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Abstract

This paper aims at disentangling Saudi Arabia's crude oil strategy, taking into account critical factors such as oil stock, crude oil price, world demand conditions and macro-economic factors. Our study estimates three Error Correction Models (ECMs), using data spanning the period 1971-2015. The empirical findings provide sufficient evidence on the way Saudi Arabia's crude oil production strategy affects crude oil market. Specifically, when world crude oil demand increases, Saudi Arabia engages into exploitative practices since it tries to impose higher prices leaving room for the increased demand to the rest of the OPEC countries (market sharing). Moreover, we argue that Saudi Arabia's strategy is in alliance with the trade-off theory of producing more crude oil to establish its market share. However, the country does not intent to fully cover all the increased demand and does not over-react to short-run demand fluctuations since such a strategy would push crude oil prices down.

Keywords: Crude oil; Error Correction Model; Energy; OPEC; Saudi Arabia

JEL Classifications: O13; O53; Q41

Introduction

Saudi Arabia holds nearly 18 per cent of the world's petroleum reserves and ranks as the largest exporter of petroleum (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 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 attributed to 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, OPEC member countries 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 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 Saudi Arabia's crude oil strategy, especially concerning the adjustment of its crude oil production related to crude oil price and world crude oil demand evolution. This paper aims at providing evidence on those questions, by providing econometric analysis of Saudi Arabia's crude oil strategy, as related to critical factors such as crude oil stocks, price, world demand, macro-economic factors, but as well other producers' production strategy. Towards this target, it develops three econometric models, one for Saudi Arabia's crude oil production, one for crude oil prices and one for world crude oil demand.

The following paper is organized as following: Section 2 provides a literature review, while section 3 provides the methodology and the data used. Section 4 provides the empirical results and section 5 derives the conclusions of the paper.

Literature Review

The main research question behind Saudi Arabia's behavior is whether it behaves within the price-market share dilemma. Most researchers describe this trade-off between higher price and market share as if Saudi Arabia is a rational monopolist, attempting to maximize revenues (Fattouh et. Al. 2016). 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 of demand. 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. Santis (2003) suggests that exports quotas and the dominant firm role for Saudi Arabia explain price and output changes. Going a step forward explains that extended price fluctuations in the short-run are attributed to Saudi Arabia's inelastic production curve and that a negative demand shock will influence deeply Saudi Arabia, which has an incentive to cut production. On the contrary when a significant positive demand shock is present, Saudi Arabia does not have the incentive to augment production.

Since oil is not produced by a single country, its revenues are realized by different economies and most significantly, the reserves are different. Countries were divided by two criteria to examine divisions among producers. These were endowment and 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 as the largest reserves, ample spare capacity, and low-interest rates, it will prefer lower prices, than what other countries would, the rest of the producers attempt to maximize wealth earlier (Eckbo 1976). Kaufmann et al. (2004) suggests that capacity utilization, production quotas, over the quotas real production and OECD crude stocks do account for the price oil fluctuations. Kaufmann et al. (2008) add that OPEC behaviour should not be restrained into a single model, as this would ignore real world complexities, and the reason behind this is differences among producing countries (geological endowment, socio-political and economic systems etc.).

But under the theory of industrial organisation 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). Alkhathlan et al. (2014) present evidence that the previous is not monolithic. They divided the production period into “Normal” ones and those of interruptions. They suggest that Saudi Arabia has a binary policy, during the “Normal” periods, they cooperate with the rest of the OPEC members, but intervene when there are disruptions. Saudi Arabia’s ultimate goal is to sustain OPEC’s production volumes. The incentive to boost oil prices for Saudi Arabia do not only stem from the welfare necessity, but also by the local capital markets. Mohanty et al. (2011) find significant and positive correlation between price and stock market returns for Saudi capital market.

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, there is no agreement over volumes even within OPEC. 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 realize that someone is cheating, this will be with a lag and not instantly. The inability to monitor and punish the cheaters instantly was 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' responses are also a decision driver. Their finding was later strengthened by Almoguera et al. (2011) who find that producers waver between collusion and non-cooperation. MacAvoy (1982) had reached different conclusions as he claimed that oil price can be best explained by market and economy fundamentals and not by cartel models. All the aforementioned, gave rise to the question over how Saudi Arabia reacts. Griffin (1985) used four different models (competitive, cartel, target revenue, property rights) for eleven OPEC members. Target revenue behaviour by OPEC was also proposed by Teece (1982). 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 rise production to bring profits back to Cournot levels to punish 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 of 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 trade-off, 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 to eliminate any temporary gains confirming its role as a discipline enforcer.

Moreover, Hamilton (1983) and Hamilton (2003) proved that oil price shocks do have a significant negative effect on economy. In his second article Hamilton (2003) suggests that price spikes have much more negative effects, when positive price shocks do not have the same importance. Hamilton (2005) suggests that as we add more data then oil price increases influence less GDP growth. Mory (1993) estimates an elasticity of -0.0551 of GNP against oil price. Hooker (1996) rejects that oil price has the same power it had in the past, as a structural break from 1975 and onwards shows that GDP or unemployment were not by-products of oil prices. Bernanke et al. (1997) also suggest that energy costs are only a small fraction of the total production costs of the whole economy. As a consequence, it was the monetary policy followed in periods of high oil prices that harmed the output. Gault (2011) highlights that a $10/barrel increase (when the price was $100/barrel) would increase price index and decrease disposable income. Gault then continues to suggest that if consumers reduce their gasoline demand, this would reduce income and consequently spending in other sectors of the economy leading to more deep GDP decrease.

Therefore, the strategy of Saudi Arabia on its production rates is uncertain, as decision making on that is being affecting by several factors. This adds further external -to OPEC- factors in the decision making of Saudi Arabia's production strategy. Therefore, the Saudi Arabia's strategy is a more complex task, which is tackled in this paper by a holistic econometric analysis, examining the Saudi Arabia's crude oil production, but as well world crude oil dynamics, as depicted in the evolution of the crude oil prices and the world crude oil demand. Finally this research does not focus on issues such as the existence of the Dutch disease or oil dependency of the kingdom as Perifanis and Dagoumas (2017) study for the Russian economy.

Methodology and data

3.1 Data

Saudi Arabia's strategy depends on world crude oil demand and crude oil price evolution. In order to capture the Saudi Arabia's strategy, we provide a holistic econometric framework, by developing three econometric models: one for Saudi Arabia's crude oil production-supply, one for crude oil prices and one for world crude oil demand, using data from the International Energy Agency, and World Bank, over the period 1971-2015.

Our variables from IEA are the World Oil Demand in KB/D, OECD crude stocks in Kilotons and Saudi Arabia's crude oil production in Kilotons. Variables from World Bank are the average real 2010 US dollars crude oil price and 2010 US dollars World GDP per capita. All the variables were examined in natural logarithms in order to obtain the respective elasticities. In order to examine the Saudi Arabia's power over crude oil price, we estimated the production shares of Saudi Arabia and the rest of producers. We proceeded by estimating Saudi Arabia's crude oil production share, by dividing Saudi Arabia's crude oil production with the global crude oil production. The remaining crude oil production share was that of the rest of producers.

To proceed with our estimations, we test our dependent and independent variables for stationarity. All of our 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 with trend and intercept for both of them. The tests are conducted at 1%, 5% and 10% levels. Since the variables are non-stationary at levels I(0), then we proceed with their first differences. All the first differences of our variables are stationary. Since all of our data are non-stationary at levels but stationary at their first differences we test whether they are cointegrated i.e. if a long run relation exists between them. The results of stationarity tests are presented in Table 1.

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 coefficients. 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:

No intercept and no deterministic trend.

Intercept and no deterministic trend

Intercept no linear deterministic trend

Intercept and linear deterministic trend

Intercept and quadratic deterministic trend.

In order to proceed with the cointegration test we use the Akaike and Schwarz criteria for the lag length. Since we have the suggested lags, the criteria suggested one lag for all models, we use the Johansen Cointegration test with Trace and maximum Eigen Values. The results show that cointegration exists for all our models i.e. a long run relation between our variables. The world oil demand model and the crude price model assume linear deterministic trend and Saudi Arabia's production model is assumed with no deterministic trend. A summary of all the cointegration tests conducted and their results is presented in Tables 2 to 4.

3.2 Methodology

Our aim was to examine the crude oil market forces and especially Saudi Arabia's role. In our effort, we tried to examine the SA crude oil production, the crude oil price and the world crude oil demand, both in long-run and short-run. We used the two step Engle and Granger (1987) method to obtain long-run and short-run elasticities, as the variables are in natural logarithms and the respective coefficients are their elasticities. Under this method, we used as time series the residuals of the long-run models (u_t) lagged by a single period in our second short-run models. This is the ECT_{-1} of our models and it is with a period lag in the short-run models. The variables of the short-run models are the first differences of the variables of the long-run models.

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 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. In three out of six 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 the use of more lags, standardised variables or omitting some of the variables from the models.

This led us to examine Ridge regressions and their corresponding V.I.F. A V.I.F near 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 crude oil price model, we have the two production shares, the Saudi and that of the Rest of the producers'. Easily understood that if the Saudis 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. For the rest V.I.F present evidence of no multicollinearity.

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 (GLS) with the Newton-Raphson method and Conditional Least Squares with Gauss-Newton method.

3.2.1 Saudi Arabia 's crude oil production in long and short-run

Our first model is about Saudi Arabia's crude oil production, as a reaction to market developments. We assume that Saudi Arabia is responding to the market signals and adjusts its supply. These signals and market implications are world oil demand, OECD crude stocks, and Saudi Arabia's market share in world crude production. We consider that Saudi Arabia will try to satisfy the higher demand by producing more or will try to defend its world market/production share. Profit maximization is a trade-off between higher prices (lower production) and higher market share (low prices). 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 Arabia's crude oil production examined in the long-run is expressed by the following formula:

$$SCOP = c + b_1 * WOD + b_2 * OECDS + b_3 * SSWOP + u_t \qquad (1)$$

where SCOP is the Saudi Arabia's crude oil production, WOD is the world crude oil demand, OECDS is the OECD crude stocks and SSWOP is the Saudi Arabia's crude oil production share. And u_t is the disturbance term. U_t is later used for the short-run as ECT_{-1}. ECT_{-1} is used with a one period lag in the short-run models. The short-run model is:

$$\Delta(SCOP) = c + b_1 * \Delta(WOD) + b_2 * \Delta(OECDS) + b_3 * \Delta(SSWOP) + ECT_{-1} \qquad (2)$$

3.2.2 Crude oil price in long and short-run

Our second model concerns the crude oil price. We aim to estimate how crude oil prices behave in relation to other market factors, considering the role of Saudi Arabia. Again, we use as an independent variable the OECD crude oil stocks. These changes are considered as of crucial importance by broadcasters, and it is yet to be proven by empirical research. We include two factors which are the production shares of Saudi Arabia and of the Rest of the World. If Saudi Arabia loses a portion of its share, the rest of the producers earns it. However, it remains a question whether the same percentage of crude oil production share by different producer has different weight on crude oil price or not.

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

$$CAR = c + b_1 * OECDS + b_2 * RWSCP + b_3 * SSWOP + u_t \quad (3)$$

where CAR is the annual average of the crude oil price in 2010 US dollars, OECDS is the OECD crude oil stocks, RWSCP is the Rest of World crude oil production share and SSWOP is the Saudi Arabia's crude oil production share. The short-run model is:

$$\Delta(CAR) = c + b_1 * \Delta(OCSC) + b_2 * \Delta(RWSCP) + b_3 * \Delta(SSWOP) + ECT_{-1} \quad (4)$$

3.2.3 World crude oil demand in long and short-run

The last model is structured under the assumption that world crude oil demand follows the general world economic growth, considering the world GDP per capita by World Bank as independent variable. The second independent variable is the crude oil price by the World Bank. The last independent variable is OECD crude oil stocks, as there is a lot of debate whether the latter drives crude oil demand, price, production or all of them collectively.

This model does not include any variable directly linked with Saudi Arabia, which is the focus of the paper. Different variables, such as SAOD variable, representing Saudi Arabia's crude oil demand, have been omitted from the model, as they proved to have neglecting impact on world oil demand. However, the model is kept to be part of this holistic econometric analysis, as it provides useful insights on the dynamics of world crude oil market.

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

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

(5)

where all the variables as described above are in natural logarithms. The short-run model is:

$$\Delta(WOD) = c + b_1 * \Delta(WGDPPC) + b_2 * \Delta(CAR) + b_3 * \Delta(OECDS) + ECT_{-1}$$

(6)

Where WOD is the world oil demand, WGDPPC is the World GDP per capita, CAR is the annual average of the crude oil price in 2010 US dollars, and OECDS is the OECD crude oil stocks.

Empirical results

4.1. Saudi Arabia's crude oil production

4.1.1 Long run

We examine the model with ARMA and running with Newton- Raphson method as there was serial correlation in our initial models. Our regression has world oil demand, and Saudi share significant at all levels. OECD stocks are significant at 10% levels. The results of the model are shown in Table 5.

World oil demand influences positively the crude production of Saudi Arabia. This is in compliance with theory, as Saudi Arabia tries to cover the extra demand with its production, increasing its revenues. The elasticity of Saudi Arabia's crude oil production to world crude oil demand is less than one (0.77), 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 stable prices and reserve exhaustion. 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 (evidence of production sharing). The elasticity is 0.77 positive, meaning that Saudi Arabia will increase its production 0.77% if world demand increases by 1%. The OECD crude oil stocks are not significant for 1% and 5%, and are positive with a low value 0.164, something that cannot be easily explained. Saudi Arabia's crude oil production share has a positive relation with its crude oil production. The coefficient which is also the elasticity of SA's crude oil 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 asymmetrical increase. 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) (Table 5).

4.1.2 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 1.036). This result might imply that SA is more ready to capture temporary demand shocks by producing more. This will increase its revenues, and confirms its ability of maintaining spare production capacity. The policy of the spare capacity is validated. Moreover, the over the unity elasticity implies its ability to smooth price fluctuations, which could pose threats to long term demand. The short-run elasticity is greater than the long-run, which is an interesting result, as it confirms Saudi ability in the oil market as price smoother. OECD stocks are significant and negative implying that Saudi Arabia is taking stocks and oil glut under consideration and adjusts its production so as not to oversupply. The rest of the coefficients are again significant but those of the ARMA. The production share coefficient is lower and (1.06) implying that SA is not trying to increase its production share fast, 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. Both short and long run elasticities remain over but close to one, which means that Saudi Arabia is eager to defend its market share. The ECT_{-1} coefficient is the speed that short-run regression has towards the long-run one, implying that the 45% of the change will happen in a year's period (Table 5). Both long run and short run models comply give with our research demands and provide good estimates as they satisfy all of our tests (White, Arch, LM and J. Bera).

4.2 Crude oil price

4.2.1 Long run

We also examine what influences price. Our dependent variable is Price, and our independent variables are the OECD crude stocks, the Saudi and the rest of the World's oil production shares. We used Generalised Least Squares and specifically the Gauss-Newton method. The results of the model are shown in Table 6.

All coefficients are significant for the 5% level of significance we use. The rest of the world production share is significant, elastic and negative (-25.70), in compliance with theory as supply quantities cannot be stable and an increase in the share means more volume to the market. 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. Saudi Arabia's share coefficient is again negative (-3.18) but much lower as an absolute value meaning that the oil kingdom has much less effect on oil price alone than the rest of producers. Another 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 (Table 6).

OECD stocks have a negative coefficient (-4.44) implying that they deflate prices, a result in compliance to the late market developments. Their coefficient is higher in absolute value than that of Saudi Arabia, implying that the market is more responsive to the oil glut than to production quotas i.e. stocks more effective on oil price. This kind of results imply the limited role that Saudi Arabia can play in comparison to other market fundamentals.

Additionally, all elasticities are much higher than unity implying increased volatility of the price. Crude prices respond very abruptly to the news whether these have to do with production quotas or stocks.

The AR is significant but not the MA coefficient.

4.2.2 Short run

In the short run regression, we have similar results (Table 6). The production shares are significant, but the rest of the producers' coefficient is much higher in absolute value (-21.21) compared to that of Saudi Arabia's (-2.83). The production elasticities have lower absolute values implying that production fluctuation can have less effect on oil price in short periods. One assumption might be that production does not reach soon enough markets or that there are technological restrictions which affect production capacity. Nevertheless, they are again high implying high volatility and lead to the same results of the long-term model. OECD is only significant at the 10% and with a higher absolute value than the long-run. This result might imply that crude stocks play a more important role for the short-run movement of the price than in the long-run. Oil glut might be the main driver for the every-day price fluctuation, something close to the latest developments. Again, our tests for heteroscedasticity and serial correlation are satisfied.

4.3 World crude oil demand

4.3.1 Long run

As it was already mentioned, we regressed world crude oil demand against World GDP per capita, crude oil price, and OECD crude oil stocks. We used ARMA conditional Least Squares with the Gauss-Newton method. The model is not spurious as R^2 is lower than Durbin-Watson stat. The results of the model are shown in Table 7.

The coefficient for OECD crude oil stocks is low and statistically significant. It is positive implying that stocks' piling increases oil demand which is a logical assumption. World GDP growth requires oil, and this drives world oil demand up. The long run elasticity is over unity (1.07) presenting that a 1% GDP growth increases oil demand by 1.07%. When the opposite stands, and world economy falls in recession, oil demand declines. We have an elastic 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 -0.01 implying that a 1% price increase would lead to a 0.01% 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, which is an other implication of low substitution. The insensitive response to price might verify the research by Hamilton (2005, 2003,1983) and Gault (2011), who suggest a negative relation between prices and output. All the tests for heteroscedasticity, serial correlation and normally distributed residuals are satisfied.

4.3.2 Short run

When the model is estimated for the short-run, the results are interesting (Table 7). OECD crude oil stocks are significant only at 10%. R^2 and adjusted R^2 are high 69%. The coefficient-elasticity of GDP slightly lower (1.01) than that in the long-run and remains over one. We have a more inelastic relation, 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.[1]

The main result, both in short and long run is that a GDP increase does add positively and almost symmetrically to global oil demand. The crude oil price elasticity is again negative less than 1 in absolute value (-0.010), and lower than that of long term. The absolute value of the short-run compared to the long-run exposes that economy does not have a better response to a price increase, but lower demand (dependence on oil-low substitution). The ECT_{-1} is statistically significant implying a well explanatory ability. The ECT_{-1} coefficient is the speed that short-run regression has towards to the long-run one, implying that the 40.67% of the change will happen in a year's period. All the tests are satisfactory which testify the robustness of the model.

Conclusions

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

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[1] 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

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 paper aims at examining the Saudi Arabia's crude oil strategy, especially concerning the adjustment of its crude oil production related to crude oil price and world crude oil demand evolution. It provides a holistic econometric analysis, by developing three econometric models, one for Saudi Arabia's crude oil production, one for crude oil prices and one for world crude oil demand. It provides evidence on Saudi Arabia's crude oil strategy, as related to critical factors, such as crude oil stocks, price, other producers' production, world demand and macro-economic factors towards this target.

The global economy is the main factor driving world crude oil demand. Economic growth increases crude oil demand levels, and requires more crude oil production to meet demand. When the alternative exists, i.e. recession, world crude oil demand decreases.

The long-run results from the Saudi crude oil production model, provide evidence that Saudi Arabia tries to catch the increased demand by increasing its production. When world crude oil 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 (production sharing). However, Saudi Arabia does not intent to fully cover all the demand increase and does not over-react, as such strategy would bring crude oil prices down. On the contrary, in the short-run, Saudi Arabia tries to more than fully cover temporary demand shocks, in order to smooth prices and not pose a threat to long-term demand. The spare capacity ability of the kingdom is confirmed, as it operates as a price smoother for temporary price shocks. The result of an elastic short-run production elasticity, when the long-run is inelastic is interesting and highlights the special case of our study. In addition, Saudi Arabia reactions present evidence for the trade-off theory as the kingdom produces more crude oil to defend its production share. This explains why Saudi Arabia continued to produce in a decreasing price environment. 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 late 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.

Low substitution of oil, as an energy source, is verified by the low price elasticities of both long and short run regressions. Either way (long and short run), demand has a very low price elasticity presenting a very insensitive relation verifying our dependence. This kind of dependence may verify the results of Hamilton (2005, 2003,1983) and Gault (2011) who suggest the negative influence of oil prices increases to the economy.

Finally, the paper argues that Saudi Arabia's crude oil production decisions are not taken in strictly economical silos but rather are the by-products of more extended aims. The price-share dilemma is sometimes neglected when broader geopolitical targets or long-term market share issues are at stake. Therefore, Saudi Arabia adjusts its production strategy away from the optimal production level, towards meeting wider policy issues.

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Acronyms

OPEC: Organization of the Petroleum Exporting Countries

ECT: Error Correction Term

GDP: Gross Domestic Product

GNP: Gross National Product

IEA: International Energy Agency

OECD: Organization for Economic Cooperation and Development

ADF test: Augmented Dickey – Fuller test

KPSS test: Kwiatkowski–Phillips–Schmidt–Shin test

ARMA: AutoRegressive Moving Average

AR: AutoRegressive

MA: Moving Average

V.I.F.: Variance Inflation Factor

GLS: Generalised Least Squares

Nomenclature:

SCOP: Saudi Arabia's crude oil production.

WOD: World crude oil demand.

OCSC: OECD crude stock changes.

SSWOP: Saudi Arabia's crude oil production share.

CAR: Annual average of the crude oil price in 2010 USD.

RWSCP: Rest of World crude oil production share.

WGDPPC: World GDP per capita in 2010 USD

SA: Saudi Arabia

Tables

Table 1
Test for unit roots 1971-2015

Level	ADF	KPSS	First difference	ADF	KPSS
WD	-3.052	0.432[a]	Δ(WD)	5.730[a]	0.169
WGDPPC	-2.592	0.427[a]	Δ(WGDPPC)	-5.334[a]	0.063
CAR	-2.368	1.413[a]	Δ(CAR)	-6.418[a]	0.108
OECDS	-1.688	8.155[a]	Δ(OCS)	-5.764[a]	0.079
RWSCP	-2.427	1.332[a]	Δ(RWSCP)	-5.723[a]	0.072
SSWOP	-2.334	0.241[a]	Δ(SSWOP)	-3.899[a]	0.069
SCOP	-2.293	0.338[a]	Δ(SCOP)	-3.994[a]	0.097

Notes: The null hypothesis of the ADF test is that the variable has a unit root and the null hypothesis for the KPSS test is that the variable is stationary. The first difference of the series is indicated by Δ.
[a] Indicates rejection of the null hypothesis at all levels (1%, 5% and 10%).
[b] Indicates rejection of the null hypothesis at 5% and 10%.
[c] Indicates rejection of the null hypothesis at 10%.

Table 2
Johansen's maximum likelihood method test for cointegration relationship
SA production model

Null Hypothesis Ho	Alternative Hypothesis, H1	Eigen Value	0.05 critical value
Maximum eigenvalues			
r=0	r=1	65.033	54.079
r⩽1	r=2	31.149	35.192
Trace statistics			
r=0	r⩾1	33.893	28.588
r⩽1	r⩾2	19.415	22.299

Trace indicates 1 CE at 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 3
Johansen's maximum likelihood method test for cointegration relationship
Crude Price Model

Null Hypothesis Ho	Alternative Hypothesis, H1	Eigen Value	0.05 critical value
Maximum eigenvalues			
r=0	r=1	30.055	27.584
r⩽1	r=2	12.408	21.131
Trace statistics			
r=0	r⩾1	57.068	47.856
r⩽1	r⩾2	27.013	29.797

Trace indicates 1 CE at 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4
Johansen's maximum likelihood method test for cointegration relationship
Demand

Null Hypothesis Ho	Alternative Hypothesis, H1	Eigen Value	0.05 critical value
Maximum eigenvalues			
r=0	r=1	37.638	27.584
r⩽1	r=2	11.178	21.131
Trace statistics			
r=0	r⩾1	55.051	47.856
r⩽1	r⩾2	17.424	29.797

Trace indicates 1 CE at 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 5
SA crude oil production model – Long Run and Short run

Variables	Coefficients	Std. Error	Coefficients	Std. Error
C	4.228[b]	1.736		
WOD	0.777[a]	0.049		
OECDS	0.164[c]	0.089		
SSWOP	1.071[a]	0.016		
AR(1)	0.125[c]	0.327		
MA(1)	0.388	0.304		
C			-0.009[a]	0.003
Δ(WOD)			1.036[a]	0.108
Δ(OECDS)			-0.572[a]	0.200
Δ(SSWOP)		.	1.062[a]	0.016
ECT_{-1}			-0.453[a]	0.158
AR(1)			1.000	2.770
MA(1)			-0.999	0.054

[a] Indicates significance at all levels (1%, 5% and 10%).
[b] Indicates significance at 5% and 10%.
[c] Indicates significance at 10%.

Table 6
Crude oil price model – Long Run and Short run

Variables	Coefficients	Std. Error	Coefficients	Std. Error
C	52.643[c]	26.191		
RWSCP	-25.704[a]	8.979		
SSWOP	-3.182[a]	1.114		
OECDS	-4.443[b]	1.938		
AR(1)	0.772[a]	0.124		
MA(1)	0.308	0.187		
C			-0.009	0.079
Δ(RWSCP)			-21.214[a]	4.467
Δ(SSWOP)			-2.835[a]	0.397
Δ(OECDS)			-7.962[c]	4.189
ECT_{-1}			-0.546[a]	0.176
AR(1)			-0.143	0.225
MA(1)			1.000	2931.893

[a] Indicates significance at all levels (1%, 5% and 10%).
[b] Indicates significance at 5% and 10%.

[c] Indicates significance at 10%.

Table 7

World crude oil demand model -Long Run and Short run

Variables	Coefficients	Std. Error	Coefficients	Std. Error
C	-4.127	2.620		
WGDPPC	1.074[a]	0.075		
CAR	-0.014[b]	0.005		
OECDS	0.433[a]	0.153		
AR	0.665[a]	0.103		
MA	0.597[a]	0.139		
C			0.001	0.003
Δ(WGDPPC)			1.011[a]	0.135
Δ(CAR)			-0.010[b]	0.004
Δ(OECDS)			0.332[c]	0.176
ECT_{-1}			-0.406[a]	0.092
AR			-0.030	0.181
MA			0.953[a]	0.057

[a] Indicates significance at all levels (1%, 5% and 10%).
[b] Indicates significance at 5% and 10%.
[c] Indicates significance at 10%.