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OPEC: How to transition from black to green gold

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HIGHLIGHTS

- Global reduction of Co_2 emissions and interest in Green energy of oil exporting nations
- Projects, e.g. Desert Tec, cause OPEC's interest to diversify energy resource production portfolio
- Low in-country retail prices of fossil fuels present a significant economic hurdle to Green Energy
- Four step analysis – overview, formal model, graphical analysis, numerical example – conducted

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ABSTRACT

Global discussions on the reduction of Co_2 emissions and the increasing interest in alternative energy sources and production technologies have started to concern oil exporting nations. International discussions on projects such as Desert Tec might also have sparked their interest to explore a possible diversification of their energy resource production portfolio. However, extremely low in-country retail prices of fossil fuels to date present a significant economic hurdle to such developments. This paper uses a formal model setup accompanied by intuitive graphical illustrations as well as a numerical example to analyze fossil fuel abundant nations' potential to transition to a supplier of renewable energy as well as possible pitfalls resulting from their status quo situation.

1. Introduction

In 1960, the founding members of the OPEC were Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. Nowadays, members are Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela (www.opec.org). As has been pointed out by Adelman and Watkins (2008), the OPEC has always held a significant market share of international petroleum supply. While it used to occupy about 53% of the entire market in the 60s and 70s of the last century, this number has declined to about 40% today (Watkins, 2006). However, this is still an impressive share, especially since petroleum is still considered to be one of the most important and influential commodities. Whether one is a strong believer of what Watkins (2006) provocatively calls the *Severe Anemic Reserves Syndrom* (*SARS*)[1] or beliefs that there is no evidence that oil is to become scarce any time soon, the increasing interest of several oil exporting countries and OPEC members in implementing solar and wind power systems cannot be denied (Trieb, 2007). This interest, however, cannot automatically be attributed to their petroleum reserves approaching depletion any time soon. Rather, the international discussions on projects such as Desert Tec (www.desertec.org) might have sparked their interest to explore new fields of economic activity, as – especially Middle Eastern or African – OPEC members are located in climate zones which can be considered promising with respect to certain Green Energy technologies. Therefore, it seems quite plausible that oil exporting countries, such as Saudi Arabia, are planning to further diversify their production portfolio in that direction.

The paper is structured as follows: the following sections – two to four – identify verbally, formally, and graphically the issues that might arise if Renewable Energy technologies – i.e. Green Gold – are introduced in an economy which is characterized by an abundance of fossil fuel resources, i.e. Black Gold – cheap and readily available fossil fuels. Section 5 presents a simple numerical example followed by some concluding remarks.

2. Price does matter

In the 1970s Heal (1976) as well as many others examined the optimal extraction of a non-renewable resource, and the question of whether there will emerge a substitute at an uncertain time in the future. The model presented in the following, however, is not concerned with finding the optimal extraction path of a non-renewable resource, once a substitute is available. The focus of

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[1] According to Watkins, SARS believers think that shortages in oil supply are due to a quickly growing scarcity.

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attention lies on the fact, that in OPEC member states, oil is supplied at an extremely low in-country price (Said et al., 2004). Due to this fact, alternative, i.e. renewable, resources are certainly destined to face a "harsh" competition. Looking at it from an economic rather than an environmental point of view, may it be electricity generation, water desalination, or transportation, who would – given these circumstances – consider solar energy, wind power, or an electric or hybrid car to be a reasonable substitute to technologies which are solely based on readily and cheaply available fossil fuels.

This issue turns out to be increasingly interesting, due to recent developments in several OPEC member states. In the following, Saudi Arabia, which appears to be one of the most influential OPEC member states, will serve as a show case for the theoretical analysis to come. This stems from the fact that Saudi Arabia seems to display an increasing interest in exploring its potential for various renewable resources in energy/electricity generation. Several studies and projects have focused on an implementation of solar and wind power based technologies (e.g. Rehman, 2005, Trieb, 2007). Until recently, Saudi Arabia, as well as the other OPEC member states, has relied primarily on fossil fuels as the sole or main input to satisfy their ever growing energy demand – in the case of Saudi Arabia an increase of 5% p.a. in energy demand is a common estimate (Trieb, 2007). At first glance one might think that the amount of oil consumed by a nation of only about 27[2] million[2] residents cannot be highly significant. As presented in the following tables, Saudi Arabia is ranked number one among OPEC members when it comes to production capacity and number four in terms of global oil reserves (Table 1).

However, it is also among the top 10 nations regarding overall or oil consumption in barrels/1000 people per day, which is shown by the following Table 2:

So, the United States, which comes in first place with respect to overall oil consumption, only occupies the 23rd place with respect to per capita consumption. China and India do not even make the top 100 and Russia comes in 81st. In per capita terms, Saudi Arabia beats them by far. Moreover, looking at production capacity and consumption, it becomes clear that Saudi Arabia is certainly one of its own best clients as it consumes – at least – 20% of its total oil production as shown by Table 3:

Taking all these findings into account, let us construct a simple mathematical example:

In 2007, Saudi Arabia consumed approximately 2,311,000 bbl/day times 365 days. This amounts to around 843,515,000 bbl/p.a.. There is data readily available for the world market price for Saudi Arabian crude oil. In 2007 its spot price ranged between around $58 and $88 per barrel.[3]

However, there is no data on in-country crude oil prices, only gasoline prices are easily available.[4] Of course, due to different tax levels and costs of refining the crude oil, this data does not allow for reliable estimates. However, it seems to be quite plausible to assume that the in-country price of crude oil is close to marginal cost of production, which is estimated at around $3.35/bbl for Saudi Arabia (Adelman and Watkins, 2008). Thereby, a difference in price of at least around $50/bbl can be assumed, which can be seen as the "gross" opportunity cost[5] of in-country oil consumption per barrel.[6] This means that in-country oil consumption in 2007 resulted in about $50 times 843,515,000 bbl of "gross" opportunity costs. This amounts to about $42,175,750,000 in 2007, which can certainly be considered a significant number. However, from these roughly $42 billion, the costs of alternative energy production would have to be subtracted to arrive at the "net", i.e. actual opportunity costs of in-country oil consumption. Of course, this simple example can only serve as a hint at the significance and economic potential of abandoning this pricing policy seemingly reminiscent of panem et circenses in oil producing nations. In the following, a theoretical economic model will be developed to present clearer and more reliable view of the issue.

3. The model

In the model presented below, the market structure characterizing the oil market is of little or no significance, as its results hold true in case of both simplifying assumptions, i.e. perfect competition or monopoly. It is known that while OPEC had about 53% of the entire market share in the 70s, nowadays it holds around 40% (Watkins, 2006). Naturally, this is far from characterizing either a competitive market structure or a monopoly. However, both assumptions have been implemented before in other models and serve to clarify the analysis. In the following Hotelling′s theory is used to calculate results (Perman et al., 2003, Hotelling, 1931). In the current setting, the demand side is altered and, instead of just one, i.e. global, demand the demand side is divided into an in-country demand (q^{ic}) and a demand for oil exports (q^{ex}). Due to geographical reasons, the two demand groups are easy to distinguish. For reasons of simplicity, it is assumed, that the two groups are characterized by identical demand curves. While the optimal price (p^{ex}) and extraction path for oil exports is calculated in line with Hotelling′s model, in-country market price is set by the government[7] at marginal production cost, i.e. ($p^{ic}=\overline{p}=c$), which is assumed to be constant over time.[8] Taking all preliminary assumptions into account, the following maximization problem emerges (Table 4):

It is obvious from Eqs. (7) and (8) that optimal in-country demand is predetermined through $\overline{p}, K,$ and a. This means that q^{ic} and $\overline{p}q^{ic}$ enter the calculation as a constant and exogenous value. Therefore, the extraction path changes accordingly (Perman et al. 2003: 519ff) (Table 5):

Eqs. (9) and (10) are used to calculate optimal exhaustion time, i.e. T^{PC}/T^{M}:[9]

$$S=\int_0^T\left[\frac{\gamma}{a}(T-t)+q^{ic}\right]dt \tag{11}$$

This results in

$$S=\left[\frac{\gamma}{a}(Tt-\frac{1}{2}t^2)+q^{ic}t\right]_0^T=\frac{\gamma}{2a}T^2+q^{ic}T \tag{12}$$

which clearly differs from the original result of Hotelling′s optimal extraction path (Perman et al., 2003: 519), where $S=(\gamma/2a)T^2$. If the new exhaustion time given through Eq. (12) is denoted by T_{ic+ex}, the following relationship between former and latter optimal exhaustion time emerges:

$$T^2=T^2_{iC+ex}+\frac{2a}{\gamma}q^{ic}T_{iC+ex} \tag{13}$$

As it is known that $\frac{2a}{\gamma}q^{ic}T_{ic+ex}>0$, the given resource stock S is depleted earlier in the current setting, i.e. $T_{ic+ex}<T$. The optimal

[2] This is the population estimate of 2007, which has been chosen to match the numbers used in oil production and consumption.

[3] http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WEPCSAMED&f=W

[4] http://money.cnn.com/pf/features/lists/global_gasprices/

[5] The author knows that the term "gross" or "net" opportunity cost does actually not exist. However, it seems an appropriate way to convey the idea that is expressed in this setting.

[6] Of course, this is a simplified portrait of the situation. It is not taken into account that market prices are likely to drop if Saudi Arabia would suddenly stop consuming oil and supply an additional couple of hundred million barrels per year.

[7] Given that gasoline prices, e.g. in Saudi Arabia, are also determined by government, this assumption is not far-fetched.

[8] According to Adelman and Watkins (2008), this holds true for Middle Eastern oil production.

[9] Without loss of validity, the following calculation refers to perfect competition only.