Energy Economics 66 (2017) 238–246

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

OPEC and demand response to crude oil prices☆

Talat S. Genc

Department of Economics and Finance, University of Guelph, Guelph, ON, Canada, N1G2W1

ARTICLE INFO

Article history:
Received 23 February 2017
Received in revised form 17 June 2017
Accepted 20 June 2017
Available online 6 July 2017

JEL classification:
D22
L13
Q35
Q41

Keywords:
Price elasticity of demand
Crude oil
Global financial/economic crisis
Brent benchmark
Market power
GMM estimation

ABSTRACT

This paper investigates demand response to crude oil price movements before and after the recent global financial and economic crisis. It employs several market power indices to structurally estimate price elasticities. A newly developed market power index for crude oil markets is implemented. In this approach OPEC is the central player and acts as a dominant producer in the global oil market. We quantify how a change in market structure (such as changes in marginal cost of production) would contribute to market power exercise of OPEC and have an ultimate impact on price elasticity of demand for oil. Our price elasticity predictions fall in a range reported in the literature, however estimates for pre-crisis deviate from the post-crisis ones. In fact, demand response to crude oil prices has almost doubled during the crisis. This severe change in price response can be associated with record price levels caused by supply shortages and surge in alternative renewable energy resources. The key advantages of this methodology over the existing literature are that it is simple to use and estimates price elasticity using a competition framework without specifying demand/supply function(s), and utilizes commonly observable market variables that can be applied to any admissible data frequency.

1. Introduction

The recent events including the global financial crisis of 2008 (which has caused downturn in economic activity all over the world and still endures in Europe and Asia),[1] the shale gas boom, and the surge of green energy initiatives (electric cars, wind and solar energy) have led to turmoil in the oil markets causing substantial oil price volatility, record prices (new highs and lows) coupled with significant budget deficits in major oil nations (OPEC, Russia, Norway).[2] In this environment, even a rumor of OPEC's possible production cut could lead to a significant price hike. For example, on Jan 28, 2016 a speculation over a possible production cut by OPEC at its upcoming meeting led to 8% price increase in a single day, even though there was a supply glut in excess of 1 million barrel per day.[3] In fact, these events are not unique to this decade. Oil markets have experienced many crises and big shocks in the past (such as low supply of 1970s, the oil glut of 1980s, financial crisis in East Asia in 1998, and positive demand shocks in 2000s due to growth and severe weather). A plethora of studies have examined these issues along with OPEC production behavior and the price formation process in oil markets.

In this study, we investigate demand response to crude oil prices before and after/during the recent financial/economic crisis using a new technique in which we offer market power indices to structurally estimate price elasticity of demand in imperfectly competitive crude oil market. The price elasticity estimates provide useful information about the degree of market power and the impact of shocks on market outcomes (prices, outputs, volatility, welfare, etc.). It is also essential to project energy demand and outline energy policies. Consequently, the purpose of this paper is to structurally estimate the price elasticity of world demand for crude oil. Although we consider oil production by all nations, the methodology we propose mainly relies on the impact of OPEC's production on demand response.

☆ I thank the editor, Perry Sadorsky, anonymous referees, and Thanasis Stengos for helpful comments and suggestions.

E-mail address: tgenc@uoguelph.ca.

[1] A series of events such as Lehman Brothers' bankruptcy, the largest one in U.S. history, on September 15, 2008, American International Group Inc.'s bailout on September 16, 2008, the bailout of housing and mortgage corporations the Fannie Mae and Freddie Mac on September 17, 2008 (the largest bailout in U.S. history costing over $187 billion), and the largest price drop in the Case-Shiller home price index in U.S. contributed the financial and economic crisis of 2008 in U.S. (Source: Wikipedia.org).

[2] Based on our calculations, the Brent oil price volatility (measured by standard deviation) during these events (Sep–Dec, 2008) has more than tripled, from $6.8/bbl to $22.8/bbl, with respect to a year earlier (Sep–Dec, 2007) level. While the maximum price level plunged from $113.49/bbl to the minimum level of $33.73 during the events in the last period of 2008, the maximum and the minimum values of year early were $95.92/bbl and $74.22/bbl, respectively. Furthermore, the price volatility after making a peak in 2008, it dropped from $28.90 to $12.34 in 2009, to $5.8 in 2010, to $7.07 in 2011, to $8.08 in 2012, and to $4.64 in 2013.

[3] Source: http://www.theweek.co.uk/oil-price/60838/oil-price-russia-blinks-first-is-this-the-end-of-the-slump Jan 28, 2016.

http://dx.doi.org/10.1016/j.eneco.2017.06.026
0140-9883/

The demand elasticity estimates in the literature are mainly based on reduced-form models. Different than others this paper considers a game-theoretic model and offers structural estimates of price elasticity. While this methodology is unique in the crude oil studies, a similar methodology is implemented by Newbery (2009) and Genc (2016) in electricity context. In this paper we offer a new market power index for crude oil and assume OPEC as a key player in the global crude oil market. The model assumes a flexible quantity competition framework (allows Cournot or dominant producer(s) with fringe competition) to model the behavior of crude oil producers and then applies an econometric approach to identify the relationship between market power measures of the Lerner Index (LI) and the Residual Supply Index (RSI) to estimate price elasticity of demand for crude oil. The advantages of this approach are *i*) it offers a simple way of structurally estimating price elasticity in a competition framework; *ii*) demand for crude oil need not be specified, it is as general as possible; *iii*) it takes into account of market power of OPEC in price formation process in the crude oil markets; *iv*) it uses a few key variables for which data points are readily available; *v*) it can employ data sets at any admissible data frequency (daily/weekly/monthly/yearly) to calculate market power indices, whereas quarterly or yearly data have been commonly assumed in the literature.

This study investigates crude oil markets in 2002–2014, covering the market outcomes before and after/during the economic and financial crisis of 2008. The goal of the paper is to compare and contrast the change in oil consumption behavior related to the crisis. We find that demand response rate is about 87% higher after the crisis than the one estimated before it. The price elasticity of demand figure for crude oil before and after the financial crisis is useful information as it has implications on investment opportunities, risk management, and environmental policy. In essence, an elasticity figure tells us how consumption or economic activity would respond to a 1% change in oil price. Of course, countries, companies, investors, and households would respond differently for oil price movements stemming from (idiosyncratic or non-idiosyncratic supply/demand related) shocks such as the crisis of 2008. However, as we find in this paper, the magnitude of demand response rate to oil price change after the crisis is highly significant and much higher than the pre-crisis level. This response rate would ultimately impact all decision makers in the world, in particular OPEC countries. Namely, after the crisis the governments have developed policies known as “Green Energy Acts” or “Renewable Energy Laws” that are intended to create aversion to fossil-fuel so as to diversify the generation portfolio, meet environmental targets, and improve air quality. These green energy initiatives supported by subsidies have also created opportunities for car producers to develop electric cars and for companies to invest in wind and solar energy products including physical and financial assets. For example, in 2013 about $113.7 billion was invested for solar power, and $80.1 billion invested for wind generation, following the same level in 2012, throughout the world (see Renewables 2014 Report). Furthermore, the increased price responsiveness for crude oil along with new shale oil and gas developments has posed problems for OPEC countries whose budgets, finances, investments, and social orders are all negatively affected.

The paper is structured as follows. Section 2 briefly reviews the literature. Section 3 defines the competition model and its solution, and describes the data sets. While Sections 4 provides the results, Section 5 extends to paper for robustness check. It concludes in Section 6 with a short discussion of key findings.

2. Literature review

Because of the challenges associated with measuring price elasticity of demand for crude oil, a common framework has been utilizing reduced-form demand models. Most of the studies find highly price inelastic demand in the short-run and more elastic demand elasticity (although less than unity) in the long-run. For example, Cooper (2003) provides an extensive coverage for price elasticity estimates for crude oil in 23 countries (mostly in the OECD). Using yearly data Cooper estimates a log-linear equation (oil consumption as a function of price of crude oil and GDP per capita) to measure short- and long-run price elasticities. He finds that short-run elasticities fall in the interval of −0.026 to −0.109. Also, long-run price elasticity for the G7 countries range from −0.18 to −0.45, which is almost within the bounds of −0.2 to −0.6 estimated by the U.S. Department of Energy. Krichene (2002) estimates demand and supply elasticities utilizing a linear reduced-form model with yearly crude oil data over 1918–1999. Krichene finds that the short-run price elasticity is −0.06 in 1918–1999, −0.08 in 1918–1973, and −0.02 in 1973–1999. His long-run elasticity estimates based on a cointegration approach (and also error correction method) are also low: −0.05 in 1918–1999, −0.13 in 1918–1973, and almost zero in 1973–1999. Hamilton (2009) assumes inelastic short-run demand for the study covering 1970–1997 in his crude oil price analysis. Among earlier studies, Pindyck (1979) estimated long-run price elasticity for crude oil in the OECD countries in the industrial sector using a translog cost function. He found that price elasticity fell into the interval of [−0.22, −1.17]. Variations in estimations in these studies mainly stem from estimation method, the frequency and form of data (time series or cross-sectional), and model specifications.

The studies examining the production behavior of OPEC and/or Saudi Arabia have also assumed low price elasticity. Examples include Mixon (1982) who assumed price elasticity of −0.5, and De Santis (2003) who assumed −0.45 in their simulations. A number of papers investigated different issues (such as supply elasticity, determinants of prices, and degree of competitiveness) in the world oil markets. For instance, Ramcharran (2002) estimated price elasticity of supply employing the log-linear supply model of Griffen (1985) using yearly production and price data in 1973–1997. He estimated negative price elasticity of supply for OPEC countries (offering support for the target revenue hypothesis) and positive supply elasticity for most non-OPEC countries (an evidence for the competitive market hypothesis). Kaufmann et al. (2008) tested the hypothesis of whether crude oil prices were determined in part by refinery capacity, non-linearities in supply conditions, and expectations during the price rises in 2004–2006. They reported that all of these factors explained the price increases. Dees et al. (2007) specified crude oil prices as a function of OPEC capacity, OECD crude oil stocks, OPEC quotas and cheating on OPEC quotas, and its model performed well in sample 1986–2003, but under-predicted real oil prices out of sample.

Econometric studies show that the oil market outcomes largely deviate from perfect competition. A common belief is that the behavior of OPEC swings between the dominant producer model and pure cartel (Griffen, 1985; Jones, 1990; Alhajji and Huettner, 2000; Ramcharran, 2002). Johany (1980) utilized dominant producer model in which OPEC acted as a dominant player, imposing the price that the others (non-OPEC countries) accept. Market observers and economic studies suggest that Saudi Arabia is the most powerful swing producer in OPEC and in the global market (Griffen and Teece, 1982; De Santis, 2003), and this hypothesis is supported by econometric evidence (Alhajji and Huettner, 2000). In OPEC, Saudi Arabia's high share of world production (over 10%), exports (over 16%), and proven reserves (over 24%) supports its role as a dominant producer (OPEC 2001). Dahl and Yucel (1991) argue that OPEC behavior is consistent with an oligopoly model. Although OPEC's crude oil export share has declined from 63.1% in 1980 to 46.4% in 2000 (OPEC 2001), its share of world production stood at 41.8% in 2014 (OPEC 2015), and it is still the game changer in oil markets. However, OPEC countries heavily need oil export revenues, and supply and/or demand shocks in the market largely impact their economies.

Recent papers on oil markets also examine a number of interesting issues including estimation of long term oil prices (Haugom et al., 2016), the impact of fuel subsidies on crude oil prices and welfare