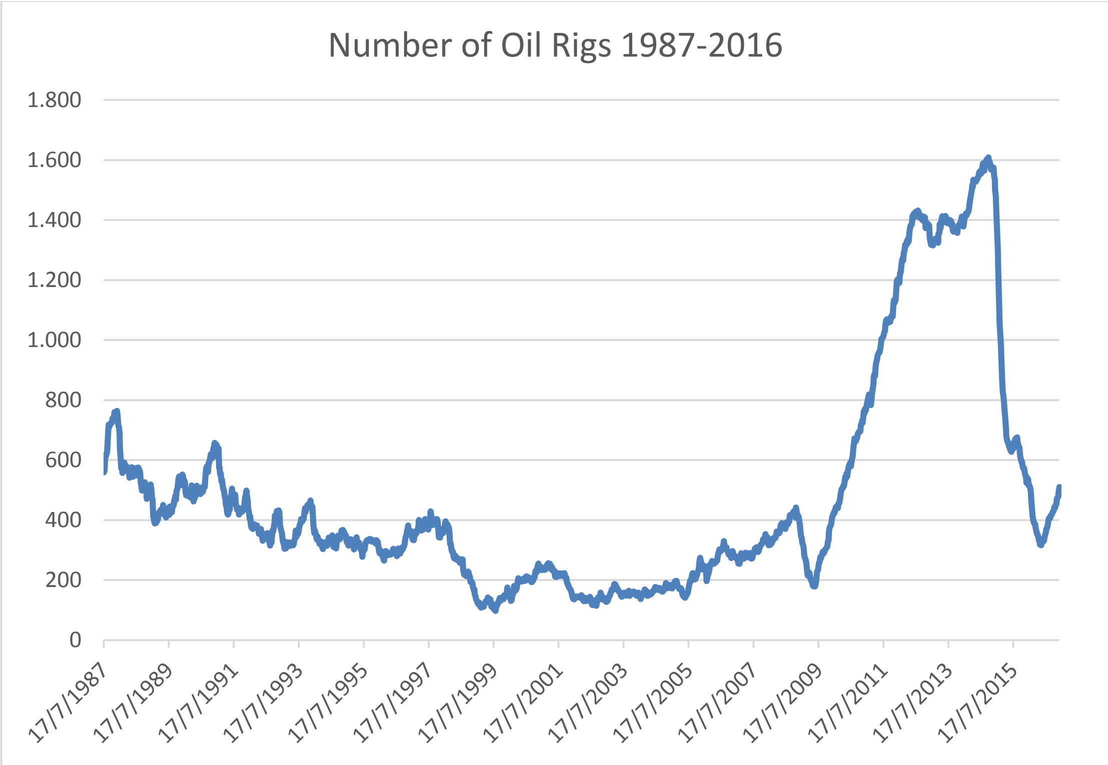

Figure 14 Baker Hughes Number of Rigs

Source: Baker Hughes

The option to wait became the mainstream policy, and US producers wait for the prices to climb. This is why they are considered as our nowadays swing producers. Their ability to respond rapidly and at low costs to oil price increases makes many economists estimate higher price elasticities of supply for unconventional oil producers. The same does not hold for price decreases as they can again hedge.

All the above constitute the belief that even if oil demand rises again, then due to the US swing production, we will not witness a price hike.

4.2 How Shale oil gained productivity

In order to understand how shale oil gained productivity one should turn his attention to measures over time, cost and production. An established measure for well productivity is the EUR or Estimated Ultimate Recovery factor. Initial 12 and 60month EUR have been increased by 41% and 22% between 2014 and 2016 in all basins.

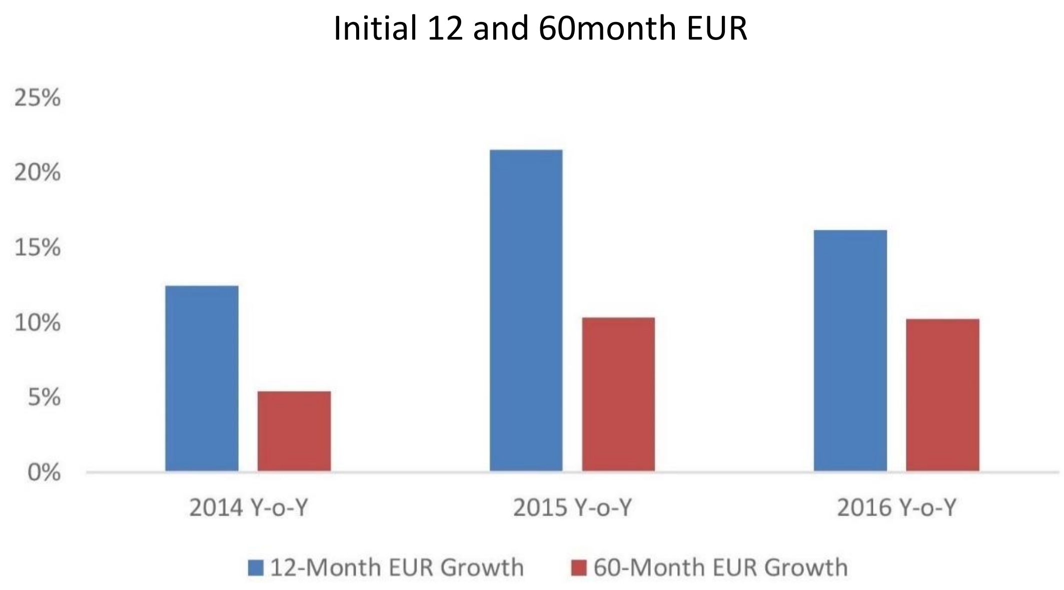

Figure 15 EUR increase in Permian, Bakken, and Powder River 2014-2016

Source: DrillingInfo Data, PetroNerds Calculations and Estimates

4.3 The Permian example

The Permian basin covers a huge area starting from West Texas to New Mexico. It has been exploited for almost a century by both ways with the unconventional way added lately, making it a hybrid play. Since the unconventional exploration, it reversed its declining production. From 2014 it succeeded to increase its production by one-third (500.000 b/d). Its production characteristics made it the most important play, and it has seen its value to skyrocket even with prices below 60$.

The late increase is justified by the implementation of new unconventional drilling techniques to reservoirs previously perceived as conventional. Bone Spring, Trend area, and Wolfcamp are great examples.

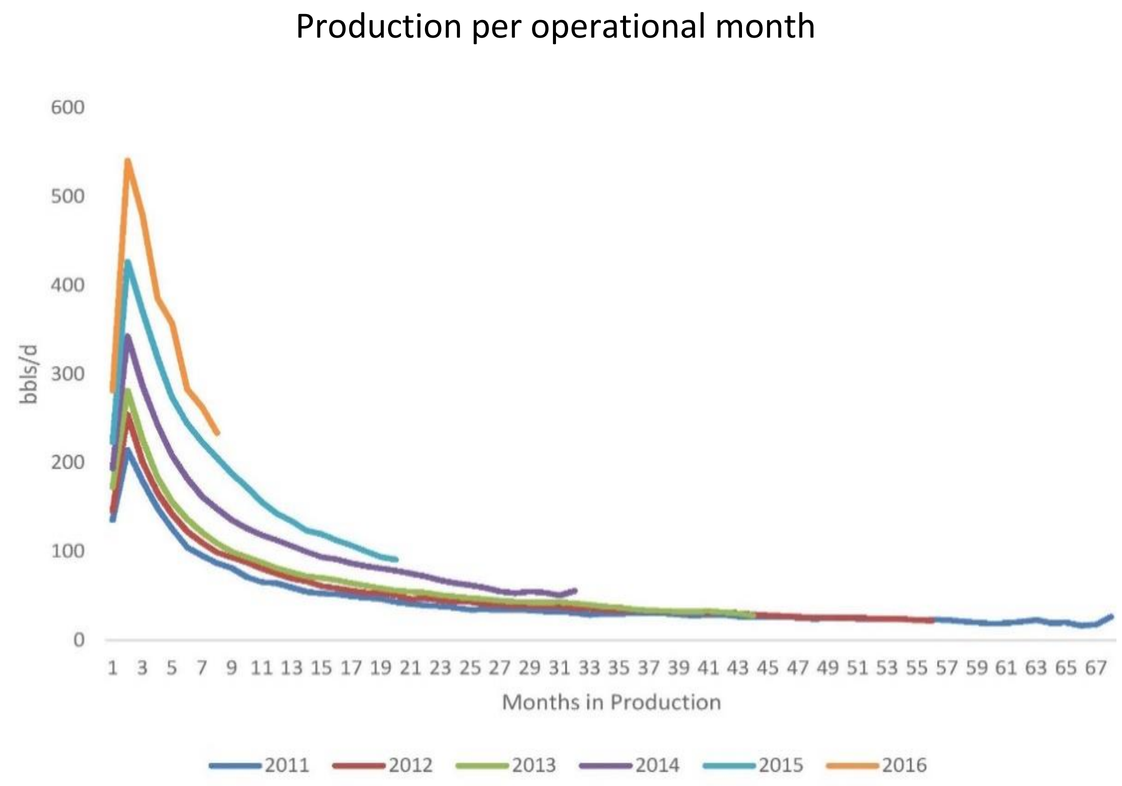

Figure 16 Permian basin type curves 2011-2016

Source: DrillingInfo Data. Horizontal wells only

The initial production rates increased by more than 200 b/d between 2013 and 2016. In 2013 a well had a IP rate of less than 300 b/d in 2013 to over 500 b/d in 2016. Again, the Permian received most of the attention as more wells were added than that of Williston, Powder River and Eagle Ford basin together. More impressing is the increase due to horizontal drilling. There was a steep increase in horizontal production with few wells compared to the vertical ones. Now horizontal oil production reached the 1,2 Mb/d when in November 2014 was just over 750.000 b/d.

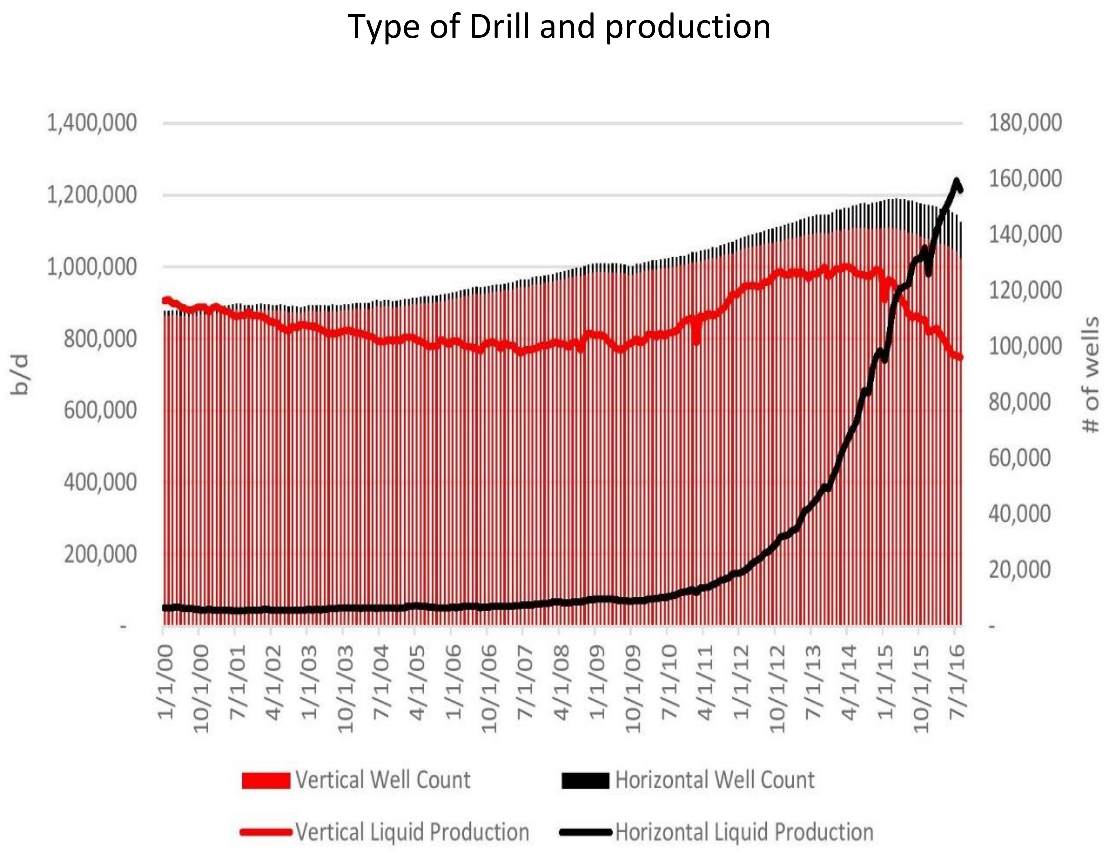

Figure 177 Permian's basin oil production (horizontal and vertical wells) 2000-2016

Source: PetroNerds, DrillingInfo Data

4.4 Factors behind the productivity gains

4.4.1 Fewer wells as new wells are halted.

Low production producers who face significant financial burdens due to the lower prices have decided to postpone new investment in drilling or to just reduce the rate of wells they added. The later no to the same extent participation of low productivity/production producers to the sample, shifted the 2015 and 2016 declining curves of average production upwards.

It is easy to understand that each year between 2014 and 2016 fewer and fewer companies added wells. This downturn forced small and limited cash operators to behave in two ways:

1. Few continued to add wells at the same or at an even higher rate, to have cashflow even in a declining price environment.
2. Others considered the option to wait as of greater value and reduced, if not eliminated drilling operations. Their activity will revive if prices were to increase.

Since the latter behaviour removed new wells of low productivity from the sample number, the productivity curves shifted upwardly. Producers turned their attention to sweet spots leaving non-core areas of plays (low production/productivity plays). Since drilling and well completion costs are mostly stable, a producer in order to have a higher return and shorter pay-back period will refrain from low production areas when low price prevails. This also transforms productivity as geology performance constitutes their options until prices rebound.

Productivity gain by less migration

Producers concentrated their efforts to find spots where they could exploit more than one reservoirs. So, they abandoned the previous logic of migrating to a certain reservoir from a single point. They started to reach different layers by only one spot and then combine them.

The Permian Basin is a good example where productivity doubles or even improves for certain operators. The Permian basin started as a conventional oilfield with vertical wells prior to 2014, but with unconventional tight oil drills reaching deeper layers and wider spots from the same well, it was made among the most noticed plays in the world.

Productivity gains by lower costs

When low price environment started to prevail, companies considered high intensity and grading-the act to choose the best acreage for exploration and inject low-cost sand to the well-as means to increase production. By both practices initial production rates and cash flow were raised in the short term.

Additionally, operators tried to gain productivity gains by a two-step approach. Easier than anything else was to reduce costs by asking deep discounts from vendors and service providers. The latter followed suit in order not to exit the market. The second step was that of efficiency gains. Drills' completion times and design became faster and more accurate. The fracture was treated with more accuracy, and lateral placement was already more precise. Both ways contributed to a between 25% and 45% decrease in drilling and completion costs, but it is quite doubtful that deep discounts will remain as prices rise. Oilfield service providers have decreased their prices in order to complete the wells and conduct fracking for the well operators.

The whole industry had a downturn from 2015 and onwards as more than 100 service provides filed for bankruptcy laying of thousands of people. Trying to avoid general disruption, prices for equipment and installations collapsed. Tank batteries, frack sand and pump jacks were either sold or rent for a fraction of their previous value.

4.4.2 Research and Development advances

Today even if drilling to total depth is an issue of few days, the period both pre-and post-drilling is slower making easier to collect data and drill more efficiently. Better understanding of the geology and quality of rock enabled more rigs, geosteering technology, longer laterals and increased horsepower and pumping. But this option was only available to well-established companies with ample finance removing the low productivity operators.

Lateral drilling depths increased even with companies asking for shorter drilling periods while on the contrary productivity did not decrease. This is in contrast to what one should expect as asking more in less time would cause more mistakes in drilling performance and placement.

4.4.3 Low costs

Since low prices both in equipment and project installation remain for over a year and a half, many operators took advantage of it and proceeded with project upgrades. All this kind of infrastructure built during the low-cost period will operate in few days if prices increase. The downturn was perceived as periodical, and many started wells leaving them in the last stage of completion. As a result, there is a backload of drilled but uncompleted wells (DUCs) which will be in few days completed if prices take a hike.

In tight oil industry, capital expenditure is considered as sunk cost, and leaving a project in mid-construction phasis not only frees cashflow for the company but leaves it with the option to continue in more favourable environment.

Less waste more productivity

Better understanding of completion designs, geology and geophysics let operators to drill more effectively the reservoirs directly to the pay zones, or this is what they claim. This led to later higher initial production rates and Estimated Ultimate Recovery.

Drill owners do not require extended fractures nowadays but rather keep them in short distance to the wellbore, in order to drain the reservoir and then have an other lateral to continue. As a result, they move from reaching distant fractures to having more lateral drillings closer. The danger which was considered as significant in the past (wells communicating between them leaving oil in the soil) is again faced with better geophysics. Concentrated lateral wells increase reservoirs recoverable quantity.

The aforementioned are only the case for companies with spare financial resources as during the price boom very few developed research and development. Most of the companies neglected to collect soil data from their wells and later analyse them. What was prevailing during the high price environment was a repetition of drilling and fracking without any attempt to reduce waste. Schlumberger oilfield service company estimated that up to 40% of a wellbore's fractures were contributing to the production.

All the above waste was decreased by not advanced developments but by rather more detailed planning.

Chapter 5: Developments in the oil market

5.1 Saudi Arabia's reaction

A lot have been said about Saudi Arabia's ability to channel oil prices by putting the hand on the pump. Markets perceived oil as a resource in scarcity. Production volumes had a direct negative correlation with prices. With all the above, it is easily understood that oil producers had two major concerns, oil price, and market share. If a producer offered a deep discount, he might win extra market share, but this should cover the loss caused by the new lower price. Market share and price are examined in short-term and long-term horizons and then the optimal strategy is tried to be pursued.

The oil producer's nightmare, even if it is for the short run, is to see his market share lost or decreased when low prices prevail. This tradeoff between price and volume was at the forefront in 1986 and 1998. In 1986 volumes went up by producers to gain revenues as prices do not decline simultaneously and follow with a lag. The opposite choice was made in 1998.[11]

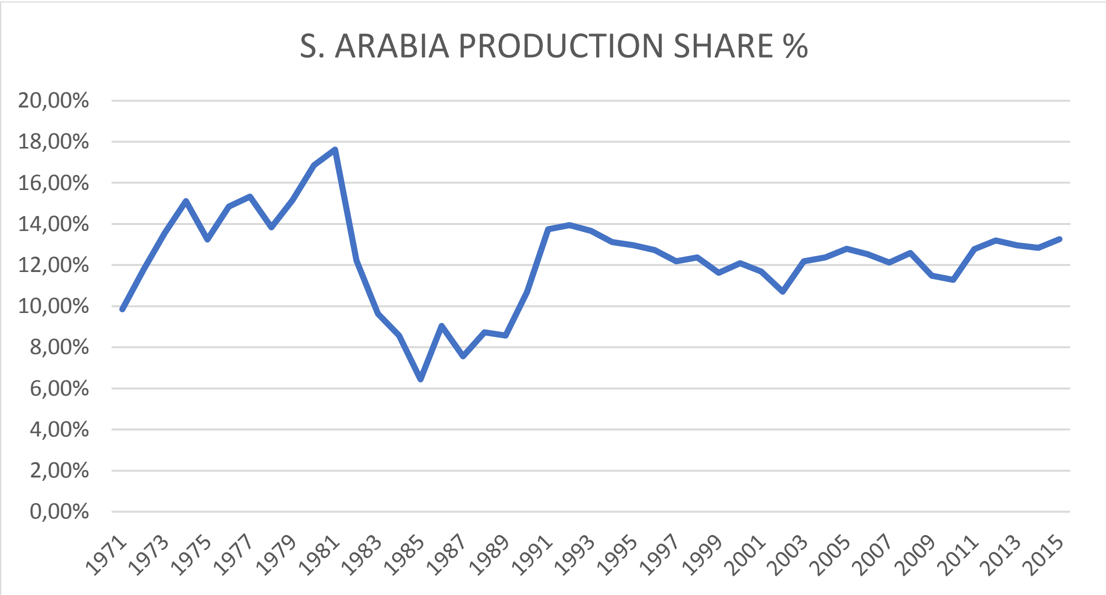

Figure 18 % Saudi Global Production Share

Source: IEA

[11] Bassam Fattouh, Oil Market Dynamics: Saudi Arabia Oil Policies and US Shale Supply Response, Hague, Oxford Institute for Energy Studies, "Crude and Refined Products Markets: Transient shock or secular change?", Workshop, 18/3/2014.

5.1.1 Signaling

Saudi Arabia, after the 1973 embargo, never used oil as a political instrument rather than preferred signaling. Signals are sent both for the short and the long term. For the short term, Saudi officials used the production announcements and press conferences. The administration also used less formal ways of communicating its signals besides the well-established official ones.[12] Signals are mostly considered as they may precedent OPEC discussions. The majority of analysts try to speculate the reasoning behind every signal.

For the long run, Saudis used investment announcements. Since Saudi Arabia is the top producer with the largest reserves, an investment expansion or postponement revealed its estimation for the future. Saudi Aramco is eager to publicise its forthcoming projects, and this is why it is considered as more than an economic entity.

The question behind all the official Saudi signals is what the kingdom considers as a fair price and whether it is ready to defend it. So far there is no solid evidence that the Saudis consider one price as fair throughout time and this varies a lot. In a case where Saudis would seek a price, they would act firmly and to one direction. In 2012 when the world community considered an intervention in Iran as something more than possible, price hiked, and SA adopted a decreasing price policy by increasing output. This was not the case the last couple of years. SA did not even adopt a price stabilizing policy but left it to float.

5.1.2 Cooperation or Unilateral action

Saudi policy has another more intriguing character. There are times that either calls for a unilateral action or a collective agreement. But today cooperation is even more difficult among so many producers. Producers' cut, in a declining price environment, is the best answer. But today many complications have arisen such as stocks which create lags. Non-OPEC members left output cuts to the members.

[12] Bassam Fattouh, Saudi Arabia's Oil Policy in Uncertain Times: A Shift in Paradigm?, Oxford Institute for Energy Studies, 21/10/2014

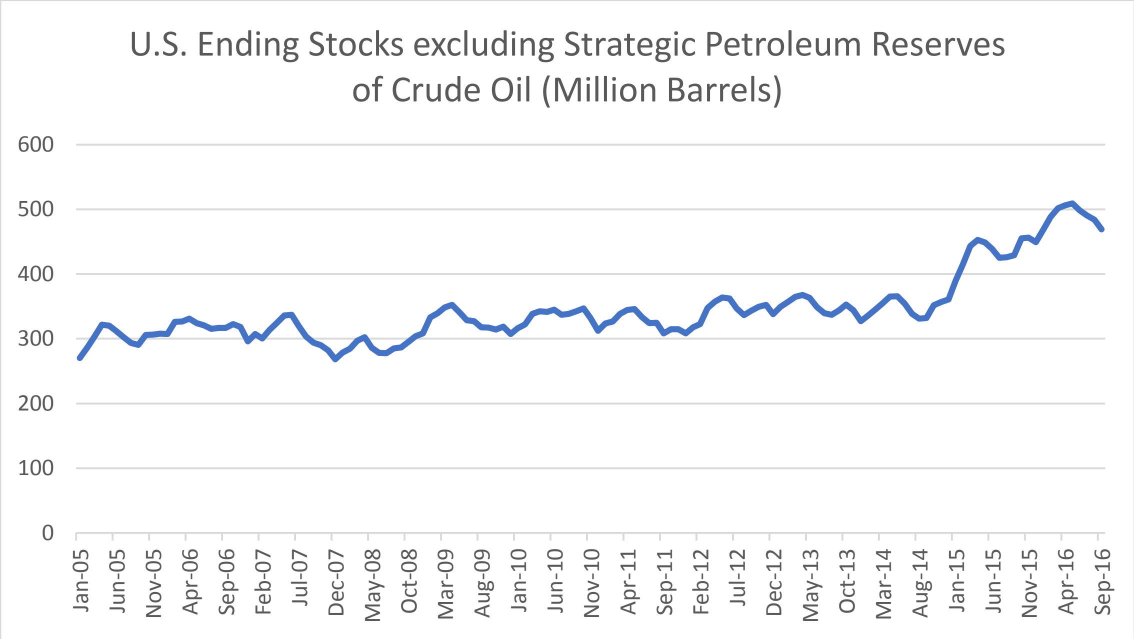

Figure 19 US stocks

Source: EIA

Experience is the driving force for many of the members, and it is harsh. Between 1973 and 1985 OPEC enforced a marker price policy by adjusting volumes. This policy left OPEC members with a cumulative 28% of market share when this was 51% in 1973.[13] The situation drove countries to different paths. Many, in an attempt to recover their market share, followed more aggressive policies and cheating among the members was quite obvious. Increasing output was a way to increase revenues.

Saudi Arabia was mainly affected. Its game changer tactic was to offer a netback pricing system which guaranteed a profit margin for oil companies. The market share started to recover, but the whole experience was something more than a misfortune. Cutting production without other producers' consensus would reduce market share and as a consequence oil revenue for Saudi Administration. This is the reason why the Saudis officials refrain from unilateral actions. Discipline between OPEC members is extremely challenging, let alone between the non-OPEC members. Some say that Saudi Arabia has the advantage to force discipline when prices are low. But forcing the prices up with a unilateral action would demand market share reduction and spare capacity investments, both extremely costly.

In addition, the focus has been shifted to Eastern consumers and competition is fierce. Saudis would not let the opportunity to slip away but economic slowdown and a shift to services increased competition. It is thought that a unilateral decision is impossible, and a different

[13] Bassam Fattouh and Anupama Sen, Saudi Arabia Oil Policy: More than Meets the Eye?, Oxford Institute for Energy Studies, OIES PAPER: MEP 13, June 2015.

proactive policy would be the case if only the price was extremely high putting the global economy under threat. This is not a realistic scenario.

The main aim is to maximise revenues, and this is what the tradeoff between high prices and market share facilitates. Since Saudi Arabia does not want nor pursues constant market share without taking into account the cost which entails, it has a mark to market adoption policy. Short term suffering for market share preservation, while waiting for the low prices that would lead other producers to the exodus, may secure long-term goals (i.e. profit maximization). The real policy is a two-step approach. If cooperation is not feasible, then leave the market to clear the fog.

But leaving the market free, as the main mechanism which will balance supply and demand, causes an other implication, feedback loss. Both supply and demand lag in order to balance. Production cannot curtail its volume instantly. Demand does not increase simultaneously with a price drop. Speculation will become even more prevalent, and concerns will multiply, as OPEC meetings will not be the only thing to consider. Stocks, economic growth and geopolitics will increase volatility, pressing prices and investments down, and economic stability will be postponed. Since Saudi Arabia has not announced a floor price and OPEC as a whole abandoned its price initiative, the situation will be worse for those around the industry. Large spreads between the highest and lowest price will prevail (increased volatility), increasing the perceived risk on oil projects. It remains a question whether Saudi Arabia will be perceived as a pole of stability or instability if turbulence appears.

Chapter 6: The crown jewel

6.1 Saudi Aramco

Not many companies can claim that they have such assets in their balance. Saudi Aramco is the largest oil producer, supplying over 10% of world's oil demand and manages (not under its ownership) 98% of the kingdom's reserves, which constitute the 25% of global oil reserves. The company is vertically integrated as apart from the upstream sector, it operates midstream and downstream both domestically and internationally. In order to understand Saudi Arabia's dependence on Saudi Aramco, one should consider that this corporation accounts for 80% to 85% of kingdom's total export earnings and 70% to 80% of government's revenues.

It is such its importance for kingdom's economic operation that its final decisions are taken mostly by the king himself. The production amount, investment decisions, pricing both domestically and internationally and subsidies are king's prerogative. Saudi Aramco does not have any authority to object decisions taken up by the crown. In order to moderate royal influence, and not let decisions, which would have a wide effect on the whole kingdom, taken up by a single person, a consensus among royal family members and market experts is sought.

Saudi Aramco owns five refineries within the kingdom to supply the local market. The total refining capacity reaches 1,75Mb/d with SAMREF and SASREF (stake holding refineries) included. What is most impressing about Saudi Aramco is its production capacity which can replace any small or medium exporter's production. There is no consensus over the real spare capacity, but the kingdom can increase its production between 10 and 10,7 MB/d. The peak can be 11 Mb/D but not for a long period. It was kingdom's ambition to develop output capacity over the 12Mb/d by 2009 and later on to 15 Mb/d. This projected spare capacity expansion was mainly explained by the kingdom's necessity to pursue a global role, let alone a dominant one in the Persian Gulf.

6.1.1 Saudi Aramco as a foreign Instrument

As it is already mentioned Saudi Arabia uses oil supply as an instrument of foreign affairs. It is uniquely placed to supply emergency quantities when market destabilises. The vehicle for this policy is the company managing the reserves, production and distribution of oil, Saudi Aramco. Saudi Aramco by itself cannot decide on its own and has a limited lobbying role domestically.

Saudi Aramco and its predecessor Aramco played various roles as a foreign policy instrument during the 70s and 80s. In our review, we concentrate on three projects which highlight its role, not only in the Persian Gulf but also globally.

6.1.1.1 Be the largest supplier of U.S.A

Saudi Aramco is a company operating upstream, midstream and downstream. When it comes to pricing, Saudi Aramco uses among one of the most complex formulas and analyses to maximize its monthly export earnings. This kind of formulas divides world market in conferences as Asian, European and US market. What formulas miss is the kingdom's need to implement its foreign policy.

The royal family decided that Saudi oil should be the major input for the US market. The directions to Saudi Aramco during the 90s were to be the largest supplier to the US, not only on an annual or averaged basis but a monthly basis. This aim covered their aspirations as they perceived that they would advance their relations with the USA. As it will be mentioned, this kind of market share dominance was challenged by the increasing Canadian output. One report referred to this policy with "Aramco's policy is to first determine the volume of sales -- as it wants to be the number one crude supplier -- and then the price".[14]

This policy was again followed during Operation Iraqi Freedom in March 2003. King Fahd stated that "Saudi Arabia will not participate in any way in the war"[15] but continued to cover world's oil disruption from missing Iraqi oil during the war and increase quantities to the US. Easily for someone to understand that Saudi Arabia reached a record market share of 20,1% in the US with 1,87 Mb/d in the first semester.

Oil supply during the war made the kingdom vulnerable to terrorist attacks in May 2003. Suicide bombings killed 34 people[16], and terrorist attacks continued until the summer. Domestic security became an issue for the kingdom and reacted with large scale police operations arrested 140.[17]

Things got worse for Saudi Administration when news reports claimed that a joint congressional report associated 9/11 2001 attacks with Saudi links.[18] This infuriated Saudis who demanded Bush administration to disclosure this part of the report. Bush administration refused, claiming that this would reveal intelligent sources and methods. This incident was almost in full swing during intense Israeli-Palestinian conflicts in June 2003. Saudis suggested a peace plan, but the US did not diplomatically press the Israeli foreign policy.

After all these events the then Saudi Aramco President and CEO Abdallah Jum Ah let the financial strains for Aramco to be known for succeeding to be the number one exporter to the US. The administration abandoned this month to month target, and it aimed at being among the first suppliers. Between the 2003 second semester and April 2004 Saudi Arabia was the third supplier behind Canada and Venezuela. From this point on, oil exports could be headed to Asian markets (China and India) under more commercial practices.

6.1.1.2 90s Capacity expansion

All oil companies appreciate their investment projects under various oil prices scenarios. These scenarios use oil prices well below current market levels to test profit sensitivity. This is also the practice for Saudi Aramco, but his does not hold when geopolitical issues come into play.

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[14] http://www.energyintel.com/print_me.asp?document_id=115331&pID=5
[15] http://www.fas.org/sgp/crs/mideast/RL33533.pdf
[16] http://www.saudi-us-relations.org/articles/2003/ioi/030821-congressional-brief.html
[17] http://www.saudi-us-relations.org/articles/2003/ioi/031007-terror-reform.html
[18] http://www.saudi-us-relations.org/articles/2003/ioi/030821-congressional-brief.html

During the second half of the 80s, it was very difficult for OPEC to maintain a price near 18$/b due to the end of the Iraq-Iran war. Both of the large exporters were reentering the market claiming old market shares. The prevailing conditions forced Saudi Arabia to mothball several reservoirs curtailing its production to 5,3 Mb/d.

All the above changed when Iraq invaded Kuwait, and UN stepped with imposing sanctions. 4Mb/d disappeared, and Saudi Aramco considered what was appropriate to stabilize the global markets. Three months later (a record time) Saudi Arabia via Saudi Aramco was producing 7,3 Mb/d.[19] Oil price deflated from 40$/b to pre-invasion levels. This success made Saudi Aramco aim at 10Mb/d by 1992.[20]

It was such the stability force brought to the market by Aramco that during the war of 1991 the prices declined. Calming down the market when disruption arises was a company's role since then. Saudi Arabia foreign affairs and Saudi Aramco's acts became almost identical.

6.1.1.3 Sovereign Challenges- The Shaybah oil field

During the 90's capacity expansion, a lot of reservoirs were again appreciated for development. One of them was the Shaybah oil field. This field was discovered in 1968 and is laid between Saudi Arabia and UAE. The field was included in numerous Saudi Aramco development plans from the 80s' and specifically in 1989's bulletin.

Since then, Saudi Aramco did not proceed with the project as it was considered as not cost effective. Although it contained extra light oil, it was far away from existing infrastructure and between borders. In addition, there was a large gas cap above. All the above to be surpassed demanded a combination of vertical and horizontal drilling. In the early 90s, this kind of technology was expensive and difficult to utilize.

It was in June 1995 that King Fahd ordered the development of the Shaybah field.[21] There were two reasons behind Saudi Aramco's delegation to develop the gigantic field. The first one was that the previously high costs had declined. The second and most important had to do with border claims.

UAE were officially formed in 1974. Saudi Arabia reached an agreement with the then new state on borders. Saudi Arabia was granted with 100% rights over Shaybah oilfield with this agreement. What was at stake was the border agreement itself as the first king of UAE Sheikh Zayed Al Nahyan never challenged the agreement. This would not be the case with his descendants. When he passed away in 2004, he was succeeded by his son Sheikh Khalifa Bin Zayed. From 2005 UAE asked for amendments to the agreement in the most formal way. Its

[19] "Capacity Ample to Replace Loss if Producers Move," *Petroleum Intelligence Weekly*, August 13, 1990

[20] "Saudis Speed Up Work to Expand Crude Potential" *Petroleum Intelligence Weekly*, October 8, 1990.

[21] Avancena, Joe, "Abdullah inaugurates gigantic Shaybah field" Saudi Gazette, March 11, 1999

Minister of Foreign Affairs Sheikh Hamdan stated that the agreement was no longer applicable.[22]

As an official response, Saudi Arabia claimed an offshore area between Qatar and UAE to halt the Dolphin mega gas project.[23]

Saudi Aramco was again the instrument of foreign policy which supported central administration's decisions. Saudi Aramco supported territorial claims with research and drilling activities, not only on the borders with UAE but also with Yemen and Jordan. Saudi Aramco's involvement in all these actions firmly establishes the belief that it is something more than an economic entity.

[22] Ibid, http://www.washingtoninstitute.org/templateC05.php?CID=2431

[23] Op Cit, Petroleum Economist. Also, for more details on the dispute and its impact on Qatar's gas developments, see *Natural Gas and Geopolitics*, ed. David G. Victor, Amy M. Jaffe, and Mark H. Hayes (Cambridge, UK: Cambridge University Press, 2006): 234-267.

Chapter 7: Diversification and integration

7.1 Vision to 2030

After all, Saudi Arabia decided to move forward and reexamine the whole direction of the economy, since oil price decline caused a lot of fiscal imbalances. IMF estimates that the deficit will be 13% of GDP for 2016. The current account deficit is estimated to reach 6,4% of GDP and balance in 2021 when oil prices recover. Bank deposits again declined, and inflation is over 4% as the state decreased subsidies on energy and water.[24]

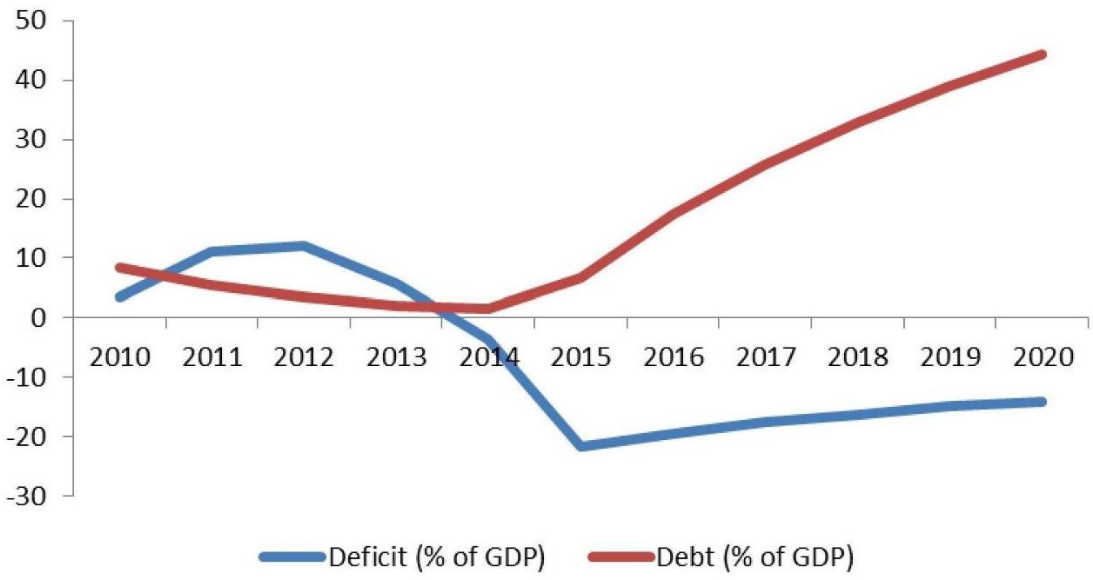

Figure 20 Saudi Arabia's debt and deficit as % of GDP

Source: IMF, World Economic Outlook, October 2015

As a response, Saudi Arabia issued the "Vision to 2030" in April 2016. The programme describes what the main goals are and tries to clarify, to some very basic extent, the way to accomplish them. The main aspect of the "Vision to 2030" for Saudi Arabia is to hold the key role in Islamic, Arab and oil world. In addition, the country wishes to become a global investment center and at the same to be transformed into a global logistics hub between Europe, Africa and Asia.[25]

The whole "Vision' is quite ambitious. When it comes to more specific goals, then things become even more clear. The first target is for SA to gain at least four positions in the Global economy and become a member of the top fifteen. The private sector's contribution to total GDP will

[24] IMF, IMF Executive Board Concludes 2016 Article IV Consultation with Saudi Arabia, Press Release Nº 16/368, 28/7/16, https://www.imf.org/en/News/Articles/2016/07/28/15/54/PR16368-Saudi-Arabia-IMF-Executive-Board-Concludes-2016-Article-IV-Consultation,

[25] Bassam Fattouh and Amrita Sen, Saudi Arabia's Vision 2030, Oil Policy and the Evolution of the Energy Sector, Oxford Institute for Energy Studies, OXFORD ENERGY COMMENT, July 2016

increase by 25% reaching 65%. Saudi Arabia's economy will be transformed from a state-driven economy to a private economy. The export industry will have to change into non-oil export. The percentage of non-oil goods and services exported would need to climb from 16% to 50%. Last but not least is the increase of foreign direct investment by 50% or from 3.8% to 5.7% of GDP.[25]

With all this kind of changes, a whole different society is expected to emerge. One with intense human capital investment and highly educated people, and all contributing to the development of the economy. Since the private sector will contribute more to the social well-being, new small and medium enterprises (SME) will have to come into play and the major support of the "Vision to 2030" is directed to them.

For all these to happen a deep governmental restructure is initiated. The Ministry of Petroleum and Mineral Resources was replaced by the new Ministry of Energy, Industry, and Natural Resources, which has broader responsibilities. The old Water and Electricity Ministry was separated to Water portfolio which moved to the new Environment, Water and Agriculture Ministry, while the electricity portfolio moved to the more relevant Energy, Industry and Natural Resources Ministry.

All these changes and goal clarification gave the appropriate credibility all the previous projects did not have. Diversification of the economy is a goal coming from the 70's while in 2005 the mostly remained on paper "Long-Term Strategy 2025" had been announced.

What the "Vision to 2030" does not engulf is an enlargement of production capacity or of spare capacity. As it was mentioned, this conception was the last resort of any oil instability caused by disruption. Saudis will spend their money on other areas since they want to diversify. But this comes from an other bitter experience. It was only 2004 when Al-Naimi announced a capacity expansion from 11 to 12.5 Mb/d. This mega project to increase capacity by almost 14% took six years and cost a lot.[25] An even newer capacity increase would require capital expenditure in storage, new pipelines, interconnections among them and the plants. Most of these costs are considered as sunk cost, and no one is sure whether they will be recovered. Probably this kind of decision is left to be reconsidered if prices rebound.

Furthermore, increasing capacity has a direct relation to future market share. There is high uncertainty whether Saudi Arabia will increase its share in order to increase capacity. And even if SA protects its share, it is highly doubtful that the pie will have the same size. New environmental regulations and firmer laws on carbon use like Emissions Trading System (ETS) in the EU might decrease oil revenue due to volumes' decline.

On the contrary, some within the kingdom refuse this narrative as they argue that spare capacity kept prices low. If Saudi Arabia refuses to signal further spare capacity extension, oil price will increase, and both of discipline and Saudi's Arabia key role in OPEC will be lost. Even worse consumers will try to find alternative ways of moving their economies. All of the above consequences would have the exact opposite to the anticipated results. Unconventional oil extraction started as an alternative to the traditional exploration during the great oil crises. It was then when the rest of the world realized the importance of energy independence.

In order to avoid fiscal bleeding through subsidising fuel and water, Saudi Administration turned its attention to natural gas. Gas consumption is promoted both for household and industrial use. Since the primary source of energy is crude, this shift requires huge capital expenditure.[25] The present production capacity has to be increased by 50% to 17.8 bcf/d by 2020 for the aim to be achieved.[25] Even greater and more efficient use of energy with natural gas will also enable the petrochemical plants to achieve cost reductions and as a result, increase competitiveness.

Diversification is among the main goals, as most of the materials and services are imported. Saudi Administration wants most of the equipment to be "Made in SA" and for this initiated the "In Kingdom Total Value Added" project. This programme aims at increasing the made in kingdom oil goods manufacture by 100%.[25]

One more aspect of the "Vision to 2030" is financing all this kind of projects. Saudi officials went on to announce that Saudi Aramco will file for an initial public offer (IPO). This was a huge announcement as the specific IPO will probably be the biggest ever in the world. By this only, it is easily understood that the local Saudi stock market is insufficient enough to handle such a listing. New York and London stock exchanges have the know-how and ample funds to carry this listing. The Saudi government announced that only 5% of the company will be publicly available. Even for this small portion, there is a lot of debate. Since valuation is mostly about the company's discounted future cash flows, the kingdom has to publish how much oil is intended to sell and how much dividend or tax will be handed to the state. All of them were considered as issues of national security, and there was not much available information. Saudi Aramco also holds the majority of country's natural gas and the charging price to the consumers is still unclear since the shift to this energy resource is promoted by the government. Even if only the 5% will be traded, the company will have to comply with the exchange's regulations and accounting standards. Moreover, the opening of a 100% state-run market will pave the way for anti-trust suits and other open competition practices. Last but not least among the charges is that Saudi Aramco will have to change its corporate model. One company initially run under Exxon Mobil standards changed its corporate governance to service broader interests.[26] For the listing to be successful, its board and subsequently the departments responsible for investment and other crucial issues will have to change.

[26] Anjli Raval, Saudi Aramco: Fix for a one-trick economy?, Financial Times, 18/5/2016, https://www.ft.com/content/9a893492-1ccf-11e6-b286-cddde55ca122, (accessed 18/10/16).

7.2 The refinery integration

As it is widely known, most of the countries producing raw materials (and crude oil is not an exception) do not process them. This kind of preference was also noticed within the kingdom. SA using Saudi Aramco as an investment tool set ambitious goals for a refinery capacity enlargement. The target was for an additional 1.2 Mb/d to the already 4.5 Mb/d of refining capacity worldwide.[27] This extra capacity will be built domestically augmenting the total capacity by 60%, from 2.1 Mb/d to 3.3 Mb/d by 2018.[27]

This is a huge change as production profile is altered. The main reason for this is that SA mostly produces heavy and sour crude oil which has to find its way to respective refining units. As a result, SA will not be in search of refineries with certain specifications but direct its production to a wider market (refined products are much more homogenous than crude oil of different varieties).

The second reason for this is the heavy losses suffered by the kingdom due to its fuel subsidies all the previous years. SA was exporting crude oil and then importing fuel oil for its domestic demand. In 2013 SA imported approximately 25% and 20% of its consumed gasoline and diesel respectively. In addition, most Saudi officials perceived the whole situation as a shortage of refining capacity and not as a shortage of crude products. In order to understand the magnitude of the budget burden one should compare the Saudi prices with the world average. In 2015 a Saudi could buy a gallon of diesel or gasoline for 25 US cents and 57 US cents respectively when the world averages were at 2$ and 1.80$.[27] As a consequence, both diesel and gasoline demand ran with a 6% and 7 % increase on average per year.

In order to boost exports, Saudi administration turned its focus to refining as the process increases volumes. A barrel of crude oil, if refined, produces products of 5 to 10% of more volume.[27] This phenomenon is named as processing gains. Since SA turned to refining, it will observe a larger production which will be sold at higher prices as high oil distillates are marketed at a premium.

Critics say that this was a mandate for the kingdom. A Large part of the produced crude is directed to power generation for domestic use. The prices of power are again subsidized resulting in non-efficient management and waste. The electric generation company burned 200.000 b/day of diesel for just 20% of its total production. Diesel which could be used for exports. Projections estimate that 2020 will be the peak year when 1 Mb/d will be burned.[27] The increasing power generation consumption could put an even heavier burden on export capacity.

[27] Jim Krane, A refined approach: Saudi Arabia moves beyond crude, Energy Policy 82 (2015) 99–104.

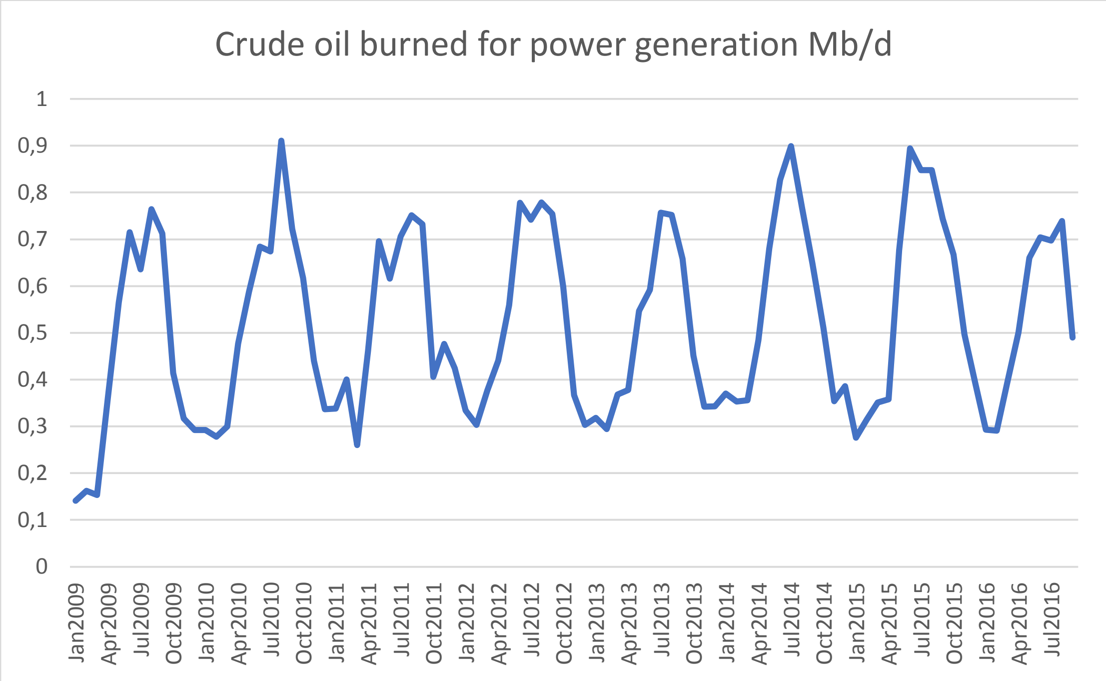

Figure 21 Crude oil burned for power generation in Saudi Arabia Mb/d

Source: Jodi

To add up on the reasons why Saudi Arabia shifted to refining one should take into account that the refinery expansion will bring international construction companies and with them a know-how transfer (or at least this is what is hoped) will occur. Refineries are being built with more diverse criteria than the rate of return as one will be built in Jazan, a city near the Saudi-Yemeni borders and one of the poorest ones. As about the general technical and education perspective, the new refineries will process under the latest cocking and cracking technologies heavy and sour oil which will demand personnel of high expertise.

Since the destination of heavy crude will change, US might be bothered some argue. US refineries had invested a lot in refining heavy crude oil. Saudi crude was a welcome input since it was priced at lower levels. Many believe that this will not be a game changer for the relations as US refineries focused lately on Canada and its oil sands production. The increased competition between Saudi and Canada forced the Arabic country to provide deep discounts. The latter was an unpleasant outcome since Saudi already loses 3$ to 6$ for every barrel that is exported to the US and not to Asian markets. Things will be worse when Keystone XL phase is completed, and Canadian oil is directed to Houston’s Refineries and terminal.

Chapter 8: Modelling Saudi Arabia’s policy and drivers

8.1 Method, data and approach

8.1.1 Methods and Data

In economic theory, the price is determined by the cross section of demand and supply. This is where economic equilibrium is found. Therefore, towards identifying the factors that affect production, we examine all components that affect prices, namely demand, Saudi Arabia’s production and prices on its own. We develop three econometric models, one for world crude oil demand, one for Saudi Arabia’s crude oil supply and the last one for crude oil prices, using data from the International Energy Agency, and World Bank, over the period 1971-2015.

8.1.2 Data Tests

8.1.2.1 Stationarity

To proceed with our estimations, we test our dependent and independent variables for stationarity. In most times time series are non-stationary at levels. The absence of stationarity at levels indicates the existence of a unit root. the tests we use are the Augmented Dickey – Fuller and KPSS test. The tests are conducted at 1%, 5% and 10% levels. If a variable is non-stationary at level I(0) then we proceed with its first difference. We first test them for the levels and if we find non-stationarity we proceed with their first difference. Since most of our data are non-stationary at levels, then we test whether they are cointegrated. The problem of non-stationarity is presented in Appendix 1. Augmented Dickey-Fuller test agrees on the non-stationarity of World oil demand and World GDP per capita at levels. Crude Real Price is stationary for 1% and 5% with KPSS when it is non-stationary at all levels for ADF test. OECD crude stock changes is stationary at levels for ADF but only at 1% for KPSS. The rest of the World Share Production is stationary at level with ADF and KPSS. This does not hold for Saudi’s Arabia Share of Production and Saudi Arabia Production as ADF finds them non-stationary at levels, but not the same result holds with KPSS. All the first differences of all variables are stationary at levels.

8.1.2.2 Cointegration results.

Since our variables are non-stationary at levels we test them whether they are cointegrated i.e. if a long run relation exists between them. Our test for cointegration is the Johansen Cointegration test. This examination is in order to avoid a spurious model which will result in low quality regressions. In order to reach an assumption, we use the Trace and Maximum Eigenvalues Statistics and their respective probability. The tests are conducted at 5% and for the follow assumptions:

1. No intercept and no deterministic trend.
2. Intercept and no deterministic trend
3. Intercept no linear deterministic trend
4. Intercept and linear deterministic trend
5. Intercept and quadratic deterministic trend.

There is cointegration between our variables in our models for all of our models. For the demand and Saudi's Arabia production models we assume no deterministic trend and a lag of 1 for Demand and 2 for SA Production. For Crude price's model, we assume Linear deterministic trend and lag of 1. A summary of all the cointegration tests conducted and their results is in Appendix 2.

The following Table 1 presents the list of variable examined.

Variable Name	Description	Data source
WORLD OIL DEMAND	Natural Logarithm of WORLD Oil Demand in kbd	IEA
WORLD GDP PER CAPITA (CONSTANT 2010 US$)	Natural Logarithm of WORLD GDP per capita (CONSTANT 2010 US$)	World Bank
REAL CRUDE OIL AVERAGE BBL	Natural Logarithm of average real crude oil price	World Bank
OECD CRUDE STOCK CHANGES	Changes of OECD members' Crude Stocks in KT	IEA
SAUDI ARABIA CRUDE PRODUCTION	Natural Logarithm of Saudi Arabia's Crude Oil Production measured in KT	IEA
SA% WORLD CRUDE PRODUCTION	Natural logarithm of S. Arabia's percentage of World Production	IEA
REST OF THE WORLD % CRUDE PRODUCTION	Natural logarithm of all other producers' percentage of World Production	IEA

Graphs of models variables

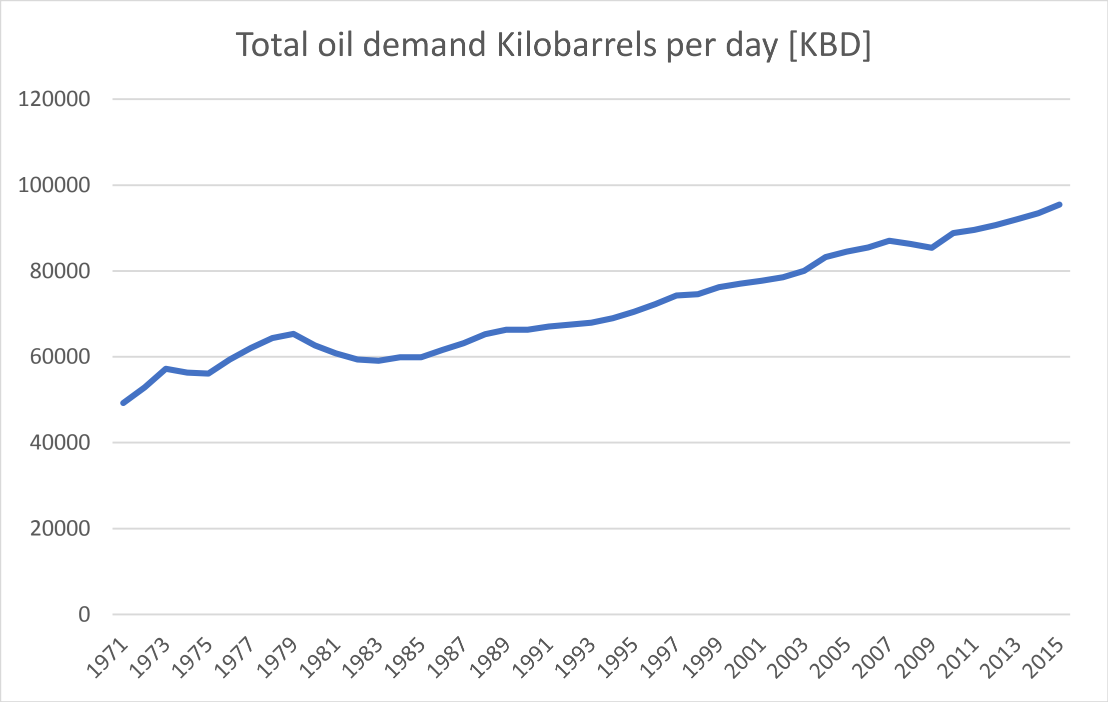

Figure 22 World Crude Oil Demand

Source: IEA

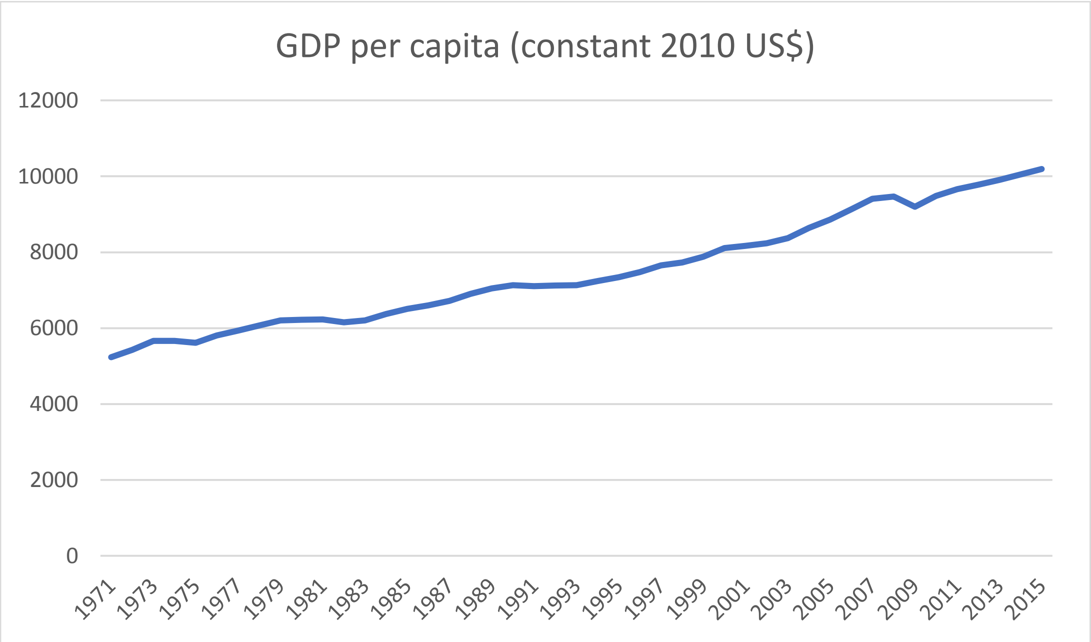

Figure 23 GDP per capita (constant 2010 US$)

Source: World Bank

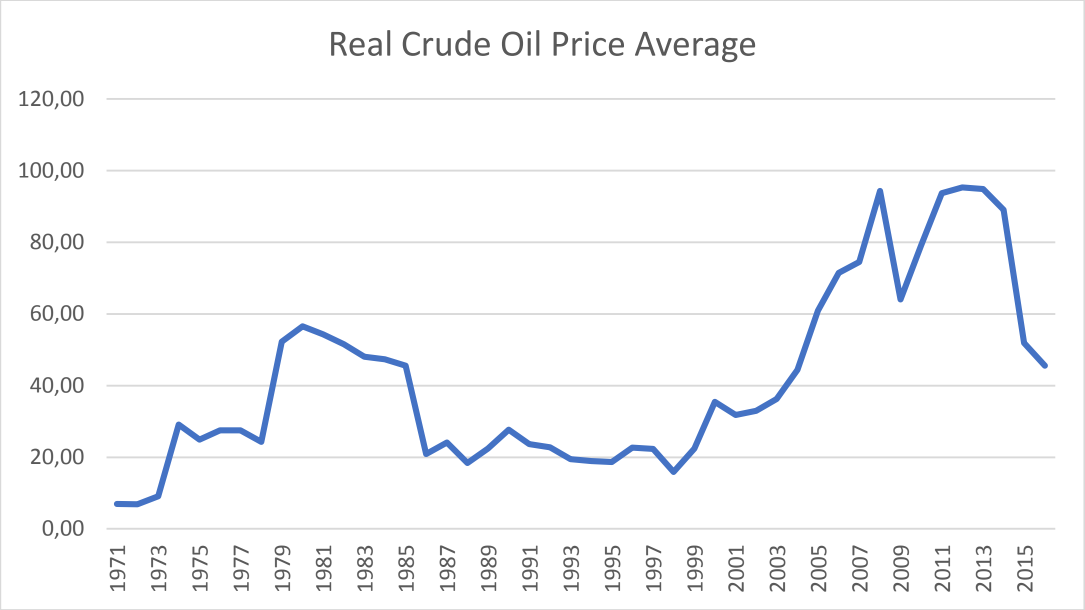

Figure 24 Real Crude Oil Price

Source: World Bank

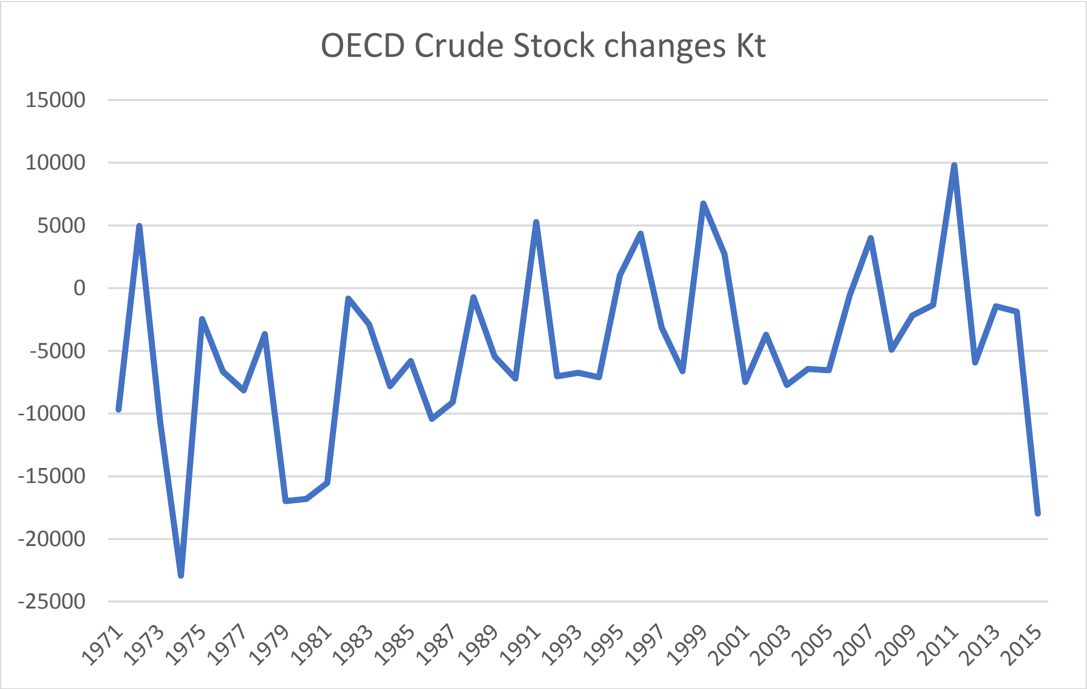

Figure 25 OECD Crude Stock Changes

Source: IEA

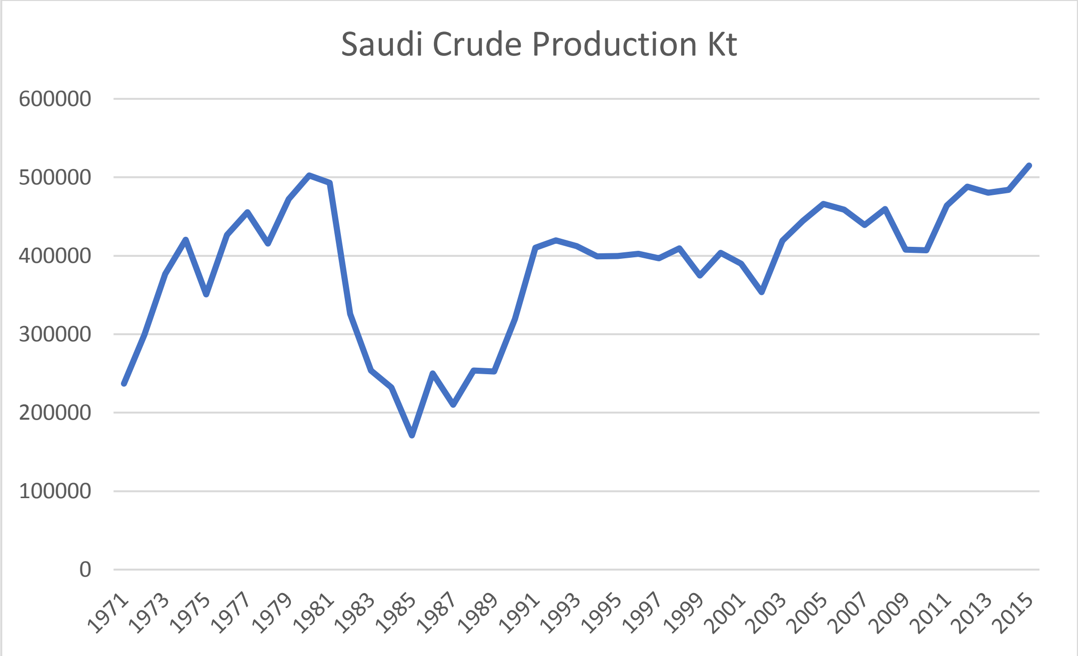

Figure 26 Saudi Crude Production

Source: IEA

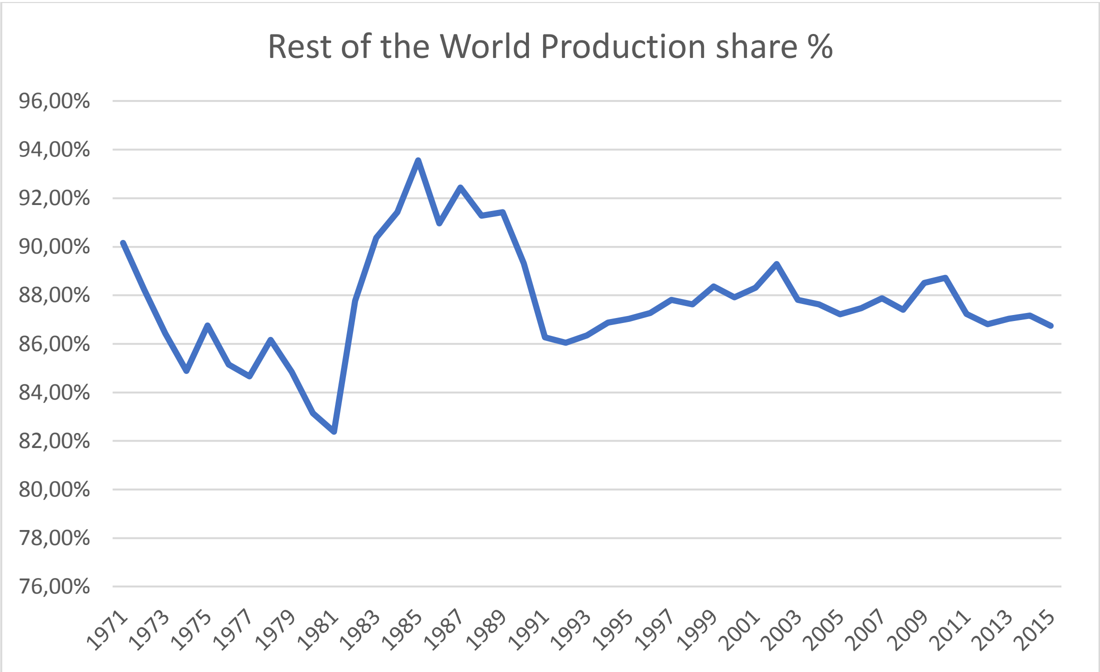

Figure 27 Rest of the World Production Share

Source: IEA

8.1.3 Data limitations

Finally, this research faces some limitations as the data used are from different sources (IEA, WORLD BANK), and their accuracy might be questioned as many oil producers regarded this kind of information as of national importance. A new initiative to overcome this shortfall was the establishment of Joint Organizations Data Initiative (JODI).

8.1.4 Model Structure

Our aim was to examine the oil market forces and especially Saudi Arabia's role. In our effort we tried to examine demand, price and SA production.

In order to have models that could explain all the above, we tested our models with several tests. Our main aim was to have models with homoscedasticity, no serial correlation and with normally distributed residuals. The tests used were the Arch, White, LM and Jarque Bera. One of our aim was also to have models which could explain the oil market efficiently enough i.e. with high R^2 and adjusted R^2.

High R^2 and adjusted R^2 may also imply multicollinearity. Multicollinearity demonstrates a interrelation between the independent variables. In 3 out of 6 models we have high R^2 . We tried several methods to avoid multicollinearity but this damaged the explanatory capability of our models i.e. we had heteroscedasticity or serial correlation or abnormally distributed residuals or a combination among them. The techniques used to avoid multicollinearity were:

1. Use of more lags.
2. Standardised variables.
3. Ommiting some of the variables from the models.

This led us to examine Ridge regressions and their corresponding V.I.F. We would like to explain that a V.I.F close to 1 presents absence of multicollinearity and hence no correlation between the n^{th} predictor with the rest of them. A V.I.F over 4 requests further investigation while a one over 10 presents evidence of strong multicollinearity. In the Price model we have the two production shares, the Saudi one and the Rest of the producers'. Easily understood that if the Sauidis hold a x market share, then the rest of the producers hold a (1-x) share. As a result this implies a high multicollinearity, but our effort was to explain the magnitude of Saudi Arabia's power over price in comparison with the rest of the world. Values on multicollinearity are in Appendixes 3 to 6.

Further, to avoid serial correlation and have models with explanatory ability, we used variables with lags (both of the dependent and independent variables) and ARMA method with AR(1) and MA(1). In addition, we used Generalised Least Squares with the Newton-Raphson method.

Finally, we used the two step Engle and Granger method to obtain long-run and short-run elasticities of our variables. Under this method we used the time series of the residuals of the long-run models in our second short-run models. This is the ECT-1 of our models and it is a period later in the short-run models. The variables of the short-run models are the first differences of the variables of the long-run models. All are presented in Appendixes 3 to 5.

8.1.5 World crude oil demand model

Our model is structured under the assumption that world oil demand follows the general world economic growth as this requires more oil for energizing growth and consumption. Our independent variable is the World GDP per Capita by World Bank. We take the World GDP per capita, as examining the model for each country separately would not add anything to the research. The second independent variable is the Real Crude Oil Pirce by again the World Bank. The last independent variable is OECD Oil Stock Changes. There is a lot of debate whether oil stock changes drive demand, oil price or production or all of them collectively .We use the OECD petroleum stocks changes. It is the only non-log data in the equation as changes can be negative.

The equation for the crude oil demand examined in the long-run is expressed by the following formula:

$$WOD = c + b_1 * WGDPPC + b_2 * CAR + b_3 * OCSC + u_t$$

where all the variables as described above are in natural logarithms but OECD Crude Stock changes and u_t is the disturbance term. U_t is later used for the short-run as ECT. ECT is used with a “delay” of one period in the short-run models. The short-run model is:

$$D(WOD) = c + b_1 * D(WGDPPC) + b_2 * D(CAR) + b_3 * D(OCSC) + ECT$$

where:

Variable	Name	Description
C	constant	Constant of the model
WOD	WORLD OIL DEMAND	Natural Logarithm of WORLD Oil Demand in kbd
WGDPPC	WORLD GDP PER CAPITA (CONSTANT 2010 US$)	Natural Logarithm of WORLD GDP per capita (CONSTANT 2010 US$)
CAR	REAL CRUDE OIL AVERAGE BBL	Natural Logarithm of average real crude oil price
OCSC	OECD CRUDE STOCK CHANGE	changes of OECD members’ Crude Stocks in KT

8.1.6 Saudi Arabia's crude oil supply model

Our second model is about Saudi Arabia's reaction to market developments. We assume that SA is responding to the market signals and adjusts its supply. These signals and market implications are world oil demand, OECD crude stock changes and SA market share in world crude production. We consider that SA will try to satisfy the higher demand by producing more or will try to defend its world market/production share. Profit maximization is a tradeoff between higher prices (lower production) and market share. One producer can augment its revenues by either taking advantages of higher prices or even by boosting production in a low-price environment to capture additional share.

The equation for the Saudi Production examined in the long-run is expressed by the following formula:

$$SCOP = c + b_1 * WOD + b_2 * OCSC + b_3 * SSWOP + u_t$$

where all the variables as described above are in natural and u_t is the disturbance term. U_t is later used for the short-run as ECT. ECT is used with a "delay" of one period in the short-run models. The short-run model is:

$$D(SCOP) = c + b_1 * D(WOD) + b_2 * D(OCSC) + b_3 * D(SSWOP) + ECT$$

where:

Variable	Name	Description
c	constant	Constant of the model
SCOP	SA CRUDE PRODUCTION IEA	natural logarithm of Saudi Arabia's Crude Oil Production measured in KT
WOD	WORLD OIL DEMAND	Natural Logarithm of WORLD Oil Demand in kbd
OCSC	OECD CRUDE STOCK CHANGE	changes of OECD members' Crude Stocks in KT
SSWOP	SA% WORLD CRUDE PRODUCTION	natural logarithm of S. Arabia's percentage of World Production

8.1.7 Crude oil price model

Our last model is the price model. We would like to estimate how price behaves in relation to other market factors. Again, we use as an independent variable the OECD petroleum stock changes. These changes are considered as of crucial importance by broadcasters, and it is yet to be proven by empirical research. The other two factors, we include, are the production shares of Saudi Arabia and the Rest of the World. If SA loses a portion of its share, the rest of the producers earn it. It remains a question whether the same percentage of crude production share by different producer has different weight on price or not. The last independent variable to crude spot price is world oil demand. Since demand increases then price should also increase.

The equation for the Real Crude Oil Pirce examined the long-run is expressed by the following formula:

$$CAR = c + b_1 * OCSC + b_2 * RWSCP + b_3 * WOD + b_4 * SSWOP + u_t$$

where all the variables as described above are in natural logarithms but OECD Crude Stock changes and u_t is the disturbance term. U_t is later used for the short-run as ECT. ECT is used with a "delay" of one period in the short-run models. The short-run model is:

$$D(CAR) = c + b_1 * D(OCSC) + b_2 * D(RWSCP) + b_3 * D(WOD) + b_4 * D(SSWOP) + ECT$$

where:

Variable	Name	Description
c	Constant	Constant of the model
CAR	REAL CRUDE OIL AVERAGE BBL	Natural Logarithm of average real crude oil price
OCSC	OECD CRUDE STOCK CHANGE	changes of OECD members' Crude Stocks in KT
RWSWOP	REST OF THE WORLD % CRUDE PRODUCTION	natural logarithm of all other producers' percentage of World Production
WOD	WORLD OIL DEMAND	Natural Logarithm of WORLD Oil Demand in kbd
SSWOP	SA % WORLD CRUDE PRODUCTION	natural logarithm of S. Arabia's percentage of World Production

8.2 Empirical results

8.2.1 World crude oil demand

Long run

As it was already mentioned, we regressed world oil demand against World GDP per capita (both of these variables were lagged up to 2 periods and used as independent variables), Crude Price, and OECD crude stock changes. Due to serial correlation we used the GLS method with Newton-Raphson. The model is not spurious as R^2 is lower than Durbin-Watson stat. The results of the model are shown in Appendix 3.

The coefficient for OECD crude stock changes is very low almost zero and statistically insignificant. The finding is that it cannot explain the dependent variable. The rest of the coefficients are all significant but that of the constant and in compliance with the theory. As the variables are in natural logarithms the coefficients are the elasticities. World GDP growth requires oil, and this drives world oil demand up. The long run elasticity is close to unity (0,966426) presenting that a 1% GDP growth increases Oil demand by 0,96%. When the opposite stands and world economy falls in recession, oil demand declines. We have an inelastic but very close to 1 elasticity of GDP, meaning that our economies are energy sensitive. This is in compliance with Kumhof and Muir (2012) who find that income elasticity of oil demand is close to 1. When the model estimates the coefficient of the crude price , we have a significant negative coefficient. This supports the theory as the relation should be negative. When prices increase, demand declines. The price elasticity is 0,0104) implying that a 1% price increase would lead to a 0,0104% decrease of oil demand. The elasticity is less than unity implying an inelastic relation i.e. world responds less sensitively in price fluctuations. The overall assumption is that world economy depends on oil but does not responds sensitively enough to price fluctuations. All the tests for heteroscedacity, serial correlation and normally distributed residuals are satisfied.

Short Run

When the model is estimated for the short-run, the results are interesting. OECD crude stock changes are insignificant when the rest of the coefficients are significant. R^2 and adjusted R^2 are high 68%. The coefficient-elasticity of GDP slightly lower (0,966364) than that in the long-run and remains less than one. We have a more inelastic ralation, presenting that oil demand is less sensitive to GDP in short-periods. This is in accordance with the 'second law of demand' or the LeChatelier principle which requires demand curves to be more elastic in long-run than what they are in the short-run.[28] The main result, both in short and long run is that a GDP increase does add positively and assymmetrically to global oil demand. The price elasticity is again negative and less than 1, even if it shows a more sensitive response (-0,024). The ECT

[28] Milgrom, P. and Roberts, J., (1996), The LeChatellier Principle, The American Economic Review, Vol. 86, No. 1 or http://web.stanford.edu/~milgrom/publishedarticles/The%20LeChatelier%20Principle.pdf

is statistically significant implying a well explanatory ability. The ECT coefficient is the speed that short-run regrassion has towards to the long-run one, implying that the 52,40% of the change will happen in a year's period. All the tests are satisfactory which testify the robustness of the model.

8.2.2 Saudi Arabia's crude oil supply

Long run

We examine the model with ARMA as there was serial correlation in our initial models. Our regression has all the coefficients significant but that of the moving average, explaining the dependent variable . The results of the model are shown in Appendix 4.

World oil demand influences positively the crude production of SA. This is in compliance with theory, as SA tries to cover the extra demand with its production, increasing its revenues. The elasticity of Saudi production to World Oil Demand is less than one (0,71), meaning that Saudi Arabia will not respond drastically, as this would decrease price. Saudi Arabia produces more, but not to fully cover the increased demand as this would lead to lower revenues. It also implies that Saudi administration attempts to catch most of the demand increase, but not to disrupt relations with the rest of the producers. The elasticity is 0,71 positive, meaning that SA will increase its production 0,71% more if world demand increases by 1%. The OECD crude stock changes have almost zero influence in SA's crude production and are significant. Saudi Arabia's global production share has a positive relation with its crude production. The coefficient which is also the elasticity of SA's production to its production share is over but close to one (1,071), which makes it elastic. This presents the Saudis' intention and readiness to increase their production share but it requires an assymetrical increase of their production in order to increase their share by 1%. This intention is not monolithic as the elasticity is over but close to unity, meaning that they will not start to produce just to augment their share without considering other conditions. This is compliance with the trade-off theory (low production-high price to high production-low price). (Appendix 4).

Short run

The short-run regression confirms some of our assumptions as the elasticity towards global demand is again positive but this time elastic (over the unity 1,037). This result might imply that SA is more ready to capture temporary fluctuations by producing more. This will increase its revenues and presents its ability, as it has spare production capacity. The policy of the spare capacity is validated. OECD stocks changes are significant but close to zero meaning that they have a low effect on SA' production policy. This might validate its policy to continue production even when stocks were pilling up. The rest of the coefficients are again significant but those of the ARMA. The production share coefficient is lower and closer to 1 (1,05) implying that SA is not trying to increase its production share fast enough even if it is easier to achieve it in the short-run.This probably indicates that Saudi Arabia's policy has not changed through time and it always had a production level that would satisfy its aims, without creating any disruptions with its colleagues. The ECT coefficient is the speed that short-run regrassion has towards to long-run one, implying that the 34% of the change will happen in a year's period (Appendix 3).

8.2.3 Crude Price

Long Run

We also examine what influences price. Our dependent variable is Price, and our independent variables are the OECD crude stock changes, the Saudi and the rest of the World's oil production shares and world oil demand. The results of the model are shown in Appendix 5.

The only insignificant coefficient is that of the OECD crude stock changes and moving average. The result might be explained that crude stocks do not affect oil price for long periods. All other variables are significant. An increase in world oil demand increases the crude price, a finding which is again in compliance with economic theory. The elasticity of price to demand is high (2,51) presenting a very sensitive relation between demand and price. Oil price responds abruptly to an increase in world demand as a 1% increase in demand would mean 2,51% higher prices. The highly elastic relation may explain the already researched relation between oil prices and GDP/GNP. The elasticity of GDP/GNP to prices was examined by Mory (1993) who estimated low negative elasticity (-0,0551). Mork et al. (1994) resulted that oil price increases influence negatively output when price declines have not effect. Several studies of GDP/GNP elasticity to oil price have been contacted with different levels of sensitivity to have been revealed. What is most impressing are the coefficients of the competitive production shares. Their coefficients are negative which is consistent with the theory, as an increasing market share always means more quantity in the market. As a result, the price declines. It is very difficult to have market share change for a producer, while keeping world's quantity constant. Countries do not have perfect cooperation between them. SA production share has a high coefficient (elasticity) meaning that a small share increase will sharply decline the price (-3,37%). The rest of the world has an even higher coefficient (elasticity) for its share (-26,32%). The result indicates that when the rest of the producers claim an increase in their production share, then prices react more abruptly. It can be explained by the concept, that the market price is more sensitive and more receptive to news by the rest of the producers, than from only one country. An other implication by the vast difference between coefficients is the aversion of SA for unilateral actions. The kingdom knows that its share decline or increase will have much less influence on the price formation, than what would be if most of the producers agreed multilaterally (Appendix 5).

Short Run

In the short run regression, we have similar findings. OECD stock changes are significant but close to zero, implying that crude stocks have not much power on smoothing price fluctuations in the short run. The production shares are significant, but the rest of the producers' coefficient is much higher (-21,14) compared to that of SA (-2,96). The production elasticities have lower absolute values imlying that production fluctuation can have less effect on oil price in short periods. Nevertheless, they are again high. World oil demand is insignificant. This result may imply that oil price might be determined by other fundamentals other than global demand. The last might be explained as demand does not changes drastically in the short-run, neither its magnitude is known soon enough. The insignificance of demand to price might also imply the lack of substitution between oil and any other form of energy source in short periods of time.

Chapter 9: Conclusions

9.1 Conclusion

The evolution of high crude oil prices for over a decade have increased sharply the sovereign reserves of Saudi Arabia and its profitability. Saudi Arabia has a strong interest to keep crude oil prices at high levels, even if this requires to decrease its own production. However, the participating countries in the OPEC are deviating from their commitments, concerning their productions rates, due to internal problems of production or aiming at supporting their balance sheets. Moreover, external -to OPEC- factors, such as the evolution of shale oil and gas in the USA, strongly affect the market share of all OPEC countries, challenging their profitability. Factors as foreign relations and security issues affect this behaviour. It is not a secret that oil is something more than a commodity for Saudi Arabia. This study aims at providing evidence on how Saudi Arabia is adjusting its crude oil production towards affecting the crude oil price and to what extent. The econometric model does not include broader geopolitical aspects as these are hard to measure.

Research develops an econometric model to estimate the crude oil production of Saudi Arabia, as related to critical factors, such as crude oil stocks, price, other producers' production, demand and macro-economic factors. In order to estimate those effects, we develop also two supplementary models, concerning world crude oil demand and crude oil prices, that are drivers to Saudi Arabia's crude oil production.

The results verify the economic theory and Saudi's power over prices. The global economy is the main factor driving world crude oil demand. The economic growth, increases demand levels, and requires more crude oil production to meet demand. When the alternative exists, i.e. recession, crude oil demand decreases.

The results, from the model that concerns the SA crude oil production, provide evidence to the extent Saudi Arabia's crude oil production strategy affects the oil market. The model provides evidence that Saudi Arabia tries to catch the increased demand by producing more. When demand increases then, Saudi Arabia tries to exploit higher prices with larger volumes, leaving part of the increased demand to the rest of the producers (does not intent to fully cover all the increase, but does not overreact which would bring prices down). In addition, Saudi Arabia reactions present evidence for the trade-off theory as the kingdom produces more oil to defend its production share. This explains why Saudi Arabia continued to produce in a decreasing price environment. This outcome derives from the fact, that compared to other analyses, we incorporate the latest years capturing the evolution of shale oil as a game changer. Therefore, the research provides insights on the kingdom's decision drivers under other -to OPEC- producers' decisions.

Finally, crude oil prices are more sensitive to others' production than that of Saudi Arabia. This makes Saudi Arabia pursue more multilateral decisions, as a different approach would decrease its production share in a low-price environment. This conclusion is in accordance with the conclusions of the latest OPEC Meeting, which are stated as “to conduct a serious and constructive dialogue with non-member producing countries, with the objective to stabilize the oil market and avoid the adverse impacts in the short- and medium-term.” Saudi Arabia realizes that its capability over global crude oil prices is limited, especially as new producers, as the USA, enter the market.

Finally, Production decisions are not taken in strictly economical sillos but rather are the byproducts of more extended aims. The price-share dilemma is sometimes neglected when broader geopolitical targets are at stake. This deviates the argument from the optimal production level to wider policy issues.

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Appendix 1

Augmented Dickey-Fuller Unit Root Test

	WOD	WGDPPC	CAR	OCSC	RWSCP	SSWOP	SCOP	Δ(WOD)	Δ(WGDPPC)	Δ(CAR)	Δ(OCSC)	Δ(RWSCP)	Δ(SSWOP)	Δ(SCOP)
Lags	1	0	0	0	7	2	0	0	0	0	1	0	0	0
Prob*	0,912	0,880	0,101	0,000	0,006	0,055	0,204	0,000	0,000	0,000	0,000	0,000	0,000	0,000
t Statistic	-0,326	-0,507	-2,585	-5,286	-3,798	-2,887	-2,214	-4,703	-5,410	-6,494	-8,417	-5,805	-6,478	-6,483
1%	-3,592	-3,589	-3,585	-3,589	-3,621	-3,597	-3,589	-3,592	-2,931	-3,589	-3,597	-3,592	-3,592	-3,592
5%	-2,931	-2,930	-2,928	-2,930	-2,943	-2,933	-2,930	-2,931	-2,604	-2,930	-2,933	-2,931	-2,931	-2,931
10%	-2,604	-2,603	-2,602	-2,603	-2,610	-2,605	-2,603	-2,604	-2,604	-2,603	-2,605	-2,604	-2,604	-2,604
Orders of Integration	I(1)	I(1)	I(1)	I(0)	I(0)	I(1)	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

* MacKinnon (1996) one sided p values

KPSS test

	WOD	WGDPPC	CAR	OCSC	RWSCP	SSWOP	SCOP	Δ(WOD)	Δ(WGDPPC)	Δ(CAR)	Δ(OCSC)	Δ(RWSCP)	Δ(SSWOP)	Δ(SCOP)
Bandwith	5	5	5	3	4	4	5	0	7	1	6	0	1	2
LM Stat	0,857	0,859	0,448	0,510	0,086	0,082	0,309	0,137	0,097	0,177	0,202	0,071	0,067	0,067
1%	0,739	0,739	0,739	0,739	0,739	0,739	0,739	0,739	0,739	0,739	0,739	0,739	0,739	0,739
5%	0,463	0,463	0,463	0,463	0,463	0,463	0,463	0,463	0,463	0,463	0,463	0,463	0,463	0,463
10%	0,347	0,347	0,347	0,347	0,347	0,347	0,347	0,347	0,347	0,347	0,347	0,347	0,347	0,347
Orders of Integration	I(1)	I(1)	I(0)*	I(0)*	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

* CAR is stationary for 1% and 5%
* OCSC is stationary for 1%

Appendix 2

Demand Nº of Lags 1 5%					
Data Trend	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No trend	Intercept No trend	Intercept No trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	1
Max Eigen	1	0	0	0	1

SA production Nº of Lags 2 5%					
Data Trend	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No trend	Intercept No trend	Intercept No trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max Eigen	1	1	0	0	0

Crude Price Nº of Lags 1 5%					
Data Trend	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No trend	Intercept No trend	Intercept No trend	Intercept Trend	Intercept Trend
Trace	0	1	1	1	2
Max Eigen	0	1	1	1	1

Demand Varialbes

Demand No deterministic trend Nº of Lag 1 Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No of CE(s)	Eigenvalue	Trace Statistic	0,05 Critical Value	Prob.**
None	0,44529	49,17524	40,17493	0,00490
At most 1	0,32428	23,83500	24,27596	0,05670
At most 2	0,11057	6,97353	12,32090	0,32770
At most 3	0,04401	1,93511	4,12991	0,19340
Trace test indicates 1 CE at 0,05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Demand No deterministic trend Nº of Lag 1 Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No of CE(s)	Eigenvalue	Max-Eigen statistic	0,05 Critical Value	Prob.**
None	0,44529	25,34024	24,15921	0,03450
At most 1	0,32428	16,86147	17,79730	0,06870
At most 2	0,11057	5,03842	11,22480	0,47190
At most 3	0,04401	1,93511	4,12991	0,19340
Max-Eigenvalue test indicates 1 CE at 0,05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

SA production variables

SA production No deterministic trend Nº of Lag 2 Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No of CE(s)	Eigenvalue	Trace Statistic	0,05 Critical Value	Prob.**
None	0,49579	44,62800	40,17493	0,01670
At most 1	0,19075	15,86838	24,27596	0,38920
At most 2	0,15199	6,97923	12,32090	0,32720
At most 3	0,00130	0,54776	4,12599	0,84790
Trace test indicates 1 CE at 0,05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

SA production No deterministic trend Nº of Lag 2 Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No of CE(s)	Eigenvalue	Max-Eigen statistic	0,05 Critical Value	Prob.**
None	0,49579	28,75962	24,15921	0,01110
At most 1	0,19075	8,88914	17,79730	0,60690
At most 2	0,15199	6,92446	11,22480	0,25610
At most 3	0,00130	0,05478	4,12991	0,84790
Max-Eigenvalue test indicates 1 CE at 0,05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Crude price variables

Crude Price Linear deterministic trend N° of Lag 1 Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No of CE(s)	Eigenvalue	Trace Statistic	0,05 Critical Value	Prob.**
None	0,67681	92,64874	69,81889	0,00030
At most 1	0,46388	44,07924	47,85613	0,10830
At most 2	0,22914	17,27338	29,79707	0,61980
At most 3	0,13053	6,08290	15,49471	0,68570
At most 4	0,00159	0,06862	3,84147	0,79330
Trace test indicates 1 CE at 0,05 level **MacKinnon-Haug-Michelis (1999) p-values				

Crude Price Linear deterministic trend N° of Lag 1 Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No of CE(s)	Eigenvalue	Max-Eigen statistic	0,05 Critical Value	Prob.**
None	0,67681	48,56950	33,87687	0,00050
At most 1	0,46388	26,80586	27,58434	0,06260
At most 2	0,22914	11,19048	21,13162	0,62820
At most 3	0,13053	6,01428	14,26460	0,61140
At most 4	0,00159	0,06862	0,84147	0,79330
Max-Eigenvalue test indicates 1 CE at 0,05 level **MacKinnon-Haug-Michelis (1999) p-values				

Appendix 3

	WORLD OIL DEMAND			
Variables	**Coefficients**	**Std. Error**	**t-statistic**	**Prob**
C	0,242944	0,302597	0,802864	0,4275
WORLD OIL DEMAND(-1)	1,297451	0,147395	8,802515	0,0000
WORLD OIL DEMAND(-2)	-0,404216	0,147115	-2,747615	0,0094
WORLD GDP PER CAPITA	0,966426	0,151116	6,395243	0,0000
WORLD GDP PER CAPITA(-1)	-1,463775	0,235220	-6,222997	0,0000
WORLD GDP PER CAPITA(-2)	0,608626	0,206267	2,950674	0,0056
REAL CRUDE PRICE	-0,010479	0,004720	-2,220058	0,0330
OECD CRUDE STOCK CHANGE	2,23E-07	3,17E-07	0,704920	0,4855

OLS	
Diagnostics	
Adj R^2	0,99466
Durbin Watson stat	1,73404
LM test	
F - statistic	1,33617
Prob F	0,27670
Obs R^2	3,22129
Prob. Chi-Square	0,19980
J. Bera	1,24589
Prob. Chi-Square	0,53636
White	
F - statistic	1,11135
Prob F	0,40560
Obs R^2	22,63386
Prob. Chi-Square	0,36380
Arch test	
F - statistic	0,52762
Prob F	0,47180
Obs R^2	0,54679
Prob. Chi-Square	0,45960

	D(WORLD OIL DEMAND)			
Variables	**Coefficients**	**Std. Error**	**t-statistic**	**Prob**
D(WORLD OIL DEMAND(-1))	1,048017	0,214697	4,881375	0,0000
D(WORLD OIL DEMAND(-2))	-0,277513	0,135104	-2,054071	0,0477
D(WORLD GDP PER CAPITA)	0,966364	0,101384	9,531758	0,0000
D(WORLD GDP PER CAPITA(-1))	-1,203182	0,234413	-5,132748	0,0000
D(WORLD GDP PER CAPITA(-2))	0,479921	0,185148	2,592092	0,0140
D(REAL CRUDE PRICE)	-0,024876	0,005256	-4,733185	0,0000
D(OECD CRUDE STOCK CHANGE)	1,99E-07	1,86E-07	1,068734	0,2927
ECTD(-1)	-0,524057	0,243280	-2,154129	0,0384
OLS				
Diagnostics				
Adj R^2	0,76683			
Durbin Watson stat	2,05450			
LM test				
F - statistic	0,48302			
Prob F	0,62130			
Obs R^2	1,22857			
Prob. Chi-Square	0,54100			
J. Bera	1,27269			
Prob. Chi-Square	0,52922			
White				
F - statistic	4,73625			
Prob F	0,04440			
Obs R^2	40,80345			
Prob. Chi-Square	0,26740			
Arch test				
F - statistic	0,21515			
Prob F	0,64530			
Obs R^2	0,22494			
Prob. Chi-Square	0,63530			

Appendix 4

	SA CRUDE PRODUCTION			
Variables	**Coefficients**	**Std. Error**	**t-statistic**	**Prob**
C	7,161320	0,295461	24,23777	0,0000
WORLD OIL DEMAND	0,711081	0,025635	27,73813	0,0000
OECD CRUDE STOCK CHANGE	-1,10E-06	2,66E-07	-4,127186	0,0002
SA % WORLD CRUDE PRODUCTION	1,071914	0,016652	64,37340	0,0000
AR(1)	0,521395	0,223939	2,328288	0,0252
MA(1)	0,243192	0,244791	0,993468	0,3266
ARMA GLS (NEWTON-RAPHSON)				
Diagnostics				
Adj R^2	0,99769			
Durbin Watson stat	1,95594			
LM test				
F - statistic	0,41569			
Prob F	0,66290			
Obs R^2	0,98748			
Prob. Chi-Square	0,61030			
J. Bera	4,28215			
Prob. Chi-Square	0,11753			
White				
F - statistic	2,54793			
Prob F	0,02190			
Obs R^2	35,38533			
Prob. Chi-Square	0,10360			
Arch test				
F - statistic	0,01557			
Prob F	0,90130			
Obs R^2	0,01631			
Prob. Chi-Square	0,89840			

	D(SA CRUDE PRODUCTION)			
Variables	**Coefficients**	**Std. Error**	**t-statistic**	**Prob**
D(WORLD OIL DEMAND)	1,037429	0,090734	11,43376	0,0000
D(OECD CRUDE STOCK CHANGE)	-1,22E-06	2,30E-07	-5,309587	0,0000
D(SA % WORLD CRUDE PRODUCTION)	1,053827	0,014648	71,94139	0,0000
ECTPROD(-1)	-0,349280	0,160503	-2,176159	0,0358
AR(1)	1,0000	1,334003	0,749623	0,4581
MA(1)	-0,999993	37,83717	-0,026429	0,9791
ARMA GLS (NEWTON-RAPHSON)				
Diagnostics				
Adj R^2	0,99397			
Durbin Watson stat	2,33547			
LM test				
F - statistic	2,06616			
Prob F	0,14140			
Obs R^2	4,42400			
Prob. Chi-Square	0,10950			
J. Bera	1,82519			
Prob. Chi-Square	0,40148			
White				
F - statistic	2,30425			
Prob F	0,02900			
Obs R^2	30,24790			
Prob. Chi-Square	0,08710			
Arch test				
F - statistic	0,52214			
Prob F	0,47400			
Obs R^2	0,54072			
Prob. Chi-Square	0,46210			

Appendix 5

	CRUDE PRICE			
Variables	**Coefficients**	**Std. Error**	**t-statistic**	**Prob**
C	-35,28515	10,62104	-3,22195	0,0020
OECD CRUDE STOCK CHANGE	-4,17E-07	6,05E-06	-0,690034	0,4944
REST OF THE WORLD % CRUDE PRODUCTION	-26,32569	9,405134	-2,799077	0,0080
WORLD OIL DEMAND	2,518702	0,874255	2,880969	0,0065
SA % WORLD CRUDE PRODUCTION	-3,378676	1,130365	-2,989014	0,0049
AR(1)	0,679187	0,154033	4,409361	0,0001
MA(1)	0,385775	0,202896	1,901341	0,0649
ARMA GLS (NEWTON-RAPHSON)				
Diagnostics				
Adj R^2	0,81233			
Durbin Watson stat	1,97824			
LM test				
F - statistic	0,20922			
Prob F	0,81220			
Obs R^2	0,44115			
Prob. Chi-Square	0,80210			
J. Bera	9,14488			
Prob. Chi-Square	0,01033			
White				
F - statistic	3,89938			
Prob F	0,01010			
Obs R^2	41,45617			
Prob. Chi-Square	0,14830			
Arch test				
F - statistic	0,52721			
Prob F	0,47180			
Obs R^2	0,54547			
Prob. Chi-Square	0,46020			

	D(CRUDE PRICE)			
Variables	**Coefficients**	**Std. Error**	**t-statistic**	**Prob**
D(OECD CRUDE STOCK CHANGE)	-8,40E-06	3,78E-06	2,223078	0,0324
D(REST OF THE WORLD % CRUDE PRODUCTION)	-21,14640	4,433200	-4,770008	0,0000
D(WORLD OIL DEMAND)	-0,861642	2,152031	-0,400386	0,6912
D(SA % WORLD CRUDE PRODUCTION)	-2,961193	0,381336	-7,765315	0,0000
ECTP	-0,522934	0,149382	-3,500639	0,0012
AR(1)	-0,168636	0,222320	-0,758529	0,4529
MA(1)	1	2353,82	0,000425	0,9997
ARMA GLS (NEWTON-RAPHSON)				
Diagnostics				
Adj R^2	0,26759			
Durbin Watson stat	1,91707			
LM test				
F - statistic	0,75606			
Prob F	0,47700			
Obs R^2	0,87587			
Prob. Chi-Square	0,64540			
J. Bera	6,32085			
Prob. Chi-Square	0,04241			
White				
F - statistic	0,52669			
Prob F	0,93060			
Obs R^2	21,81303			
Prob. Chi-Square	0,78990			
Arch test				
F - statistic	0,25209			
Prob F	0,61830			
Obs R^2	0,26278			
Prob. Chi-Square	0,60820			

Appendix 6

WORLD OIL DEMAND			
	RAW RIDGE	Std. Ridge	V.I.F
WORLD GDP PER CAPITA	0,878293	0,976571	2,11113
REAL CRUDE OIL	0,006754	0,026153	1,90952
OECD CRUDE STOCK CHANGE	-6,30E-07	-0,02454	1,18027
R^2	0,974011		

SA CRUDE PRODUCTION			
	RAW RIDGE	Std. Ridge	V.I.F
WORLD OIL DEMAND	0,705516	0,464492	1,129027
OECD CRUDE STOCK CHANGE	-1,02E-06	-0,026124	1,148262
SA % WORLD CRUDE PRODUCTION	1,073365	0,821836	1,078533
R^2	0,996380		

CRUDE PRICE			
	RAW RIDGE	Std. Ridge	V.I.F
OECD CRUDE STOCK CHANGE	1,18E-06	0,011857	1,42387
REST OF THE WORLD % CRUDE PRODUCTION	-66,69326	-2,56961	54,2051
WORLD OIL DEMAND	3,285975	0,848652	1,26276
SA % WORLD CRUDE PRODUCTION	-8,352266	-2,50863	53,0693
R^2	0,604186		