Int. J. Nonlinear Anal. Appl. In Press, 1–16
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2023.29789.4263

Saudi Arabian oil policies in Vision for 2030 plan and its influence on global oil market with a game theory approach

Behrooz Baikalizadeh[a], Atefeh Taklif[a,*], Farshad Momeni[a], Davood Daneshjafari[a], Afshin Javan[b]

[a]*Faculty of Economics, Allameh Tabataba'i University, Tehran, Iran*

[b]*General Director of OPEC Affairs, Petroleum Ministry, Tehran, Iran*

(Communicated by Madjid Eshaghi Gordji)

Abstract

It is important to assess Saudi Arabia's economic performance because its role in the global oil market and how international investors perceive its actions have global consequences. The goal of the article is to analyze the role of Saudi Arabia in the world oil market and the world economy for a long historical period. It is shown that the strategic behavior of Saudi Arabia has always been and continues to be subordinated to ensure a stable supply of oil in the world oil market. Under the Saudi Arabian leadership, OPEC aims at pursuing an economically rational and responsible policy, supporting the balance of the demand for oil and its supply, thus allowing to avoid deep and lasting oil price decline. Until very recently, an important factor impacting the formulation of Saudi oil policy was maintaining strategic interaction with the US. The restructuring of the world oil market driven by the shale revolution and the nearing peak of global oil demand have created new challenges for Saudi Arabia's oil strategy. The OPEC+ situational agreement enacted in 2017 by OPEC and non-OPEC countries to voluntarily reduce levels of oil production temporarily allows to keep a supply–demand balance in the world oil market preventing from substantial drop in oil prices. At the same time, the agreement opens opportunities for competitors, first of all American producers of tight oil, to maintain and expand export niches. The shale revolution created a situation in which the oil interests of the US and Saudi Arabia came into open conflict. For political and strategic considerations, a price war to crowd American oil producers with their relatively high production costs out of the market is not a feasible option for the Kingdom. Attempts to transform the state oil company Saudi Aramco into a mega supermajor utilizing the global economic and financial potential have failed as the leading international banks and corporations avoided the company's IPO. The failure of Saudi Aramco's partial privatization is a signal of a false start of a company to open the Saudi economy to the large-scale inflow of foreign investment. Paradoxically, the long-term perspectives of Saudi Arabia crucially depend on how effectively it will use the coming 10- 20 years of oil export earnings for diversification of the national economy outside the oil sector.

Keywords: economic transformation, oil politics, world oil market, Saudi Arabia, OPEC
2020 MSC: 91-XX, 91B24

*Corresponding author
Email addresses: behroozbaikalizadeh@gmail.com (Behrooz Baikalizadeh), at.taklif@gmail.com (Atefeh Taklif), farshad.momeni@gmail.com (Farshad Momeni), daneshjafari@yahoo.com (Davood Daneshjafari), a.javan@nioc.ir (Afshin Javan)

Received: December 2022 *Accepted:* February 2023

1 Introduction

This issue was abundantly tackled in the literature. For instance, Hamilton [13] noted that oil price shocks caused the first US post-war recessions. Also, Ayadi et al. [2], Bernanke et al. [4], Brown and Yücel [7], Kahn and Hampton [14], Gisser and Goodwin [12], and Wu and Ni [26] all agreed on the negative impact that oil price shocks have on the oil-exporting countries' economic growth due to the impact of oil price shocks on the financial surpluses required to finance economic and social development, which in turns implies a weakening of these countries' ability to meet their development obligations quoted from Claessens et al. [9]. Brichs [6] showed that oil is still the most important resource and economic power that controls the development process in Arab countries, particularly in Saudi Arabia. Hence, the development experiences in the past two decades have proven that Arab oil has relied on and still uses direct and indirect effects on most of the factors that affect development in Arab countries and on incentives for economic integration among them. It also contributes effectively to economic development by providing the foreign currencies necessary to finance goods and services, given that Consumerism and Capitalism are strategic products that can be used to build a large industrial base as one of the production elements needed for any industry. Also, Onyemelukwe [23] showed that economic growth is affected by oil reserves given that abundant oil reserves help countries to set their future development plans, achieve an increase and efficiency in the growth and development rates, and thus increase the income per capita through which society is wealthier However, many theories focused on natural oil resources in general. The most important is the classical theory defended by Adam Smith, which consecrates economic growth and development based on the scarcity of natural resources. The new classical theory, advanced by Marshall and Guillebaud [19], believes that economic growth and development depend on production elements available in society (i.e., work, capital, land, or natural resources). Likewise, the narcissist theory, developed by Narksis, calls for relying on domestic natural resources in the first place for economic development due to a lack of confidence in foreign investment and foreign trade because the terms of trade are in favor of the developing countries compiled from Barbier [3]. As mentioned above, many studies have concentrated on this issue. While some dealt with Arab countries, other studies were global, examining the effect of oil price shocks on countries' economic growth. For instance, we can cite the work of Manama [18], who found that the oil sector in Arab countries depends on oil export revenues, and output fluctuations in oil prices exacerbate macroeconomic volatility. It is also an exhaustible resource, so oil-dependent countries have to promote sufficient non-oil sectors before their oil reserves are exploited to diversify the economy, recognising to policies and additional strategies that encourage domestic technological capabilities and enhance natural resources processing. They also have to improve the competitiveness of their non-oil exports. So, the present study reflects that the recent drop in oil prices has put further pressure on oil countries' government resources, making the context of economic diversification difficult but also more urgent. That is why policymakers are urged to simultaneously protect financial sustainability while pushing forward to facilitate economic diversification. Structural reforms outlined in Vision 2030 are much needed to shift the economy to a more sustainable path, and even if only a small part of Vision 2030 is being implemented, the Saudi economy will look very different in 2030 than it does now. The key question is whether these changes will have a substantial impact on oil policy and the evolution of the energy sector. In this comment, we argue that while the recent announcements and organizational changes are substantial and the overall objectives of Vision 2030 are very ambitious, the impact on oil policy and the energy sector is likely to be more subtle than current expectations.

Saudi Arabia has rich oil resources and accounts for one-sixth of the world's oil reserves. Since the discovery of the Dammam Oilfield in 1938, the world's largest onshore oilfield, the destiny of Saudi Arabia has been closely connected to oil, around which its energy strategy has been evolved. Previously, it focused on seizing control of domestic oil resources and the international oil market through OPEC, and currently, it adopts a moderate oil policy intended to maintain its share of the international oil market. At present, Saudi Arabia is OPEC's largest oil producer, accounting for one-third of OPEC's oil production, and with rich oil resources, a conciliatory regional policy and pro-Western diplomacy and other well-established advantages, it has occupied a core position in the OPEC power structure. Recently, within OPEC, something has changed, with Qatar withdrawing and member countries such as Iran and Qatar announcing that to will gradually turn to focus on natural gas, and moreover, the United States has become the world's largest oil producer. As a result, OPEC will surely have a declining influence on the world's oil market. In the future, OPEC, as never before, will be under huge challenges from the United States, the world's largest oil producer, and the attitude of Saudi Arabia will be critical.

Evolution of the Saudi Arabian Energy Strategy. In Saudi Arabia, the development of the energy strategy began in the 1960s, when King Faisal realized that oil revenue might provide the funds necessary for economic modernisation and national security, and the focus of the energy strategy was to regain control of oil resources. In 1960, when the Middle East had become a major oil producer in the world, Saudi Arabia and other 4 oil producers set up OPEC, under which oil producers in the Middle East began to promulgate the uniform oil policy, intending to seek for a legitimate status in international oil market and to break up the monopoly of international oil market by the so-called "Seven Sisters", i.e. seven European and US oil companies. Thereafter, to a considerable extent, it was through OPEC that Saudi Arabia realized its energy strategy. In the 1960s, through OPEC, Saudi Arabia and other oil producers restricted oil production and opposed international oil companies ' control and forced down oil prices. To a considerable extent, this has contributed to the signing of the Tehran Agreement in 1971, under which oil producers took back the oil pricing power. Subsequently, the OPEC retook control of national natural resources from international oil companies. When the Middle East War broke up in 1973, to strike Israel and its supporters, the Arabian OPEC members announced the take-back of posted prices and directly raised posted prices from 2.89 US dollars to 5.119 US dollars per barrel, and further up to 11.65 US dollars in 1974, resulting in the first oil crisis. In 1975, to effectively curb the then overwhelming power of the OPEC to manipulate international oil market, the International Energy Agency (IEA) was founded by the OECD countries, including the United States, to coordinate national energy policies on behalf of leading oil-consuming countries and to be in better position to cope with the issue of OPEC oil supply.

In the dualistic game between oil producers, as represented by the OPEC, and oil consumers, as represented by the IEA, the OPEC has been weakening in terms of market influence, and later on, it sought to maximize its interest and stabilize global oil market by using oil price mechanisms and production quotas to influence international oil market. In 1978, a revolution erupted in Iran to overthrow the government of Pahlavi, and the second oil crisis occurred in the Middle East as a result of panicked oil buying and soaring oil prices. Due to the oil crisis and high price, non-OPEC countries became motivated to step up oil exploration and development, and their share in the world's oil production rose from 50.4% in 1979 to 69.8% in 1985. The international oil market was oversupplied and became a buyer's market rather than a seller's market. In 1982, OPEC had no choice but to cut oil production and prices. To cope with the precipitating price, one of the means for OPEC is to cut production and maintain a stable price; however, such a reduction, if prolonged, may reduce its share and undermine its influence on the international oil market. When the international oil market is balanced in terms of demand and supply, OPEC also has to discuss the strategic issue of whether to cut production and maintain the price or to increase production and market share.

In general, a country needs energy resources for its economic development. This causes the 45th demand for energy resources to be higher. Among the energy sources that are in high demand is 46 oil. Oil, also known as crude oil and petroleum, that is found beneath the surface of the Earth, is 47 one of the factors of economic growth. Since oil is the most important industry to the globe, people 48 daily life depends much on it [16]. One of the sectors that depends most on oil is transportation, where oil is used in the form of petrol (gasoline) and diesel-derived products for transporting goods from producers to consumers.

The oil prices are determined by the global supply and demand. The price of the oil is reflected based on its production and consumption movement. An intergovernmental organization that coordinates and consolidates the oil policy is the Organization of the Petroleum Exporting Countries (OPEC). The function of OPEC is to stabilise any volatile oil prices by controlling the 5 production of the member countries, supply oil to consumers regularly and ensure a fixed income to the production of oil-producing countries as well as a fair return on capital. OPEC can generally set oil production controls for its member countries by setting targets or quotas. This oil 8 production control is to influence the oil price shocks as a suggested strategy [8]. The oil production and price issues were discovered a long time ago and will always be a continuous problem for the globe, especially during the current global threats of the coronavirus pandemic. Some other oil price shock events are political instability, global economic crisis and natural disasters, which influence the bad economic performance of the affected country. It is also a question of the economic performance of the affected countries since the continuous movement control order or lockdown is worrying everybody. The continued spread of the pandemic could be observed in the impact on the declining oil prices. Hence, the oil industry players have taken part in an oil price war. The oil price shock events also impact the supply and demand of oil, oil reserves in a conflict region and the usage of oil for daily activities such as food delivery and goods transportation. Oil production and price issues have been discovered continuously, therefore, this paper discusses the topics of oil production and price jointly in this paper since the problems are closely to each other. Oil, as one of the important resources for the world, has been taken into account as a precious asset, correlated with the conflicting interests among numerous oil players such as governments, countries, and companies, as well as producing and consuming countries [1]. These aspects are similar to fundamentals in the game theory framework, where the conflict among the oil industry players has been considered.

1.1 Vision to 2030

Oil prices 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 the GDP and balance in 2021 when oil prices recover. Bank deposits again declined, and inflation was over 4% as the state decreased subsidies on energy and water. As a response, Saudi Arabia issued the “Vision to 2030” in April 2016. The program 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 the 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. With all these kinds 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.

What the “Vision to 2030” does not address 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 another bitter experience. It was only in 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, and interconnections among them and the plants. Most of these costs are considered as sunk costs, and no one is sure whether they will be recovered. 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 to increase capacity. Even if SA protects its share, it is highly doubtful that the pie will be the same size. New environmental regulations and firmer laws on carbon use like the Emissions Trading System (ETS) in the EU might decrease oil revenue due to volume decline.

1.2 The oil sector and oil revenues will remain central to Saudi Arabia’s economy

During an interview with Western media outlets, Deputy Crown Prince Mohammed bin Salman alleged that the kingdom is indifferent to whether the price of oil is \$30 or \$70. Not surprisingly, this was interpreted as meaning Saudi Arabia no longer cares about oil prices, and its output policy is no longer tied to the objective of maximizing oil revenues. An extreme interpretation was that Saudi Arabia might even welcome a low-price environment, as that would make it easier to push through the substantial reforms contained in Vision 2030. Yet, the fact remains that the Saudi economy, including the non-oil private sector, still relies heavily on government spending that is fueled by oil revenues. Furthermore, the political stability of the country is directly linked to the ability of the government to distribute rent to the population, including creating jobs in the public sector. As recently emphasized by Al-Falih, the objective of reducing reliance on oil ‘does not mean that the kingdom’s opportunities of optimizing its benefits from its natural resources, including oil, will receive less attention in the current economic phase than in previous phases. Increasing our oil revenues will help us to build a range of other economic sectors in the kingdom besides international investments.5’ Despite the size of its fiscal buffers, low oil prices have been painful for the kingdom. Saudi Arabia has been drawing down on its foreign reserves, increasing its borrowing, exploring schemes to increase taxes (including VAT), reducing government spending, cutting energy subsidies and scaling back spending on capital projects. These adjustments are already taking their toll on the economy. Growth is slowing down, stock markets have fallen from their high levels, the Saudi Riyal peg has come under pressure, and consumers have been hit by higher energy prices and growing inflation. One also cannot assume that further reforms, such as entirely removing energy subsidies and fully liberalizing prices, will not risk strong public opposition. Indeed, the fallout from the recent increase in water charges is a case in point. The water and electricity minister was fired following public complaints over a surge in prices, with Mohammed bin Salman describing the ministry’s implementation of the new water tariff as ‘unsatisfactory’. The implicit social contract has indeed proved to be elastic and sufficiently malleable to accommodate the recent energy price increases. However, it may not prove sufficiently resilient to accommodate any further price increases. The Saudi government is already rethinking the energy subsidy reform program and has plans to introduce compensatory schemes to offset the higher costs for households in low-income brackets to gather support for the reforms.

In a resource-based economy, the regulation of exports is crucial. Most oil-producing countries, like Saudi Arabia, the United Arab Emirates or Russia, export via regulated monopolies. Other countries, like Norway and Canada, have decided to open their export activity to competition. In these countries, many firms can produce oil and directly export it to international spot markets where they compete. Some oil-producing countries have recently experienced an economic shift toward export nationalization: the government of Argentina decided in 2012 to expropriate Repsol YPF and acquired more than 51% of the company. Other countries have carried out a shift in the other direction.

As an example, Norway and the United Kingdom increased competition in their production and export activity in previous decades. The U.S. has recently shifted its position from allowing no crude oil export to an unconstrained export system. Like oil, gas-producing countries also show different behaviors in their design of export markets. For example, Russia authorizes only Gazprom Export to export gas. Likewise, Algeria with Sonatrach. On the contrary, Norway has opened its export market to firms other than Statoil.

1.3 Oil producers

According to the BP Statistical Review of World Energy [11], the six biggest oil producers in 20153 were the U.S. (12,354 thousand barrels/day), Saudi Arabia (12,349 thousand barrels/day), Russia (11,227 thousand barrels/day), Iran (4,600 thousand barrels/day), Canada (4,460 thousand barrels/day), and China (4,000 barrels/day) (China has a comparable production as United Arab Emirates). It should be noted that the U.S. is not a net oil exporter, but the country still has non-negligible export volumes that are worth analyzing. Because of the international sanctions in the past that forbade international trade, Iran's export activity is not of interest in this work. However, it should be very interesting to analyze how Iran is going to structure its oil and gas export market since the very recent economic (re)opening of the country and the strong reduction in international sanctions. The U.S. and Canada are good examples of where the production and the export markets are quasi-completely open. In both countries, most producing firms (more than 10 for both countries), like ExxonMobil (U.S.), Chevron Corporation (U.S.), Halliburton (U.S.), Petro-Canada (Canada), Canadian Natural Resources (Canada), and Husky Energy (Canada), can export oil to foreign countries either on the spot markets or via bilateral agreements. In contrast, the Saudi production and export activities are extremely concentrated: only the state-regulated company Saudi Aramco is allowed to extract and export oil, mostly via long-term contracts. China counts only three main companies to exploit oil resources (Sinopec, CNOOC, and PetroChina). The Russian case is quite interesting: six big companies share the local oil production in Russia: Gazprom, Rosneft, LUKoil, Loukos, Surgutneftegaz, and TNK-BP (a joint-venture associating BP and the local AAR consortium), but only Gazprom (with a Russian government share of more than 51%) via its branch Gazprom Export, can sell oil to European and Asian consumers.

2 Methodology

Review of the Game Theory on Oil Production and Price Applications Game theory is a mathematical discipline and is largely applied by economists. In a game, the strategic interaction among the players is taken into account with the assumption that all players are rational. However, rational behavior will generate sustained decisions and remove the uncertain decisions for the long run result [24]. In game theory, generally, the basic elements are players, strategies and payoff. Game theory is a study of the interaction among numerous players where every player has a set of strategies that can be chosen, either one or more than one strategy with particular probabilities [5]. Game theory has two types of games, which are competitive and cooperative. The conflict situation is called a noncooperative game 38, while the cooperation situation is called a cooperative game. This section focuses on the oil production first, then the oil price. Later, both oil production and the price of literature are reviewed.

Oil production works of literature are studied by Boyce and Vojtassak [10], who used Nash equilibrium and subgame perfect equilibrium in game theory to examine a model of 'oil ' igopoly exploration and production. The study makes sure the firms use strategic exploration to influence the rival's actions and study the strategic exploration and strategic production that affect each other. The result showed that the Nash equilibrium yield expectations differ significantly combined between over-exploration and under-yields. The Nash equilibrium concept is preferred instead of the subgame perfection equilibrium concept in this study. In making a decision, stakeholders individually have the conflict of preferences on the investment value should be invested, which in turn should they act. Willigers et al. [25] provided a game theory framework to study players' preference relationships, uncertain solutions and commercial drivers on jointly three oil fields where the two-player game model was used. The joint fields will support the choosing of alternatives, the timing and the order of the investment, also reducing the risk or negative impact on a project. The trade-offs of players' preferences to choose alternatives not taking into account any criteria 4 in decision making.

2.1 Strategic games

In this section, the types of normal games with n players in game theory are defined as conflict situations, including players' gains and losses. In such games, n players interact with each other through strategy selection or approach selection. In addition, all players choose their strategy at the same time [22]. For simplicity, we limit the pure strategy set of players to two strategies and the number of players to two players. A strategy is defined as a probability distribution over all possible actions or actions of the players. So that we have two pure strategies: A mixed strategy s_m is also defined by $s_m = (x_1, x_2)$ which:

$$x_1, x_2 \neq 0, \qquad x_1 + x_2 = 1 \tag{2.1}$$

a match $G = (S_1, S_2, P_1, P_2)$ by efficiency functions P_2, P_1. And their set of strategies means; S_1 is defined for the first player and S_2 is defined for the second player. Also efficiency functions included $P_2 : S_1 \times S_2 \to R, \quad P_1 : S_1 \times S_2 \to R$

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$$
$$B = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \tag{2.2}$$

Matrix A represents the efficiency of the row player, and matrix B represents the efficiency of the column player. The element a_{ij} is the payoff of the row player (first player) for choosing the pure strategy S_j from the set S_1 when the column player (the second player) chooses the pure strategy ni from the set and. The element b_{ij} is also the column player's reward for choosing the strategy S_j from the set S_2 when the row player chooses the pure strategy S_i from the set S_1. The set of families of 2×2 games are usually classified in three subclasses as follows:

$$\begin{cases} if : (a_{11} - a_{21})(a_{12} - a_{22}) > 0 \\ or : (b_{11} - b_{12})(b_{21} - b_{22}) > 0 \end{cases} \tag{2.3}$$

where in; at least one of the two players has a dominant strategy and therefore there is only one strict Nash equilibrium. Under the second class

$$\begin{aligned} if : &(a_{11} - a_{21})(a_{12} - a_{22}) < 0 \\ &(b_{11} - b_{12})(b_{21} - b_{22}) < 0 \\ &(a_{11} - a_{21})(b_{11} - b_{12}) > 0 \end{aligned} \tag{2.4}$$

where in; There are two pure equilibria and one mixed equilibrium. under the third class)

$$\begin{aligned} if : &(a_{11} - a_{21})(a_{12} - a_{22}) < 0 \\ &(b_{11} - b_{12})(b_{21} - b_{22}) < 0 \\ &(a_{11} - a_{21})(b_{11} - b_{12}) < 0 \end{aligned} \tag{2.5}$$

The first subclass includes those types of games in which each player has a dominant strategy such as; Prisoner's Puzzle (PD) game. At the same time, these types of games also include a larger set of popular games, because only one player needs to have a dominant strategy. In the second subclass, none of the players has a dominant strategy, such as the game of couples' conflict. BOTS). Despite this, both players get the highest efficiency by playing the first strategy with their second strategy. This is stated in the following condition:

$$(a_{11} - a_{21})(b_{11} - b_{12}) > 0. \tag{2.6}$$

The only difference between the third subclass and the second is the fact that players do not get the highest payoff by playing their first or second strategy, such as; games for example coin matching game (MG). This article is expressed with the following condition:

$$(a_{11} - a_{21})(b_{11} - b_{12}) < 0. \tag{2.7}$$

A sustainable strategy should be better against any other strategy than playing those strategies against itself. Mathematically speaking, a 5 strategy is evolutionarily stable if for every strategy we have

$$\begin{aligned} &\pi(s, s) > \pi(t, s), \quad \text{or} \\ &\pi(s, s) = \pi(t, s) \ \& \ \pi(s, u) > \pi(u, u) \end{aligned} \tag{2.8}$$

where in; $\pi(t, s)$ Strategy efficiency S and in the game, it is equal to strategy t.

3 Modelling Saudi Arabia's policy and drivers

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 1971-2017.

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 the KPSS tests. The tests are conducted at 1%, 5% and 10% levels. If a variable is nonstationary at level I(0), then we proceed with its first difference. We first test them for the levels, and if we find non-stationary, we proceed with their first difference. Since most of our data are non-stationary at levels, then we test whether they are cointegrated. The augmented Dickey-Fuller test agrees on the nonstationarity 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 the ADF test. OECD crude stock changes are stationary at levels for ADF but only at 1% for KPSS. The rest of the world's 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.

3.1 Cointegration results

Since our variables are non-stationary at levels, we test whether they are cointegrated, i.e. if a long-run relation exists between them. Our cointegration test is the Johansen Cointegration test. This examination is to avoid a spurious model, which will result in low-quality regressions. 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 following 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.

The following Table 1 presents the list of variable examined.

Table 1: The list of variable

Variable Name	Description	Data source
WORLD OIL DEMAND	Natural Logarithm of WORLD Oil Demand in kbd	IEA
WORLD GDP PER CAPITA	Natural Logarithm of WORLD GDP per capita	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

3.2 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 the Joint Organizations Data Initiative (JODI).

4 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 the 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 Price by 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:

$$WOD = c + b_1 \times WGDPPC + b_2 \times CAR + b_3 \times OCSC + u_t \tag{4.1}$$

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:

$$D(WOD) = c + b_1 \times D(WGDPPC) + b_2 \times D(CAR) + b_3 \times D(OCSC) + ECT \tag{4.2}$$

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	Natural Logarithm of WORLD GDP per capita
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

5 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 advantage 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:

$$SCOP = c + b_1 \times WOD + b_2 \times OCSC + b_3 \times SSWOP + u_t \tag{5.1}$$

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:

$$D(SCOP) = c + b_1 \times D(WOD) + b_2 \times D(OCSC) + b_3 \times D(SSWOP) + ECT \tag{5.2}$$

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

5.1 Crude oil price model

Our last model is the price model. We would like to estimate how price behaves about 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 producers has different weights 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 Price examined in the long run is expressed by the following formula:

$$CAR = c + b_1 \times OCSC + b_2 \times RWSCP + b_3 \times WOD + b_4 \times SSWOP + u_t \tag{5.3}$$

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:

$$D(CAR) = c + b_1 \times D(OCSC) + b_2 \times D(RWSCP) + b_3 \times D(WOD) + b_3 \times D(SSWOP) + ECT \tag{5.4}$$

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

5.2 World crude oil demand

5.2.1 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.

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	1.33617			
F-statistic	0.27670			
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	0.40560			
Prob. F	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**
C	1.048017	0.214697	4.881375	0.0000
WORLD OIL DEMAND(-1)	-0.277513	0.135104	-2.054071	0.0477
WORLD OIL DEMAND(-2)	0.966364	0.101384	9.531758	0.0000
	-1.203182	0.234413	-5.132748	0.0000
WORLD GDP PER CAPITA	0.479921	0.185148	2.592092	0.0140
WORLD GDP PER CAPITA(-1)	-0.024876	0.005256	-4.733185	0.0000
	1.99E-07	1.86E-07	1.068734	0.2927
	-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			
Prob. Chi-Square	40.80345			
Arch test	0.26740			
F-statistic	0.64530			
prob. F	0.21515			
Obs R^2	0.22494			
Prob. Chi-Square	0.63530			

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 the world economy falls into recession, oil demand declines. We have an inelastic but very close to 1 elasticity of GDP, meaning that our economies are energy sensitive. This complies with Kumhof and Muir [15], who find that the 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 in oil demand. The elasticity is less than unity, implying an inelastic relation, i.e. world responds less sensitively to price fluctuations. The overall assumption is that the world economy depends on oil but does not respond sensitively enough to price fluctuations. All the tests for heteroscedasticity, serial correlation, and normally distributed residuals are satisfied.

5.2.2 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 is slightly lower (0.966364) than that in the long run and remains less than one. We have a more inelastic relation, presenting that oil demand is less sensitive to GDP in short periods. This is following the 'second law of demand' or the LeChatelier principle, which requires demand curves to be more elastic in the long run than what they are in the short run 28. The main result, both in the short and long run, is that a GDP increase does add positively and asymmetrically 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 is statistically significant, implying a well-explanatory ability. The ECT coefficient is the speed that short-run regression has towards the long-run one, implying that 52.40% of the change will happen in a year's period. All the tests are satisfactory, which testifies to the robustness of the model.

6 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. World oil demand positively influences the crude production of SA. This complies 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 enough to fully cover the increased demand, as this would lead to lower revenues. It also implies that the 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 by 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,e 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 of their production 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 in compliance with the trade-off theory (low production-high price to high production-low price).

SA CRUDE PRODUCTION				
Variables	**Coefficients**	**Std. Error**	**t-statistic**	**Prob**
C	1.048017	0.214697	4.881375	0.0000
D(WORLD OIL DEMAND(-1))	-0.277513	0.135104	-2.054071	0.0477
D(WORLD OIL DEMAND(-2))	0.966364	0.101384	9.531758	0.0000
D(WORLD GDP PER CAPITA)	-1.203182	0.234413	-5.132748	0.0000
D(WORLD GDP PER CAPITA(-1))	0.479921	0.479921	0.185148	0.0140
D(WORLD GDP PER CAPITA(-2))	-0.024876	0.005256	-4.733185	0.0000
D(REAL CRUDE PRICE)	1.99E-07	1.86E-07	1.068734	0.2927
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			
Prob. Chi-Square	40.80345			
Arch test				
F-statistic	0.21515			
prob. F	0.64530			
Obs R^2	0.22494			
Prob. Chi-Square	0.63530			

6.1 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 stock changes are significant but close to zero, meaning that they have a low effect on SA's production policy. This might validate its policy to continue production even when stocks were piling 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.

6.2 Crude price

6.2.1 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 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 [21], who estimated low negative elasticity (-0.0551). Mork et al. [20] found that oil price increases influence output negatively, while price declines have no effect. Several studies of GDP/GNP elasticity to oil price have been conducted with different levels of sensitivity to have been revealed. What is most impressive 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 the 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 from the rest of the producers than from only one country. Another implication of 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.

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
OLS				
Diagnostics				
Adj R^2	0.81233			
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			

6.2.2 Short run

In the short-run regression, we have similar findings. OECD stock changes are significant but close to zero, implying that crude stocks did not have 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, implying 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 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 the demand to price might also imply the lack of substitution between oil and any other form of energy source in short periods.

This section is devoted to outlining the empirical evidence and discussing our main results. It was important to perform the unit-root test to minimize spurious regression because the test guarantees that the variables used in regression are stationary since they are differed, and the interest equation is estimated through the stationary process [17]. According to the ADF unit root and Philips-Peron tests displayed, we corroborate the hypothesis that all-time series, except for LLVS and LBOP, all other time series of LGDP, LOPG, LNOX, LFDI, and LTRS are nonstationary in levels, and the first difference can be accepted. Based on the unit-root test results, we infer that the time series we studied have a different order of integration. Given the results of the ADF and PP tests, except for LVS and BOP, all other variables (GDP, OPG, NOX, FDI, and TRS) are stationary in the first difference I(0) and have the order of integration.

where:

GDP: GDP (constant 2010 US$).

OPG: OPIC average crude global oil prices (barrel/$).

NOX: non-oil exports (current US$).

FDI: foreign direct investment, net infows (BoP, current US$).

LVS: portfolio investment, net (BoP, current US$).

TRS: total reserves (current US$).

BoP: net trade in goods (BoP, current US$).

βs: parameters.

$\pounds$: standard error. Using data from 1969–2019.

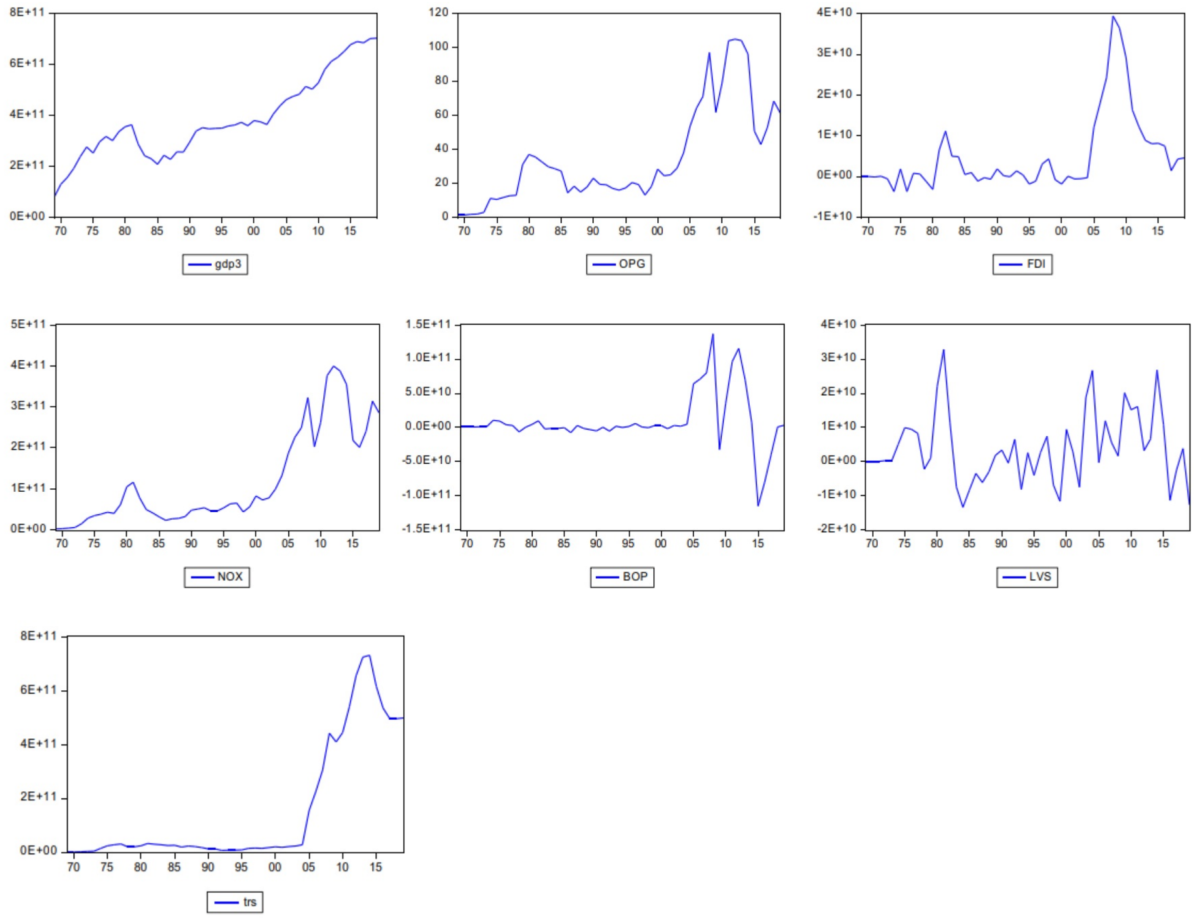

Figure 1: Endogenous variable diagrams

7 Conclusion

The economic literature provides many ways to model imperfect competition. However, the extent to which market power should be exerted by a player is not treated in the literature.

The immense challenges in transforming the Saudi economy do not mean there won't be change in Saudi Arabia. Structural reforms outlined in Vision 2030 are much needed to shift the economy to a more sustainable path, and even if only a small part of Vision 2030 is being implemented, the Saudi economy will look very different in 2030 than it does now. The key question is whether these changes will have a substantial impact on oil policy and the evolution of the energy sector. As discussed above, despite expectations of a diminished role, the Saudi energy sector (and particularly the oil and gas sector) remains key to a smooth transition to the vibrant economy envisioned and will continue to play a vital role in the country's future. Furthermore, the overall direction of Saudi oil policy in terms of its production and investment policy, maintaining spare capacity, integrating down the value chain through investing in refining and petrochemicals, increasing the role of gas in the energy mix, introducing efficiency measures and deploying renewables in the power mix to free crude oil for exports are not likely to change in the next few years as has been confirmed by the NTP. In fact, one could argue that the Saudi energy sector would benefit from a more integrated energy policy that takes a holistic view of the energy challenges facing the kingdom. But the Saudi energy sector will not be immune from the changes in other parts of the economy, as the recent restructuring of the energy ministry, the recent increase in energy price, the emphasis on local content policies, and plans for a partial public listing of Saudi Aramco have shown. The restructuring and reorganization of such a vital sector and the acceleration of some policies may bring benefits and achieve efficiency gains, but they will also generate uncertainties and risks, which need to be carefully assessed and managed.

The evolution of high crude oil prices for over a decade has sharply increased the sovereign reserves of Saudi Arabia and its profitability. Saudi Arabia has a strong interest in keeping crude oil prices at high levels, even if this requires decreasing its own production. However, the participating countries in the OPEC are deviating from their commitments concerning their production 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 behavior. It is not a secret that oil is something more than a commodity for Saudi Arabia. This study aims to provide 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. To estimate those effects, we also develop two supplementary models concerning world crude oil demand and crude oil prices, which 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 that 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, Saudi Arabia tries to exploit higher prices with larger volumes, leaving part of the increased demand to the rest of the producers (it does not intend to fully cover all the increase but does not overreact, which would bring prices down). In addition, Saudi Arabia's 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 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 under the conclusions of the latest OPEC Meeting, which are stated as "to conduct a serious and constructive dialogue with non-member producing countries, 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 silos 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.

This study underlines the importance of establishing and adopting an unambiguous regulatory framework for reserves reporting in Saudi Arabia to improve transparency about the permissible assumptions in the estimation and reporting of domestic oil and gas reserves by petroleum-producing companies active in the country. Around the globe, national reserves' reporting frameworks and guidelines play an important role in how hydrocarbon producers aggregate and estimate their oil and gas reserves. We also demonstrate that when the choice to act as anticipative or passive is given to the players, the closed loop Nash equilibrium is very unlikely to occur. The most probable outcome is a full exercise of market power and both countries concentrating the market at the maximum. All our results hold when the marginal production cost is constant or linear. Future work could introduce an asymmetry between the exporting firms with regard to their cost structure and find the conditions under which the competitive paradox in closed loop disappears. An interesting complex extension could model a continuous and endogenous decision of market power exercise by the countries. Other kinds of interaction between the firms could be explored.

(a) Economic production diversification with a focus on non-oil exports to avoid the negative effect of oil price shocks in the long term.

(b) Encouraging local investment and increasing employment opportunities.

(c) Increasing production and productivity and reducing unemployment, which supports the emergence of vision 2030 in the axis of governance and community by applying rational governance, accountability, justice, good governance, and transparency. This will encourage creativity and initiative and link the learning outcomes in universities to the requirements of the Saudi labor market through the development of universities according to the Vision 2030 targets. That is why many universities rushed towards updating and developing their curricula to obtain international accreditation.

(d) Maintaining the economic balance in external payments and diversifying global markets, enhancing competitiveness, and establishing a geographical trend towards Arab, African, and Asian markets, and towards economic integration in these countries. This will avoid any deterioration in the budget deficit, creating exchange rate stability and reducing inflation rates.

References

[1] F.C. Araujo and A.B. Leoneti, *Game theory and 2×2 strategic games applied for modeling oil and gas industry decision-making problems*, Pesquisa Operac. **38** (2018), 479–497.

[2] O.F. Ayadi, A. Chatterjee, and C.P. Obi, *A vector autoregressive analysis of an oil-dependent emerging economy—Nigeria*, OPEC Rev. **24** (2000), no. 4, 329–349.

[3] E.B. Barbier, *Economics, Natural-Resource Scarcity and Development (Routledge Revivals): Conventional and Alternative Views*, Routledge, 2013.

[4] B.S. Bernanke, M. Gertler, M. Watson, C.A. Sims, and B.M. Friedman, *Systematic monetary policy and the effects of oil price shocks*, Brook. Papers Econ. Act. **1997** (1997), no. 1, 91–157.

[5] R.B. Bratvold and F. Koch, *Game theory in the oil and gas industry*, Way Ahead **7** (2011), no. 01, 18–20.

[6] F.I. Brichs, *Political Regimes in the Arab World: Society and the Exercise of Power*, Routledge, 2012.

[7] S.P. Brown and M.K. Yücel, *Energy prices and aggregate economic activity: an interpretative survey*, Quart. Rev. Econ. Finance **42** (2002), no. 2, 193–208.

[8] Y. Chang, J. Yi, W. Yan, X. Yang, S. Zhang, Y. Gao, and X. Wang, *Oil supply between OPEC and non-OPEC based on game theory*, Int. J. Syst. Sci. **45** (2014), no. 10, 2127–2132.

[9] S. Claessens, M.A. Kose, L. Laeven, and F. Valencia, *Understanding financial crises: causes, consequences, and policy responses*, CAMA Working Paper 05/2013, Available at SSRN: https://ssrn.com/abstract=2295199 or http://dx.doi.org/10.2139/ssrn.2295199

[10] S. Dubey, J.N. Sarvaiya, and B. Seshadri, *Temperature dependent photovoltaic (PV) efficiency and its effect on PV production in the world*, Energy Procedia **33** (2013), 311–321.

[11] B. Dudley, *BP Statistical Review of World Energy 2016*, British Petroleum Statistical Review of World Energy, Bp lc. editor, Pureprint Group Limited, UK, 2019.

[12] M. Gisser and T.H. Goodwin, *Crude oil and the macroeconomy: Tests of some popular notions: Note*, J. Money Credit Bank. **18** (1986), no. 1, 95–103.

[13] J.D. Hamilton, *Oil and the macroeconomy since World War II*, J. Politic. Econ. **91** (1983), no. 2, 228–248.

[14] G.A. Kahn and R. Hampton, *Possible monetary policy responses to the Iraqi oil shock*, Federal Reserve Bank of Kansas City Econ.Rev. **2** (1990), 19–32.

[15] M. Kumhof and D. Muir, *Oil and the world economy: some possible futures*, Phil. Trans. Royal Soc. A: Math. Phys. Eng. Sci. **372** (2014), no. 2006, p. 20120327.

[16] A.A. Losáñez, C.B. Gárate, and A.G. Lebrero, *Application of game theory to oil producing countries*, Res. Paper, Academic Year 2017–2018, HEC Paris, 2018.

[17] L. Mahadeva and P. Robinson, *Unit root testing to help model building*, London: Centre for Central Banking Studies, Bank of England, 2004.

[18] B. Manama, *Economic diversification in oil-exporting Arab countries*, Ann. Meet. Arab Ministers of Finance, Int. Monetary Fund Washington, DC, USA, 2016.

[19] A. Marshall and C.W. Guillebaud, *Principles of Economics: An Introductory Volume*, London: Macmillan, 1961.

[20] K.A. Mork, *Business cycles and the oil market*, Energy J. **15** (1994), no. 1_suppl, 15–38.

[21] J.F. Mory, *Oil prices and economic activity: is the relationship symmetric?*, Energy J. **14** (1993), no. 4, 151–161.

[22] A. Nove, Z. Matthews, S. Neal, and A.V. Camacho, *Maternal mortality in adolescents compared with women of other ages: evidence from 144 countries*, Lancet Glob. Health **2** (2014), no. 3, e155–e164.

[23] C.C. Onyemelukwe, *The Science of economic Development and Growth: The Theory of Factor Proportions*, Routledge, 2016.

[24] J.A. Reneke, *A game theory formulation of decision making under conditions of uncertainty and risk*, Nonlinear Anal.: Theory Meth. Appl. **71** (2009), no. 12, e1239–e1246.

[25] B.J. Willigers, K. Hausken, and R. Bratvold, *Uncertainty and preferences in a joint E&P development program analyzed in a game-theoretic framework*, J. Petrol. Sci. Eng. **74** (2010), no. 1–2, 88–98.

[26] M.-H. Wu and Y.-S. Ni, *The effects of oil prices on inflation, interest rates and money*, Energy **36** (2011), no. 7, 4158–4164.