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The macroeconomic effects of oil price shocks: Evidence from a statistical identification approach

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ABSTRACT

We analyze the dynamics in the global crude oil market based on a structural vector autoregressive model. We identify the model by presuming that reduced form residuals can be traced back to structural shocks that are independently distributed over the cross equation dimension. The resulting point estimates of the impulse response functions allow for a direct comparison with the outcomes of more conventional identification approaches. Our results are remarkably similar to the results regarding oil market dynamics in Kilian and Murphy (2012) and Inoue and Kilian (2013) even though they rely on statistical arguments instead of a set of theory-based a priori restrictions. Based on the results from our statistical approach, we investigate the cumulative contributions of different oil shocks on the rapid fall in oil prices at the end of 2008 and 2014, as well as the effects of different oil shocks on macroeconomic aggregates in the US, the euro area, and China.

1. Introduction

A proper understanding of the effects of oil price shocks on the business cycle and consumer prices is crucial for the optimal conduct of fiscal and monetary policy, especially in times of a sharp rise or

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fall in oil prices (Bodenstein et al., 2012; Kilian and Lewis, 2011). There is growing consensus in the literature about the need to differentiate between several types of oil shocks when analyzing the effects of oil price fluctuations on macroeconomic aggregates. The identification of these different shocks, however, remains controversial. Kilian (2009) suggests to impose zero restrictions on some instantaneous effects to identify supply and demand shocks in a structural vector autoregressive (SVAR) model of the global crude oil market. These restrictions are, inter alia, based on the assumption of a vertical short-run supply curve of crude oil. In contrast, numerous other studies, including those of Peersman and Van Robays (2009, 2012), Kilian and Murphy (2012, 2014), Lippi and Nobili (2012), Baumeister and Peersman (2013), and Inoue and Kilian (2013) impose theory-based sign restrictions on the structural impulse responses to disentangle different types of oil price shocks.

In this paper, we refrain from theory-based zero or sign restrictions and employ a recently proposed statistical approach that relies on a non-Gaussian framework of independent shocks for identification purposes (see Herwartz, 2015). In short, the independence-based identification approach proceeds under the assumption that (serially uncorrelated) reduced form residuals of the VAR can be traced back to structural shocks that are independently distributed over the cross equation dimension. As shown by Gouriéroux and Monfort (2014), the structural shocks – apart from their sign and ordering – can be exactly recovered from the reduced form residuals if they are independent, and if at most one marginal structural shock process is Gaussian. Hence, this identification approach only relies on a priori assumptions with regard to the shocks generating distributions, and neither on assumptions with regard to contemporaneous dynamics (zero restrictions) nor on assumptions with regard to qualitative outcomes (sign restrictions).

Although independence-based identification (under the assumptions outlined above) allows to recover a unique set of structural shocks, the approach remains silent on the economic interpretation of these shocks. The approach is useful, however, in that its results may be compared to the assumptions and results of more conventional theory-based identification approaches. If the results of the statistical approach proved to be similar to the results of a more conventional approach, we would be more confident about the estimates obtained from the conventional approach. At the same time, if the results of the statistical approach matched economically motivated identifying restrictions, the structural shocks identified by statistical arguments could be interpreted straightforwardly from an economic point of view.

We apply this procedure in the context of the common low-dimensional VAR model of the global crude oil market, which has previously been employed by Kilian (2009), Kilian and Murphy (2012), Inoue and Kilian (2013), and Lütkepohl and Netšunajev (2014). The model enables us to differentiate between distinct demand and supply shocks, but is less likely to comprise closely related economic processes compared with higher dimensional empirical models. We first document that the residuals in this class of VAR models are non-Gaussian. We then show that the estimate of the structural impact multiplier matrix generated by the statistical approach satisfies the economically motivated sign pattern that provides the basis for the sign restriction approach in aforementioned studies. This allows us to label the shocks as oil supply shocks, aggregate demand shocks, and oil-specific demand shocks. Comparing the estimates of the impulse response functions across alternative identification approaches is complicated by the fact that sign-identified models are only set-identified. The median response functions commonly reported for sign-identified structural VAR models are misleading from an economic point of view (see Fry and Pagan, 2011, Kilian and Murphy, 2012, Inoue and Kilian, 2013). For the purpose of comparison, we therefore report estimates of the most likely sign-identified model following the study by Inoue and Kilian (2013), which relies on the set of sign and additional inequality restrictions proposed by Kilian and Murphy (2012). We show that the structural response functions generated by this approach are similar to those obtained from the statistical identification approach, lending credence to the results of Kilian and Murphy (2012) and Inoue and Kilian (2013). We also show that imposing zero restrictions as in Kilian (2009) generates structural response functions that are broadly similar to those obtained from the statistical identification, even though our estimates provide some evidence against these restrictions.

Apart from comparing more conventional identification approaches with the results of the statistical approach proposed by Herwartz (2015), we contribute to the literature on oil market models in