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Is the recent low oil price attributable to the shale revolution?

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ABSTRACT

The U.S. Energy Information Administration estimates that approximately 52% of total U.S. crude oil was produced from shale oil resources in 2015. We examine whether the recent low crude oil price is attributable to this shale revolution in the U.S., using a SVAR model with structural breaks. Our results reveal that U.S. supply shocks are important drivers of real oil price and, for example, explain approximately a quarter of the 73% decline between June 2014 and February 2016. Failure to consider statistically significant structural changes results in underestimating the role played by global supply shocks, while overestimating the role of the demand shocks.

1. Introduction

The global oil market is experiencing many changes. Because of the new technology used to extract crude oil and natural gas thus leading to the shale revolution[1], the production level of oil and natural gas in the U.S. has risen rapidly, with the level of crude oil reaching almost that of Saudi Arabia and Russia in 2015, as shown in Fig. 1. As a result, the U.S. resumed exporting crude oil and natural gas from 2016, after a 40-year ban. At the same time, the global crude oil price fell substantially, and the U.S. real import price fell more than 73% June 2014–February 2016, making it the most rapid decline within this time frame since 1973[2]. Observing these new phenomena (the shale revolution in the U.S. and low oil price), many analysts in the oil industry have predicted that a new normal era for the global oil market has begun, and that the oil price will remain somewhere between U.S.$35 and U.S.$50 per barrel in the future[3].

In this study, we conduct a series of structural break tests using an empirical model, like that of Kilian (2009), to check whether recent changes in the oil market are significant to be considered a break, and whether these phenomena are interrelated. More specifically, we conduct the structural break test proposed by Bataa et al. (2014) to individual series in a structural VAR model (SVAR) to decompose the series into a level component, seasonality component, outliers, and a dynamic component. Once the level and seasonality components and outliers are removed from individual series, based on the first-stage structural break test, we apply the test approach of Bataa et al. (2013) to our SVAR model to determine if the dynamic coefficients of the SVAR and the volatilities of structural shocks have undergone structural breaks. We also conduct historical decomposition exercises based on the results of the break test for the SVAR, and examine if the shale revolution and the low oil price are related.

Kilian (2017) examines the impact of the U.S. fracking boom and demonstrates that the U.S. shale oil production had played a role in the low crude oil price in 2016 based on Kilian and Murphy (2014). Using a variant of the Kilian (2009) model, however, we also address whether the low crude oil price is attributable to the U.S. shale production but allow structural breaks in the model. The Kilian (2009) model is popular and widely examined and extended by studies such as Kilian and Park (2009), Kang et al. (2017), among others. The difference between these studies and this paper is that we allow structural breaks in the Kilian model because changes in the oil production technology such as shale production in the U.S.

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[1] The shale revolution is a new combination of horizontal drilling and hydraulic fracturing to produce oil and natural gas.

[2] The Western Texas Intermediate (WTI) crude oil price reached U.S.$26.21 per barrel in February 2016, which is a record low since July 2002.

[3] See Hartmann and Sam (2016) and Barnato (2016) 'Oil's new normal may be lower than you think,' CNBC May 31, 2016.

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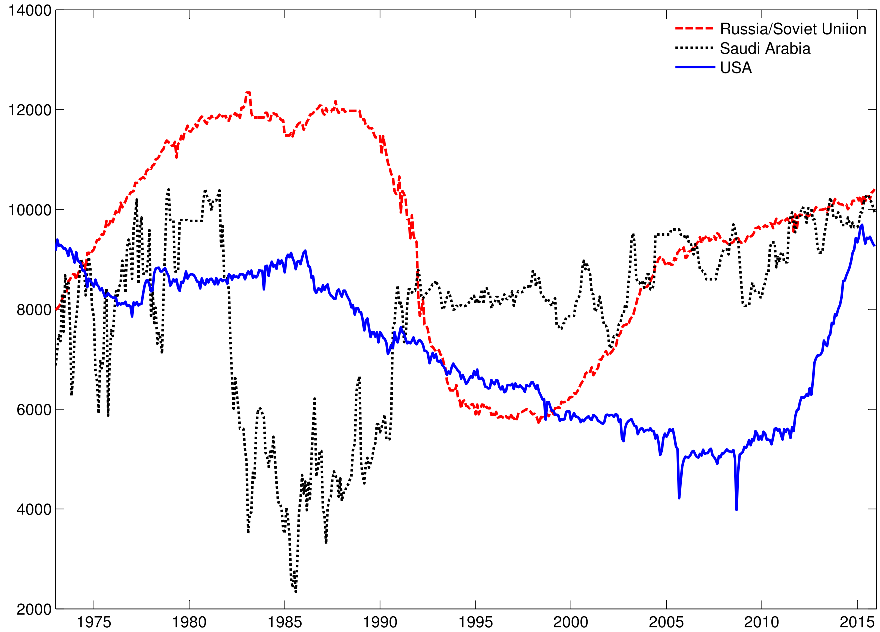

Fig. 1. Oil production levels among main oil producers. Note: Thousand barrels per day.
Source: International Energy Agency.

and changes on the demand side due to changes in environmental regulation may cause changes in the dynamics of the oil market.

In terms of the dynamics of the oil market, our findings can be summarized as follows. First, U.S. oil production growth has experienced a structural change from a decline of approximately 1.56% a year before the shale revolution to an increase of 4.92% after the revolution. Interestingly, its dynamic coefficients have remained stable. Second, the volatilities of all structural shocks have been subject to structural breaks, and we do find a U.S. supply shock break related to the shale revolution. The shock volatility to the global aggregate demand influencing all commodity prices, has jumped to historic heights since the Global Financial Crisis (GFC). Third, the historical decomposition exercise reveals a substantial contribution from the U.S. supply to the recent low price of crude oil. Fourth, we also find that the failure to account for structural changes in dynamic coefficients overestimates the role of demand shocks and underestimates the role of supply shocks in the oil market. This evidence suggests that the U.S. oil production increase due to the shale revolution has increased the significance of the U.S. supply shock to movement in the real oil price.

Our study is organized as follows. Section 2 briefly presents the econometric methodology employed in this paper and describes data used in the analysis. Empirical evidence is provided in Section 3, and concluding remarks are offered in Section 4.

2. Econometric methodology and data

The econometric methodology used in this study builds on that of Bataa et al. (2016). A critical difference is that we have put the growth rate of U.S. oil production in the first place of the SVAR. Hence, the SVAR in this study consists of four variables; the growth rate of the U.S. oil supply, the growth rate of the global oil supply, changes in the measure of global real economic activity, and the growth rate of the real price of oil. We maintain the recursive identification assumption for the contemporaneous relation between these variables, that, for the first two variables, implies that the U.S. oil supply is unaffected by within-month global oil supply shocks, but that the global oil supply depends on its own within-month shocks and U.S. oil supply shocks as well. This assumption means that the global oil supply includes the U.S. oil supply and the U.S. is one of the main oil producers. According to the recursive identification assumption for the contemporaneous relation between the variables in the SVAR, $\mathbf{A}_0$ will be a lower-triangular matrix in the following baseline-constant parameter equation:

$$\mathbf{A}_0\mathbf{y}_t = \sum_{i=1}^{p}\mathbf{A}_i\mathbf{y}_{t-i} + \boldsymbol{\varepsilon}_t, \tag{1}$$

where $\boldsymbol{\varepsilon}_t = (\varepsilon_{uoils,t}, \varepsilon_{goils,t}, \varepsilon_{aggd,t}, \varepsilon_{oild,t})'$ denotes a vector of structural shocks with variances of U.S. oil supply, global oil supply, aggregate demand, and oil specific demand shocks σ^2_{uoils}, σ^2_{goils}, σ^2_{aggd}, σ^2_{oild}, respectively. The shock vector $\boldsymbol{\varepsilon}_t$ is both serially and mutually uncorrelated and, hence, $E(\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t') = \boldsymbol{\Sigma}$ is diagonal, and constant in the baseline case.

The vector moving average (VMA) representation of the SVAR, which shows the temporal patterns of responses to the shocks, can be derived as

$$\mathbf{y}_t = \left(\sum_{i=0}^{p}\mathbf{A}_i^*L^i\right)^{-1}\boldsymbol{\varepsilon}_t = \left(\sum_{k=0}^{\infty}\boldsymbol{\Psi}_kL^k\right)\boldsymbol{\varepsilon}_t = \sum_{k=0}^{\infty}\boldsymbol{\Psi}_k\boldsymbol{\varepsilon}_{t-k}, \tag{2}$$

where $\mathbf{A}_0^* = \mathbf{A}_0, \mathbf{A}_i^* = -\mathbf{A}_i, \quad i = 1, \ldots p$, and elements of the jth column of $\boldsymbol{\Psi}_k$ give the vector of IRFs for a unit shock to the jth element of $\mathbf{y}_t$ at horizon k.

The historical decomposition of ith element of $\mathbf{y}_t$ is

$$y_{i,t} = \sum_j\sum_{k=0}^{\infty}\Psi_{i,j}^{(k)}\varepsilon_{j,t-k} \tag{3}$$

where $\Psi_{i,j}^{(k)}$ is row i and column j of $\boldsymbol{\Psi}_k$, and $\varepsilon_{j,t}$ is the jth element of $\boldsymbol{\varepsilon}_t$.

Pagan and Robertson (1998) note that in a recursive system, one can always test whether any restrictions placed on $\mathbf{A}_i$ in Eq. (1) are valid, such as a necessity to have the same lag structure in every equation. Although we still have a maximum of two years of lag in this study, as in Kilian (2009), who argues for this long lag based on the industry feature, we apply a heterogeneous specification. First, as