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OPEC: Market failure or power failure?

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HIGHLIGHTS

- ▶ Hotelling models abstract from the essence of oil technology.
- ▶ Members of OPEC do not act as members of a classical cartel.
- ▶ Political–economic considerations influence objectives.
- ▶ The aim of Saudi Arabia, the price leader, is to keep price moderate.
- ▶ Supply was inelastic in the 2000s. Saudi investment was not adequate.

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ABSTRACT

The actions of OPEC and Saudi Arabia are discussed in terms of their objectives and their technical and social constraints. It is concluded (1) that OPEC does not act as a cartel and (2) that Hotelling's rule is not an important feature of pricing or production. OPEC's (more specifically, Saudi Arabia's) ideal policy is to keep price moderate to try to assure a market for their high reserves over the long run. Such an action would require heavy investments in capacity, including in excess capacity, for times of interruption of supply from other countries as in the 1990s and for times of high demand as in the 2000s. The action may be inconsistent with other objectives and in any case may be too difficult to achieve.

1. Introduction

In the past 30 and more years, economic models of OPEC and the world oil market have been direct applications of the theories of oligopoly and of exhaustible resources. The stylized facts of these models can be summarized as follows. The actors are portrayed as producers of a homogeneous product. The level of reserves of each actor is known and fixed. Their objective is to maximize their discounted profit, subject to the actions of their rivals. In maximizing present value, they exert market power through adjustment of current output. Exhaustibility of their own and of their rivals' reserves dominates the determination of dynamic equilibrium. A central role is played by Hotelling's rule, an arbitrage condition stating that marginal revenue net of marginal cost must rise to obey a dynamic condition involving the rate of interest.

Many econometric investigations have attempted to check the validity of these models, which we call Hotelling models. In the aggregate they have been inconclusive. For example, careful econometric studies by Smith (2005) and Kaufmann et al. (2008, p. 348) find conflicting explanations of OPEC behavior and conclude that OPEC does not fit a single economic model.

The present paper steps away from Hotelling models. Section 2 addresses implications of dynamic optimization in a strategic context with discounted profit as the objective. One step is to work with a disaggregated technology for the incentives and choices facing the main producers. The analysis is grounded in technical and natural features. In light of the discussion, Section 3 steps away from discounted profit and proposes a more flexible economic objective for the main actor in OPEC, Saudi Arabia.

Like a slight turn of a kaleidoscope, these steps re-form market patterns, retaining some familiar aspects but being different enough to suggest why empirical work has found inconsistencies. Given the legendary secrecy of OPEC and its component regimes, shedding some light in this way may be the best that outside analysts can do.

The assessment advanced is that all producers but one act as price takers, but not as the price takers in a Hotelling model. The prospect of exhaustibility has limited influence and Hotelling rents are insignificant. Instead, producers are strongly constrained in the present by technology and nature. The main producer in

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OPEC, Saudi Arabia, does not act as a price taker. But it does not behave as a classic profit maximizer and its objectives do not coincide with those of a classic cartel participant. Considerable qualitative information leads us to propose that the policy that Saudi Arabia *ought to pursue* in its own interest is close to one of its recent policies, namely attempting to keep price within an acceptable band. In particular, the Saudi interest is not in raising the price to extract monopoly profit but to restrain the price to conserve its market in the long run. Restraint is a classic policy of a dominant minerals producer with large, high-quality reserves.

In keeping with the findings of Smith and Kaufmann, the paper does not have a single model of OPEC. The subject has too many facets for a tractable mathematical model. Rather, it tentatively borrows from, extends and informally stitches together a number of economic models. It discusses aspects of OPEC's decisions that include the technology of production and the political–economic attributes of the producers. We draw a composite sketch from many independent witnesses.

2. Critique of Hotelling models applied to OPEC

2.1. Technological and natural features of oil production

Saudi Arabia has a strategic storage program (cf. Ghafour, 2007). It is aimed at ensuring oil supplies during wartime while serving as a reserve for periods with high oil prices. The program consists of five underground sites in the form of large caverns, with a capacity of over 12 million barrels of different oil products, including gasoline, jet fuel, diesel and lubricants. Some 700 km of pipelines link storage facilities with refineries and distribution centers (Arab News, 2003).

Dynamic, nonrenewable-resource models typically assume that an oil producer is able to produce any quantity of oil required at any instant. As price or the interest rate changes the firm adjusts production according to a condition called *Hotelling's rule*. In its simplest, most familiar form the rule stipulates that price net of marginal cost (or marginal revenue net of marginal cost if market power is being exerted) rises at the rate of interest. The reason is that a limited quantity of the exhaustible resource is to be allocated over the future. If, in a proposed allocation, a given unit of the resource earns less, in present-value terms, than it would earn if reallocated to another time, then it is reallocated. Once all possible such reallocations are completed, the marginal unit earns the same net present value in each time period. Therefore, the current net marginal value rises at the rate of interest.

If Hotelling's analysis were valid, the high capital cost of creating the storage sites and specialized pipelines, as well as the current expense of pre-extracting and pre-refining the various products, would be unnecessary. The existence of these sites is an indication that the stylized fact that production can adjust instantaneously to obey Hotelling's rule is inaccurate.

What, then, is the purpose of the storage program of the world's premier producer? Understanding this purpose depends on understanding the conditions of production. Technology and geology constrain the response to economic variables such as price and the interest rate. Important considerations are the rate of output as a fraction of reserves, the total level of recovery from a reserve and the rate of decline of production.

Producing oil requires first finding it through exploration and then investing in productive capacity by drilling production wells and, for secondary recovery, wells for the injection of water or gas to drive oil toward the production wells. The wells are arranged in a geometric pattern chosen to maximize the value of output over time. The maximization of net present value balances (a) incurring up-front costs to increase the number of production and injection wells and (b) being able to extract the reserve more effectively and more quickly. These decisions impose a productive capacity over much of the reservoir's lifetime.

Oil output from any reservoir is also constrained by geology. Reserves are found in rock formations with varying degrees of porosity. The oil must migrate through the porous channels of the rock toward a producing well, where it is lifted to the surface (cf. Cairns, 2009). Engineers are loath to produce beyond a so-called *maximum efficient rate;* otherwise, final recovery may be substantially reduced. The range is between 3 and 8% of the recoverable oil reserves per year (Hyne, 2001).

Reserves are defined by the level of recovery anticipated from the quantity of oil in place. Recovery can range from 30 to 70% of original oil in place (Amit, 1986; Davidson, 2007). Horizontal drilling and a variety of tertiary or enhanced extraction methods can be used later in the lifetime to increase ultimate recovery, at a further sunk cost that imposes another capacity limit (Caldwell and Heather, 1997). These methods are expensive. Higher prices provide an incentive for investment in enhanced recovery. Even so, the range of ultimate recovery from producing fields depends on the quality of the oil and the physical properties of the reservoir rocks.

Eventually even advanced methods are insufficient to maintain production, and the level of output begins a steady decline. Hook et al. (2009, p. 2266) find decline rates of 4.8% for OPEC giant fields in comparison with 7.5% for non-OPEC fields. Natural decline usually begins after a period of fairly constant, capacity production. Enhanced recovery has played a significant role in moderating the decline rates of many mature fields. After enhanced recovery has been used, however, the reservoir sees steeper decline.

Because of natural decline, output at some installations may be less than (a) rated capacity and (b) the level of production that has been observed for some time. If there is not continual investment in new fields, national production may decline once decline begins at major fields. For example, Fattouh (2011) reports that production in Dubai dropped from 400,000 bbl/d in 1990–1995 to under 120,000 in 2004 to about 90,000 in 2009. Changes in the level of national production caused by evolving constraints could be misinterpreted as a deliberate cut back.

A stated goal of Saudi Aramco, the national oil company (NOC), is reported to be to improve recovery by 20% at its major producing fields so as to increase its recoverable reserves (Baxter, 2009). To achieve this target, the company intends to use both improved conventional recovery and enhanced recovery, increasing recovery in many fields to as high as 70% from the current 50% (Saleri, 2004). This goal is a further curious feature of Saudi oil production, for it is in a position to develop other fields. Adelman (1992) reported that at the beginning of the 1990s the Saudis had not developed 40 of 55 available commercial oil fields. Later, in observing that only nine of 80 potential fields were exploited, Adelman (2004) cited a lack of investment in development and production that he attributed to an attempt to support world prices. One task is to explain why Saudi Arabia is stressing enhanced production when it has so many undeveloped fields.

Moreover, the product is not homogeneous. Most desired is light (having short hydrocarbon molecules), sweet (having low sulfur content) crude. Light, sweet crude is most appropriate for fuels. Somewhat heavier oils are used for heating oil. Demands vary by product through the year but supplies do not. The heavy molecules can be broken into smaller ones, but refining capacity must be dedicated; for example, Citgo's refining capacity in Louisiana is dedicated to Venezuelan heavy oil. Given a capacity to do it, gas molecules can be, effectively, stitched together to form desirable liquids. Delivery of product depends not only on