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An analysis of oil production by OPEC countries: Persistence, breaks, and outliers

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ABSTRACT

This study examines the time series behaviour of oil production for OPEC member countries within a fractional integration modelling framework recognizing the potential for structural breaks and outliers. The analysis is undertaken using monthly data from January 1973 to October 2008 for 13 OPEC member countries. The results indicate there is mean reverting persistence in oil production with breaks identified in 10 out of the 13 countries examined. Thus, shocks affecting the structure of OPEC oil production will have persistent effects in the long run for all countries, and in some cases the effects are expected to be permanent.

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1. Introduction

According to the Energy Information Administration, in 2008 roughly 43% of the world's oil production was attributed OPEC member countries. Furthermore, OPEC member countries have approximately 70% of the proven oil reserves in the world. Table 1 displays country specific oil production for 1973 and 2008, as one can see oil production in Algeria, Angola, Ecuador, Iraq, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) show an increase while Indonesia, Iran, Kuwait, Libya, Nigeria, and Venezuela show a decrease relative to 1973. Furthermore, the International Energy Agency (IEA) and the Energy Information Administration (EIA) project an increase in global demand for oil over the next several decades which raises the question on whether this increased demand can be met by OPEC oil production.

OPEC's oil production is influenced by a myriad of factors such as the price of oil and market conditions, i.e. the global demand for oil along with the production associated with non-OPEC oil producers and the geopolitical environment. OPEC has generally been successful in utilizing production cuts to prevent declines in price while on the other hand offsetting disruptions in the supply of oil and the rise in oil prices by increasing production. However, the pursuit of output policies has become more complicated given the emergence of the futures market in signaling oil prices and the corresponding adjustments in oil production. Indeed, the effectiveness of output policies hinges on the effectiveness of OPEC to influence market participants' expectations in the futures market along with OPEC's long-term investment plans to expand production capacity (Fattouh, 2007).

By the early 1970s, in addition to the oil embargo, OPEC oil production was influenced by the change in the oil pricing system from multinational oil companies to OPEC with the halt on authorizing new concessions by OPEC governments, movement towards equity participation in the existing concessions, and in some cases the nationalization of the oil industry. As a result by the late 1970s, multinational companies diversified their oil supply sources in the development of oil reserves outside of OPEC. In response to higher oil prices by the early 1980s, the discovery of oil reserves in non-OPEC countries in conjunction with advances in new technology brought forth an increase in the supply of oil to the international market resulting in downward pressure on oil prices with OPEC losing market share. With the infusion of non-OPEC oil producers and their prices more responsive to competitive market conditions, OPEC abandoned the administered oil pricing system by the mid-1980s instead moving to market-reference pricing based on the price quotes provided by oil price reporting agencies. However, the limited liquidity of the spot market gave way to the use of the futures market which provided greater liquidity and price transparency.

OPEC would adjust production quotas to achieve a desired price target zone. However, OPEC's ability to influence price is dependent on market participants' expectations in the futures market. Essentially, OPEC's decisions on production quotas provided signals to the market about OPEC's desired range of prices, the effectiveness of the signals depended on the whether the market believed that

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Table 1
OPEC countries oil production.
Source: Oil production from *OPEC Annual Statistics Bulletin* 2008 in thousands of barrels per day. Oil reserves in millions of barrels (mb).

Countries	Oil production in barrels October in 2008	Oil production in barrels October in 1973	Oil reserves declared mb 2008
Algeria	1873.99	1059	12,200
Angola	1991	162	9500
Ecuador	496.874	220	6511
Indonesia	990	1447	3990
Iran	4100	5977	137,620
Iraq	2327.578	1846	115,000
Kuwait	2628.738	3060	101,500
Libya	1745	2370	44,271
Nigeria	2185	2200	37,200
Qatar	924.756	600	25,405
Saudi Arabia	9400	7796	264,063
U.A.E.	2660.912	1669	97,800
Venezuela	2360	3381	172,323
Total	33683.85	31,787	**1,027,383**

OPEC could make the necessary production adjustments in light of market conditions (Fattouh, 2007). In the face of a decrease in the global demand for oil, OPEC would attempt to defend a target price by cutting production. However, the success of such production cuts hinges on the coordination efforts and bargaining power of OPEC member countries. On the other hand, while coordination to increase production quotas may be easier with an increase in the global demand for oil, OPEC may not respond quickly to this upward trend given uncertainty about future demand (Fattouh, 2007). Due to the large investment outlays required and the irreversibility of the investment, the decision to wait and not increase oil production would be more profitable than to increase oil production when the trend may turn out to be false (Dixit and Pindyck, 1994; Gately, 2004; Fattouh, 2007).

The ability of OPEC to increase production capacity is also influenced by state control of the oil sector and the geopolitical climate. With respect to investment and production in member countries with state control of the oil sector, the increasing demands on the government to finance other socio-economic projects imposes budgetary constraints on national oil companies to expand production capacity. Also, an unfavorable geopolitical climate for OPEC member countries in terms of security concerns and sanctions would have an adverse impact on the investment climate and thus may limit capacity expansion.

In light of the myriad of influences on OPEC's oil production, understanding the time series behaviour of OPEC oil production is critical in the assessment of the impact of oil shocks and structural breaks on both oil supply and the repercussions for global economic activity.[1] Specifically, this study examines the degree of persistence, potential breaks, and outliers of oil production for each OPEC member country within a fractional integration modelling framework. In particular, two important features commonly observed in oil production data are the persistence across time (Lien and Root, 1999; Kang et al., 2009) and breaks in production (Altinay and Karagol, 2004; Lee and Chang, 2005; Narayan and Smyth, 2008; Rao and Rao, 2009).[2] Modelling the degree of persistence is important in that it can reflect the stability of production in a particular country and given the importance of oil production to other sectors of an economy the persistence of such shocks may be transmitted to other sectors of the economy and macroeconomic aggregates as well. Such transmission of shocks has implications for the effectiveness of government intervention or stabilization policies.

Breaks and outliers are other important features that are present in monthly oil production data which may be attributed to fluctuations in oil prices, changes in the world geopolitical climate, and country-specific socio-economic events, among others.[3] Indeed, if oil production is stationary $I(0)$, shocks to oil production will be transitory and following major structural breaks in oil production, the supply of oil will return to its original equilibrium with the disruptions in oil production only having a temporary impact on the economic activity. However, if oil production contains a unit root (i.e., if it is nonstationary $I(1)$), shocks to oil production will have persistent effects on the supply of oil with the disruptions in oil production having a permanent impact on the economic activity (Narayan et al., 2008).[4] In the present paper we extend the models based on $I(0)$ and $I(1)$ hypotheses to the fractional $I(d)$ case, which permits the examination of the dependence oil production between periods.

Despite the importance of oil as an energy source and the previous research on the oil industry, there are no studies that specifically analyse the persistence, breaks, and outliers associated with OPEC oil production. While studies consider, for example, oil consumption (Mohn and Osmundsen, 2008; Lean and Smyth, 2009), returns on investment in oil (Boone, 2001) and oil exhaustion (Tsoskounoglou et al., 2008; Höök and Aleklett, 2008; Karbassi et al., 2007), no studies have explored the long memory/persistence properties of OPEC oil production.

The remainder of this study is organised as follows. Section 2 presents a review of the previous literature. Section 3 details the methodology. Section 4 presents the data and the empirical results. Section 5 deals with the discussion of the results, while Section 6 provides concluding remarks.

2. Brief overview of the literature

As mentioned earlier, determining whether shocks to oil production are transitory or persistent is relevant in the

[1] Five founding members are Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela with nine other members joining later: Qatar (1961); Indonesia (1962)—suspended its membership in January 2009; Libya (1962); United Arab Emirates (1967); Algeria (1969); Nigeria (1971); Ecuador (1973)—suspended its membership from December 1992 to October 2007; Angola (2007); and Gabon (1975–1994), see Kaufmann et al. (2008).

[2] From an econometric viewpoint the two issues are highly related noting that the omission of breaks may spuriously increase the degree of persistence in the data.

[3] Smith (2009) provides an excellent discussion of the world oil market with respect to production decisions and its effect on price. Kaufmann et al. (2008) on OPEC oil production.

[4] See, for example, Lean and Smyth (2009) for the relevance of testing for unit roots.

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