Energy Economics 49 (2015) 227–238

Contents lists available at ScienceDirect

Energy Economics

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

Do exchange rates respond asymmetrically to shocks in the crude oil market?

Bebonchu Atems [a,*,1], Devin Kapper [b,1], Eddery Lam [c,2]

[a] School of Business, Clarkson University, 8 Clarkson Avenue, Potsdam, NY 13699, United States
[b] Clarkson University, Potsdam, NY 13699, United States
[c] Department of Economics, Rochester Institute of Technology, 1 Lomb Memorial Dr, Rochester, NY 14623, United States

ARTICLE INFO

Article history:
Received 7 July 2014
Received in revised form 28 January 2015
Accepted 31 January 2015
Available online 2 March 2015

JEL classification:
G15
Q43

Keywords:
Oil price shocks
Exchange rates
Vector autoregressive (VAR) models

ABSTRACT

The paper argues that exchange rates respond asymmetrically to different shocks to the crude oil market. We apply Kilian's (2009) methodology to disentangle shocks to the crude oil market into distinct demand and supply shocks, and examine the response of the U.S. real and nominal trade-weighted U.S. dollar exchange rate indexes, as well as six other bilateral exchange rates to these shocks. Our analysis indicates that oil supply shocks have no significant effects on exchange rates, while global aggregate demand and oil-specific demand shocks lead to depreciations. We further show that exchange rates respond asymmetrically to shocks in the crude market depending on whether the shocks are large versus small, or positive versus negative.

1. Introduction

Despite the constant development of alternative sources of energy, oil still accounts for the largest fraction of energy worldwide.[3] As a consequence of this heavy dependence on oil, and based on past experience with oil shocks, a large body of research has attempted to estimate the effect of oil shocks on macroeconomic variables. An important paper by Hamilton (1983) finds a significant negative relationship between oil prices and output. Hamilton (1983) provides evidence that oil price changes could be treated as exogenous to the U.S. economy. Several tests support the assertion that oil price increases are followed by decreases in output. Other studies have shown that this result extends to other variables including GDP (Bachmeier et al., 2008; Hamilton, 2003), inflation (Bachmeier and Cha, 2011; Blanchard and Gali, 2009), monetary policy (Bachmeier, 2008; Bernanke et al., 1997), current account deficits (Van Wijnbergen, 1985), the balance and terms of trade (Backus and Crucini, 2000), and employment and wages (Keane and Prasad, 1996).

To the extent that oil prices affect the above variables, they should affect exchange rates, as well. From a theoretical viewpoint, oil shocks may be transmitted to the exchange rate through different channels: the terms of trade, wealth effects and the associated trade balance and portfolio reallocation (Bodenstein et al., 2010; Buetzer et al., 2012). Coudert et al. (2007) find that oil prices affect US Dollar real exchange rate through its effect on US net foreign assets. Amano and Van Norden (1998) provide evidence that a 10% rise in oil prices causes a 1.7% depreciation of the Yen and a 2.6% appreciation of the U.S. dollar. Basher et al. (2012), and Cheng (2008) document a depreciation of the U.S. dollar following oil price shocks.

The above papers treat oil shocks as exogenous with respect to the economy. Kilian (2009) offers an alternative view of the effects of oil shocks. He argues that a drawback of existing studies is that by treating oil price shocks as exogenous, reverse causality becomes a problem in regressions that relate oil price changes on macroeconomic variables. Kilian (2009) shows that GDP responds differently to an oil price change depending on the nature of the underlying shock. If the price of oil rises because of a shock to oil supplies, GDP is expected to fall. If on the other hand, the price of oil rises because of a positive shock to world output, and thus the demand for oil, GDP is expected to rise. Kilian and Park (2009) argue that a similar story can be told with respect to the stock market. Using an identified vector autoregressive (VAR) approach, they show that oil supply shocks decrease the Center for Research in Security Prices (CRSP) value-weighted market portfolio, but oil price increases due to increases in world demand cause the portfolio to appreciate.

* Corresponding author.
E-mail addresses: batems@clarkson.edu (B. Atems), kapperdp@clarkson.edu (D. Kapper), lame2@unk.edu (E. Lam).
[1] Tel.: +1 315 268 4469.
[2] Tel.: +1 585 475 2435.
[3] The BP Statistical Review of World Energy (2009) shows that oil accounted for 35% of global energy use in 2008, higher than coal (29%), natural gas (24%), nuclear (6%) and hydropower (5%).

http://dx.doi.org/10.1016/j.eneco.2015.01.027
0140-9883/

In this paper, we argue that one limitation of existing studies on the relationship between exchange rates and oil shocks is that they treat oil prices as exogenous. The expected response of exchange rates, however, will differ depending on whether oil prices have risen due to a shock raising the demand for oil, or an oil-market shock decreasing its supply. If the price of oil rises due to an increase in global output, and hence global demand for oil, this may lead to a reallocation of world wealth such that there is an increase in demand for foreign currency and a decrease in demand for U.S. dollars, causing the dollar to depreciate against the foreign currency (Golub, 1983). However, if the price oil rises due to oil production disruptions and markets expect the US economy to be less vulnerable to the higher prices than the rest of the world, this may increase the demand for U.S. dollars, leading to an appreciation of the dollar. Accordingly, we apply Kilian's (2009) methodology to decompose oil market shocks into measures of demand and supply shocks that characterize the endogenous behavior of oil price changes, and examine the response of several exchange rates to these shocks.

In general, we find that exchange rates depreciate following an oil-specific demand shock. Similarly, global aggregate demand shocks are typically associated with a depreciation of the exchange rate, while global oil supply shocks have no significant impact. Our analysis further investigates whether the distinct oil shocks affect exchange rates differently depending on whether they are large versus small, or positive versus negative shocks. We find that the global supply shocks, whether positive versus negative, or large versus small, have little effects on exchange rates. Our results also show that positive aggregate demand shocks cause exchange rates to depreciate. The negative global aggregate demand shocks seldom have any effects on exchange rates. Similarly, large global aggregate demand shocks always cause depreciations, while the corresponding small shocks have no significant effects. Impulse response functions show that in all cases, positive (large) oil-specific demand shocks cause exchange rate depreciations, but negative (small) shocks are insignificant.

The rest of the paper proceeds as follows. In the next section, we present the data and methodology employed to decompose oil shocks into distinct demand and supply crude oil market shocks. Section 3 presents and discusses the results, while Section 4 concludes.

2. Decomposing shocks to the crude oil market

2.1. Data

Our dataset consists of monthly data from 1974:1 to 2013:6 on global crude oil production, the real price of oil imported by the U.S., a measure of global real economic activity, the real and nominal trade-weighted U.S. dollar exchange rate indexes, and selected bilateral exchange rates between the U.S. dollar and other currencies. The bilateral exchange rates we consider include the Australia/U.S. (AUD/$), Canada/U.S.(CAN/$), New Zealand/U.S. (NZD/$), Norway/U.S. (NOK/$), Sweden/U.S. (SEK/$), and the U.K./U.S. (UK/$) exchange rates. We define the exchange rates as the price of the U.S. dollar in terms of the foreign currency, so that an appreciation corresponds to an increase in the exchange rate. All the exchange rate data were collected from the St. Louis Federal Reserve Economic Database (FRED). Data for global crude oil production were collected from the Energy Information Administration (EIA). Data on real economic activity was collected from the website of professor Lutz Kilian at http://www-personal.umich.edu/lkilian/reaupdate.txt. Kilian (2009) constructs this index from an equal-weighted index of the percent growth rates from single voyage bulk dry cargo freight rates measured in dollars per metric ton.[4] The measure of the nominal crude oil prices is the refiner's acquisition cost of imported crude oil, and was collected from the EIA. The nominal crude oil prices and nominal exchange rates were deflated using the U.S. consumer price index (CPI) available from FRED.

2.2. Methodology

2.2.1. Unit-root tests

The basic framework for this paper is motivated by Kilian (2009) with one modification. Kilian (2009) estimates a VAR model with the *percentage change* in world crude oil production, the *level* of global real economic activity, and the *level* of the real price of oil. A VAR model that contains a mix of stationary and nonstationary variables may suffer from the kind of spurious regression problem documented by Granger and Newbold (1974). Accordingly, we begin by pretesting our variables for stationarity, carrying out an augmented Dickey–Fuller test for all the variables. Table 1 shows the results from this test. The conclusion from the test is that all the exchange rate series are nonstationary in levels but stationary in first differences. In addition, we find that global oil production and the real price of oil are nonstationary in levels but stationary in first differences, while the index of real economic activity is stationary. Consequently, unlike Kilian (2009) who uses a mixture of I(0) and I(1) variables, our VAR model consists of only I(0) variables.

2.2.2. The VAR model

Denote the percentage change in global crude oil production in month t by p_t, the measure of global real economic activity by y_t, and the percentage change in the real price of oil in month t by O_t. Then a reduced-form VAR model of the variables can be written as:

$$\begin{aligned} p_t &= \alpha_0 + \sum_{i=1}^{24}\alpha_{1i}p_{t-i} + \sum_{i=1}^{24}\alpha_{2i}y_{t-i} + \sum_{i=1}^{24}\alpha_{3i}O_{t-i} + e_{st} \\ y_t &= \beta_0 + \sum_{i=1}^{24}\beta_{1i}p_{t-i} + \sum_{i=1}^{24}\beta_{2i}y_{t-i} + \sum_{i=1}^{24}\beta_{3i}O_{t-i} + e_{yt} \\ O_t &= \gamma_0 + \sum_{i=1}^{24}\gamma_{1i}p_{t-i} + \sum_{i=1}^{24}\gamma_{2i}y_{t-i} + \sum_{i=1}^{24}\gamma_{3i}O_{t-i} + e_{ot}. \end{aligned} \tag{1}$$

For the ease of the ensuing discussion, rewrite Eq. (1) as:

$$X_t = \alpha + \sum_{i=1}^{24} A_i X_{t-i} + e_t \tag{2}$$

where $X_t = (p_t, y_t, O_t)'$ and $e_t = (e_{st}, e_{yt}, e_{ot})'$. The reduced-form residuals, e_t are uncorrelated with variables in period $t-1$ and earlier. We

Table 1
Augmented Dickey–Fuller unit root tests.

Variable	Level			Log first differences		
	None	With trend	With drift	None	With trend	With drift
Oil production	0.956	−3.334	−1.132	−17.215	−17.235	−17.246
Real oil price	−0.990	−2.060	−2.372	−12.358	−12.410	−12.358
REA index	−4.473	−4.567	−4.497	−15.973	−15.970	−15.975
RTWER	−0.334	−2.380	−2.261	−14.097	−14.070	−14.086
NTWER	−0.627	−2.436	−1.477	−13.920	−13.922	−13.924
AUD/$	−1.602	−1.989	−2.479	−13.632	−13.767	−13.638
CAN/$	−0.825	−1.563	−1.721	−13.464	−13.595	−13.451
Y EN/$	−1.442	−2.363	−1.538	−13.172	−13.255	−13.254
NZD/$	−0.971	−2.134	−2.689	−13.087	−13.286	−13.103
NOK/$	−0.149	−2.419	−2.477	−13.338	−13.327	−13.323
SEK/$	0.159	−2.051	−2.067	−13.436	−13.459	−13.434
UK/$	−1.290	−3.105	−3.095	−13.726	−13.733	−13.730

Notes: The optimal lag length for the tests was determined using the Schwarz Information Criterion (SIC). The 5% critical value for the test with drift = −2.87; trend = −3.42; and none = −1.95.

[4] For a detailed description of the construction of this index, the reader is referred to Kilian (2009). Kilian (2009) discusses an alternative measure of real economic activity derived from OECD industrial production. However, as this index excludes emerging market economies such as China and India whose increased demand has driven up commodity prices, we use the real economic activity index based on single voyage bulk dry cargo shipping rates. In addition, we find that the results obtained from using either index for our dataset are qualitatively and quantitatively similar.