Economic Issues, Vol. 23, Part 2, 2018

Oil Price Shocks and Stock Market Performance in the BRICs: Some Evidence using FAVAR Models

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Abstract

This paper examines the response of real stock prices to oil price shocks for four selected emerging economies over the period from January 1991–March 2011. To overcome the problem of omitted information in small-scale vector autoregression (VAR) models, the factor augmented vector autoregressive (FAVAR) approach proposed by Bernanke et al (2005) is utilised. In addition, Stock and Watson (2002b) has been followed in order to extract two factors that are significantly related to a large set of world-level and country-specific macroeconomic variables. The extracted factors are then used as regressors in recursive VARs to assess the response of stock prices to oil price shocks. The key results suggest that the response of stock prices to oil price shocks is quite persistent and precise, but asymmetric across the four economies. Specifically, we observe that stock prices in Brazil and India respond negatively to oil price shocks, whereas the response in China is positive. We also observe that stock prices in Russia initially respond positively, however, the response becomes negative after four months. The impulse-response results indicate that the impact of oil price shocks on stock prices is smaller for China than for the remaining three countries. Overall, our results suggest that the use of the FAVAR approach allows us to obtain more coherent evidence on the effects of oil price shocks on stock prices, by obtaining relatively more precise responses and thus increasing understanding of such shocks from a theoretical point of view.

JEL Classification: G1, Q4
Keywords: emerging economies, FAVAR, oil price shocks, stock prices

1. Introduction

Despite the numerous studies that have extensively investigated oil price effects on macroeconomic performance, the literature on the response of stock markets and stock prices to oil price shocks is still growing. Several researchers have shown that oil price dynamics significantly affect a number of macroeconomic activities. In particular, studies such as Hamilton

(1983), Mork *et al* (1994), Lardic and Mignon (2008), Lescaroux and Mignon (2008) and Hamilton (2009a) have all provided evidence of significant and negative effects of oil prices on GDP growth. Some studies have also shown that an increase in oil prices is likely to produce inflationary effects: see Cologni and Manera (2008). Hamilton (2003, 2005) shows that nine out of ten recessions in the US have been preceded by oil price shocks. Further, empirical research including Hamilton (1983), Daniel (1997), and Carruth *et al* (1998) have rejected the hypothesis that the relation between oil prices and output is just a statistical coincidence, by providing significant evidence on oil price effects. Another strand of studies has argued that the oil price affects the performance of stock markets through its impact on the macroeconomy.

A common intuition emerging from these studies is that since oil is one of the most important factors of production, any oil price increase will lead to increased production costs (Kim and Loungani 1992; Backus and Crucini 2000; Arouri and Nguyen 2010). These higher costs will be passed onto consumers, resulting in higher consumer prices. These inflationary pressures will lower aggregate demand, including consumption and investment spending, deteriorate consumer sentiment and thus, in turn, lead to a slowdown in overall economic activity (Barro 1984; Hamilton 1988, 1996, 2011; Abel 2001; Bernanke 2006). Clearly, stock markets tend to respond negatively in such economic downturns (Jones and Kaul 1996; Sadorsky 1999).

The relationship between oil prices and stock markets can also be explained as follows. According to economic theory, the price of any asset should be determined by the discounted value of expected future cash flows associated with it (Fisher 1930; Williams 1938). Therefore, it is expected that any factor that could affect the discounted value of cash flows of assets may have a significant influence on the prices of these assets. In this context, any increase in oil prices should result in a decline in stock prices. This is because higher oil prices would increase costs of production, which would result in a decrease in firms' earnings, and in sequence this would reduce the firms' value. In this case, any hike in the oil price would cause a reduction in equity prices.

However, the effect of oil prices on stock prices can be the opposite for oil-exporting countries. In particular, oil price increases would not only increase earnings of those firms that produce oil but also increase the country's income. These increases in income are expected to bring a rise in consumer spending and investments and thus productivity and the level of employment which would, in turn, enhance the performance of the stock markets (see Jiménez Rodriguez and Sánchez 2005; Bjørnland 2009; Filis *et al* 2011).

Another channel through which oil prices would have an effect on stock markets is the uncertainty that oil price dynamics create in financial markets (Friedman 1977; Ramey and Ramey 1991; Doran and Ronn 2008). Volatilities in inflation rates, arising from oil price shocks, would cause increases in uncertainty concerning variations in future prices, distort price signals and thus reduce the efficiency of the overall economic system. These are all expected to have an inverse impact on the performance of stock markets. As a result, there is a negative relationship between stock prices and oil shocks.

Oil price shocks can impact a firm's share prices through its impact on the investment behaviour of the firm as well. Several studies, including Glass and Cahn (1987), Mohn and Misund (2009), Elder and Serletis (2009, 2010),Yoon and Ratti (2011), and Henriques and Sadorsky (2011) have documented statistically significant impacts of oil price uncertainty on firms' investment decisions. One can also predict a positive impact of oil price shocks on stock market performance. Oil price shocks lead to increasingly large economic risk (Hamilton 1983). Since high risk is considered an instrument of achieving higher economic growth, economies with high variance are also likely to have high growth on an average. In this context, oil price shocks are expected to be positively related to stock market performance (Black 1987).

The nature of the response of stock markets to oil price shocks, however, also depends on the origins of the shocks. In particular, the market would react positively to oil shocks originating on the demand side.[2] On the other hand, stock markets respond negatively if the shocks originate on the supply side. For more on the nature of oil price shocks and their effects, see Hamilton (2009b) and Kilian (2009).

Although several empirical studies have examined the impact of oil prices on stock market returns, the findings of these studies are mixed.[3] Accordingly, this paper aims to examine the impact of oil price shocks on stock returns in four major emerging economies, the BRICs, using the Factor Augmented Vector Autoregressive (FAVAR) model. To the best of our knowledge, although this methodology has been often applied in other literatures, none of the existing studies have applied the FAVAR approach to investigate the influence of oil price shocks on stock market performance.

More precisely, the FAVAR methodology overcomes several limitations that the standard VAR methodology possesses. In particular, it enables including a large set of variables in the estimation when examining the impact of oil price shocks on stock market performance. Thus, researchers can include not only domestic factors that are important in formulating the interactions between oil prices, stocks and stock returns, but also international factors such as world GDP growth and world inflation. Another important feature of FAVAR is that it allows us to model jointly the dynamics of world-level and country-level variables within a single consistent empirical framework. In that respect, we see our empirical strategy as an improvement over the numerous papers that have compared the impulse responses of stock prices to oil price shocks on the basis of models estimated separately for each country (e.g. Angeloni *et al* 2003). Therefore, we use a data set that involves three common world oil market indicators, major currencies exchange rates, consumer price index (CPI), and percentage change in GDP for both world and emerging economies. In addition, several country-specific factors have been taken into consideration for each country. Further, we extract two common factors from the dataset and augment the main VAR model with these factors, to give more information when estimating the effects of oil price shocks on stock prices.

The rest of the paper is structured as follows: Section 2 presents the literature review, Section 3 describes the econometric framework, Section 4 reports the empirical results and Section 5 concludes the paper.

2. Literature Review

The literature includes extensive research aiming to examine the impact of oil prices on stock market returns. At best, the findings of these studies are mixed. For instance, Jones and Kaul (1996) study the relationship between real oil prices and real stock returns for the US, Canada, Japan, and the UK using quarterly data. They find a significant negative impact of oil prices on real stock returns for all four countries.[4] However, Chen *et al* (1986) examine the effects of oil prices on stock market returns, along with a variety of macroeconomic factors. They use monthly data for the US, covering the period 1953–1983. They find no statistically significant effect of oil prices on stock returns.

In a wide-ranging study by Driesprong *et al* (2008), the effect of oil prices on stock returns has been analysed, based on monthly data for the period October 1983–April 2003. Their sample includes 18 developed and 30 developing countries. They find a negative and statistically significant effect of oil prices on stock market returns for 17 out of 18 developed countries. They also find a negative relationship between oil prices and stock returns for developing countries, although they report that the relationships are not statistically significant for most of developing countries. Apergis and Miller (2009) and Jammazi and Aloui (2010) also fail to find a significant relationship between oil prices and the performance of stock markets.

Narayan and Sharma (2011) examine the effect of oil prices on stock returns using daily time series data for the period 5 January 2000 to 31 December 2008 for 560 US firms. They find that there is a statistically significant effect of oil prices on firm returns. However, they show that this effect varies across industries. Further, their analysis shows that there is a significant lagged effect of oil prices on stock returns. Filis *et al* (2011) examine the effect of oil prices on stock returns for three oil-exporting countries, namely Canada, Mexico, and Brazil, and three oil-importing countries, namely the US, Germany, and the Netherlands. Their study is based on monthly data. They find a negative relationship between oil prices and stock market returns for all countries. They also show that while the correlation of the two markets increases in response to demand-side oil price shocks, the relationship is not affected by supply-side oil price shocks. Similarly, Arouri and Nguyen (2010) examine the impact of oil prices on stock returns for European countries, and they find that oil prices have a tendency to exercise a statistically significant effect on stock market index returns.

Several other studies have also examined the response of stock returns to oil price shocks. For instance, Lee and Chiou (2011) examine the response of Standard and Poor's 500 (S&P) returns to West Texas Intermediate (WTI) oil prices and find that large variations in oil prices have a statistically significant impact on stock returns. However, they find that small variations in oil prices have a statistically insignificant effect on S&P returns. Similarly, Cifarelli and Paladino (2010) examine the effects of oil prices on stock returns and exchange rates. They find that fluctuations in oil prices have a statistically significant influence on both stock price and exchange rate changes. Choi and Hammoudeh (2010) also find statistically significant correlations among Brent oil, WTI oil, gold, silver, and stock prices in the US. Another study, by Chang *et al* (2013), examines S&P500, Dow Jones, NYSE, and FTSE100 stock indices response to variations in crude oil markets, namely Brent and WTI. They do not find any significant evidence of conditional correlations for returns across examined markets. Nevertheless, they find that the conditional shocks are significantly correlated in the same market. They also find little evidence of volatility spillovers between crude oil and stock returns.

Basher and Sadorsky (2006) and Arouri and Rault (2012) study how stock markets of the Gulf Cooperation Council (GCC) countries respond to oil price fluctuations.[5] They find a positive and statistically significant effect of positive oil price shocks on stock market performance. Several other studies have also reported a statistically significant response of stock markets to oil price shocks. Among others, see Sadorsky (1999), Lardic and Mignon (2008), Nandha and Faff (2008), Park and Ratti (2008), Hamilton (2009a, 2009b), Kilian (2009), Kilian and Park (2009), Oberndorfer (2009) and Chen (2010), who report that oil price shocks (either supply- or demand-side) have a significant impact on stock prices. In particular, Chen (2010) examines whether increased oil prices leads stock market recessions. His empirical analysis is based on monthly data covering the period January 1957-May 2009 for the S&P stock index. He finds that higher oil prices increase the likelihood of the stock market moving into bear territory.

Park and Ratti (2008) study the response of stock markets in the US and 13 European countries to oil price volatility and oil price shocks. They find a significant impact of oil price shocks on stock returns. However, Kilian and Park (2009) provide evidence of differential effects of oil price shocks on real stock returns in the US, depending on the nature of the shocks. Nandha and Faff (2008) examine the impact of oil price rises on stock returns using data for 35 industrial sectors, and they find higher oil prices have a negative impact on stock returns for all sectors except extractive industries: mining, oil and gas. Chiou and Lee (2009), estimating an autoregressive conditional jump intensity model, conclude that variations in oil prices have a significant negative effect on stock returns in the US. Sadorsky (1999) also provides evidence of a significant influence of oil price volatility on stock returns.

On the other hand, other studies have found the effect of oil price shocks on stock prices to be statistically insignificant. For example, Al-Fayoumi (2009) finds no statistically significant association between oil price shocks and stock market performance. Similarly, Al Janabi *et al* (2010) find that GCC stock markets are more efficient in terms of information than oil prices. This implies that information concerning oil prices cannot be used to predict these stock markets. Nordhaus (2007) points out that the effect of oil price shocks turns statistically insignificant in several countries because of greater wage flexibility. A similar picture is reported by Blanchard and Galí (2007), who also suggest that oil price shocks do not have a significant impact on the performance of stock markets.

In exploring the impacts of oil price and oil price shocks on stock returns, most of these earlier studies have relied mainly on either standard vector autoregression (VAR) models or ARCH/GARCH models. Since these methods do not perform efficiently with large numbers of variables, they restrict researchers to considering only a limited number of variables in their estimation. In particular, the VAR procedure assumes that the relevant information set for the identification of oil price co-movement is summarised by its lagged values. However, additional information concerning other domestic and international macroeconomic indicators, not included in the VAR, may be relevant to the dynamics of oil prices and stock returns. Bearing in mind such limitations of the methods applied previously in this area, in the present research we examine how oil price shocks influence stock market performance by applying the factor augmented vector autoregressive (FAVAR) approach proposed by Bernanke *et al* (2005). The FAVAR approach enables us to overcome the problem of omitted information of a small-scaled VAR model by including more information in the specification. Our empirical analysis is based on monthly data covering the period from January 1991 to March 2011 for the BRICs: Brazil, Russia. India and China.

3. Econometric Methods

3.1 The Factor Augmented Vector Autoregression (FAVAR) Model

The basic idea of the model proposed by Bernanke *et al* (2005) aims to solve VAR dimensionality problems and allow researchers to utilise a large dataset through a small number of unobservable factors.[6] Following Stock and Watson (2002a), we use a large dataset, X_t, to extract two unobservable factors (i.e. $K = 2$), $F_t = [F_{1t}, F_{2t}]$. These factors summarise all additional information that are meant to reflect theoretically motivated concepts such as ‘economic activity’, ‘price pressures’, or ‘credit conditions’, which cannot easily be represented by one or two series but rather are reflected in a wide range of economic variables. In contrast to X_t, Y_t denotes an *m – dimensional* vector of observable economic variables assumed to drive the dynamics of an economy. The joint dynamics of F_t and Y_t evolve according to the following state equation:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + e_t \qquad (1)$$

where $\phi(L)$ is a comfortable lag polynomial of finite order d, e_t is an error term with mean zero and covariance matrix Σ. In our application, interest rates, exchange rates, stock market prices, and industrial production are assumed to be directly observable and included in vector Y_t, whereas the effects of other domestic and world macroeconomic variables are accounted by the unobservable factors F_t. Equation (1) cannot be estimated without knowledge of F_t.[7] Therefore, a large 'informational dataset' X_t can be used to extract common factors using the following observation equation, as in Bernanke *et al* (2005):

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t \qquad (2)$$

where X_t is a large dataset related to un-observed factors, F_t, and the observed variables Y_t. Λ^f is an $(n \times k)$ matrix of factor loadings, Λ^y is an $(n \times m)$, e_t is an $(n \times 1)$ vector of error terms. Error terms have mean zero, and either normal and uncorrelated, or display a small amount of cross-correlation, depending on whether estimation is done using likelihood or principal components.[8] If the terms in $\phi(L)$ that relate Y_t to F_t are all zero in equation (1), then it is a standard VAR in Y_t. Otherwise the equation, as referred to by Bernanke *et al* (2005), is a factor augmented vector autoregression (FAVAR) model. If the true system is a FAVAR model but is estimated as a standard VAR, that is, relevant factors are omitted, then the estimates obtained from the standard VAR system will be biased.

Bernanke *et al* (2005) therefore consider two alternative approaches to estimating both observations and the state space equations of the FAVAR model. The first one is a two-step approach proposed by Stock and Watson (2002a). According to this approach, initially, principal component techniques are used to estimate the common factors $\mathbf{F}$, and then the parameters leading the dynamics of the state equation are obtained using standard classical methods for VARs. The second approach is a single-step Bayesian likelihood approach. By comparing both methods in the context of an analysis of the effects of monetary policy shocks, Bernanke *et al* (2005) find that the two-step approach yields more plausible results. Another advantage of this approach is its computational simplicity. The main advantage of the static representation of the dynamic factor model given by equation (2) is that the factors can be estimated by principal components (see Stock and Watson 2002a).

Accordingly, the common factors have to be extracted from the large macroeconomic dataset prior to estimating the term structure model. As in Bernanke *et al* (2005), this is achieved using standard static principal components following the approach suggested by Stock and Watson (2002a). In particular, let V denote the eigenvectors corresponding to the k largest eigenvalues of the $T \times T$ cross-sectional variance-covariance matrix XX^t of the data set. Then, subject to the normalisation $F^tF/T = I_k$, estimates $\hat{F}$ of the factors and $\hat{L}$ the factor loadings, are given by:

$$\hat{F} = \sqrt{T}V \qquad (3)$$

$$\hat{\Lambda} = \sqrt{T}X'V \qquad (4)$$

3.2 Data

We employ monthly data covering the period from January 1991 to March 2011, a total of 243 observations for each series.[9] In our case, the vector Y_t comprises exchange rates, interest rates, share price indices, industrial production indices, and spot prices for WTI crude oil traded on the New York Mercantile Exchange (NYMEX).[10] X_t corresponds to the dataset used for the extraction of the common factors. It embodies 29 time series variables that are meant to capture world and country specifications separately. World-level variables include gold prices, major currencies' exchange rates, oil production, oil stocks, CPI and gross domestic product changes for the BRICs and the world overall. Country specifications cover exports, imports, country CPI, country producer price index and the foreign exchange rate.[11] Our focus is to apply real oil price shocks and analyse the impact on each country's stock market price. Therefore, we deflate the nominal oil price used in Y_t using the US CPI for all urban consumers, all items, to construct real prices. Oil prices in the NYMEX respond (to some extent) to global supply and demand factors. Hence, the dataset includes series that are available from the US Energy Information Administration (EIA) on world crude oil production and stocks. It is important to stress that the data on crude oil stocks refer only to what is known as primary stocks.[12] The complete list of the series, the sources and the choice of filtering are reported in Table 6 in Appendix A. As is standard in the literature, all series converted to be stationary, if necessary.

The series have been demeaned and standardised before extracting the principal components.

4. Empirical Results

4.1 Preliminary Tests

Before presenting empirical results relating to the response of stock prices to oil price shocks, we present summary statistics of the world-level macroeconomic indicators and country-specific macroeconomic variables included in the analysis. Table 1 reports descriptive statistics for world indicators, while

Table 1: Summary statistics: World indicators

World Variable	*Obs*	*Mean*	*Std. Dev*	*Min*	*Max*
lop	243	3.570	0.478	2.600	4.779
lgp	243	6.188	0.360	5.650	7.132
laex	243	-0.334	0.160	-0.715	0.0324
lbex	243	-0.501	0.096	-0.729	-0.339
ljex	243	4.711	0.124	4.389	4.967
lcos	243	6.843	0.073	6.714	6.997
lcop	243	11.120	0.074	10.985	11.229
lcpiw	243	4.342	0.384	3.351	4.821
gdpem	243	4.815	2.901	-3.773	9.442
gdpw	243	2.316	3.323	-8.183	5.389

Note: The world variables shown in the first column of the above table are in logs and described as follows: lop; oil price, lgp; gold Price, laex; Australian Dollar in terms of US Dollars, lbex; Great Britain Pounds in terms of US Dollars, ljex; Japanese Yen in terms of US Dollars, lcos; total crude oil stocks, lcop; total crude oil production, lcpiw; world consumer price indices, gpdem; GDP Volume, % Change, emerging world, gdpw; world GDP Volume, % Change, for Emerging & Developing Economies.

summary statistics of the variables for each country is reported in Table 2. Specifically, the tables present the mean, standard deviation and the minimum, and maximum values of the underlying variables. The mean of log oil prices over the examined period is 3.570, while the average value of log gold prices is

Table 2: Summary statistics: Country-specific variables

Variable	*Obs*	*Mean*	*Std. Dev*	*Min*	*Max*
Brazil					
lex	243	-0.133	2.657	-9.115	1.639
lir	243	3.738	1.831	2.158	9.513
lsp	243	2.825	3.347	-7.936	5.559
lexp	243	7.893	0.346	7.142	8.564
limp	243	7.684	0.516	6.880	8.732
lfex	243	10.888	0.824	8.727	12.640
lcpi	243	3.263	2.706	-5.911	4.884
lppi	243	3.032	2.851	-6.453	4.938
India					
lex	243	4.027	0.230	3.274	4.338
lir	243	1.987	0.623	-0.158	4.382
lsp	243	4.252	0.715	2.602	5.650
lexp	243	8.422	0.798	7.119	10.323
limp	243	5.411	1.081	3.099	7.341
lfex	243	10.673	1.411	6.890	12.628
lcpi	243	4.383	0.377	3.573	5.090
lppi	243	4.377	0.323	3.666	4.962
lipi	243	4.347	0.398	3.675	5.222
China					
lex	243	2.375	0.153	1.950	2.582
lir	243	1.534	0.507	0.993	2.346
lsp	243	4.723	0.729	2.300	6.234
lexp	243	10.197	1.022	8.119	11.945
limp	243	10.070	0.996	8.012	11.933
lfex	243	12.366	1.484	9.846	14.929
cpi	243	4.828	6.699	-2.675	27.697
lipi	243	2.618	0.404	0.742	3.503
Russia					
lsp	159	4.183	1.120	1.273	5.590
lex	159	3.615	0.365	2.093	3.977
lir	159	1.735	0.908	0.000	4.939
ppi	159	1.512	2.320	-8.371	7.427
lcpi	159	4.404	0.563	2.906	5.166
lexp	159	9.636	0.650	8.433	10.765
limp	159	9.161	0.700	7.993	10.358
lfex	159	11.096	1.441	8.800	13.275
lipi	159	4.545	0.173	4.154	4.822

Notes: Country specific variables shown in the first column above includes: stock prices, country exchange rate, interest rate, country producer price index, country consumer price index, exports, imports, foreign exchange rate, and industrial production index.

6.188. The standard deviation estimates suggest that the oil prices appear more volatile than gold prices over the period under study. Mean world GDP growth is 2.316, while the mean of log world CPI is 4.342. The value of the US dollar with respect to the Australian dollar is more variable as compared with its value against the Japanese yen or UK pound sterling.

Looking at the descriptive statistics of the country-specific variables, we observe that across the BRICs, the log value of stock prices on average is highest in China, followed by India. However, stock prices are less volatile in India than the other three countries. It should also be noted that in all the four economies, the fluctuations in stock prices are higher than variations in oil prices during the sample period. We also observe that there are significant differences between the four countries with respect to other variables. For example, India has lowest interest rate on an average, with a mean value of 1.187, while this figure is 3.738 for Brazil. The mean log CPI of each country is similar to that of for whole world, with the exception of Brazil where inflation, on average, is lower. However, the standard deviation of log CPI suggests that month-to-month changes in CPI for three out of the four economies are higher than for the world. We also note that, on average, India has higher industrial production compared to other three countries included in the sample.

In the next step, we apply the modified Dickey-Fuller t test for a unit root (known as the DF-GLS test) proposed by Elliott *et al* (1996) in order to identify the order of integration of each time series. The results in levels and in first differences for world indicators and country-specific variables are reported in Tables 3 and 4, respectively. The Akaike Information Criterion (AIC) is applied to select the optimal lag order for Dickey-Fuller GLS regressions. We also consider a linear time trend in the series while testing for unit roots. The estimates given in Table 3 provide evidence that all the word-level indicator variables are non-stationary in levels. However, all indicators appear to be stationary in first differences. The results in Table 4 demonstrate that almost all of the country-specific variables follow a unit root in levels. However, CPI in

Table 3: Unit root test results: World indicators

Variables	*Without trend*	*With trend*	*Without trend*	*With trend*
	level		*difference*	
lop	-1.108(1)	-2.141(1)	-7.823(1)***	-8.629(1)***
lgp	1.542(1)	0.370(1)	-6.074(2)***	-12.319(1)***
laex	-0.768(1)	-0.948(1)	-6.082(2)***	-7.309(2)***
lbex	-1.274(1)	-1.913(1)	-0.888(7)	-3.379(2)***
ljex	-0.032(1)	-1.755(1)	-0.829(8)	-3.087(6)***
lcos	-0.393(1)	-1.458(1)	-2.698(7)***	-9.500(1)***
lcop	0.068(1)	-1.948(1)	-10.870(1)***	-12.675(1)***
lcpiw	-1.025(13)	0.444(13)	-4.166(1)***	-3.531 (2)***
gdpw	-2.792(12)	-2.752(12)	-7.775 (2)***	-7.775(2)***
gdpem	-2.579(1)	-2.657 (1)	-10.707 (1)***	-10.673(1)***

Notes: *** represents the significance at the 1% level.

Table 4: Unit root test results: Country-specific variables

Variables	*Without trend*	*With trend*	*Without trend*	*With trend*
	level		*difference*	
Brazil				
lsp	0.553(4)	-0.707(4)	-3.773(3)***	-3.879(3)***
lex	0.186(3)	-0.624(3)	-3.072(2)***	-4.046(2)***
lir	-0.543(1)	-2.266(1)	-1.236(1)	-2.930(1)**
lppi	-0.132 (2)	-1.233(2)	-2.239(1)**	-3.705(1)**
lcpi	-0.213(1)	-1.348(1)	-1.774(1)*	-3.712(1)**
lexp	-0.340(12)	-2.178(13)	-3.241(3)***	-5.599(3)***
limp	-0.565(1)	-2.455(1)	-2.430(2)***	-5.741(2)***
lfex	1.165(1)	-1.183(1)	-0.963(2)	-3.099(2)**
India				
lsp	0.954(1)	-2.790(1)	-2.706(4)***	-7.613(1)***
lex	1.153(1)	-0.690(1)	-8.260(1)***	-10.509(1)***
lir	-2.376(2)**	-3.475(2)**		
lppi	5.293(1)	-1.025(1)	-3.152(2)***	-6.479(1)***
lcpi	1.866(12)	-1.352(12)	-3.210(3)***	-5.422(3)***
lexp	2.723(12)	-0.716(12)	-3.047 (4)***	-5.509(4)***
limp	3.175(1)	-2.250(1)	-2.652(3)***	-4.721(3)***
lfex	2.596(2)	-1.415(3)	-3.918(2)***	-5.704(2)***
lipi	1.317(14)	-1.597(14)	-2.472(4)**	-3.478(4)***
China				
lsp	0.329(1)	-1.480(1)	-10.207(1)***	-10.340(1)***
lex	-0.501(1)	-1.122(1)	-9.309(1)***	-9.885(1)***
lir	-0.040(1)	-1.183(1)	-9.914(1)***	-9.940(1)***
cpi	-2.702(7)***	-2.615(7)**		
lexp	1.690(13)	-2.416(13)	-7.650(5)***	-5.911(5)***
limp	2.195(13)	-2.001(13)	-7.849(6)***	-4.403(6)***
lfex	3.399(1)	-1.462(1)	-2.999(4)***	-4.812(4)***
lipi	-1.763(3)	-2.589(3)	-15.071(2)***	-15.066(2)***
Russia				
lsp	0.602(1)	-2.117(1)	-6.820(1)***	-6.878(1)***
lex	0.741(1)	-1.519(1)	-6.652(1)***	-7.176(1)***
lir	-1.414(1)	-3.070(1)	-7.265(1)***	-8.785(1)***
ppi	-6.518(1)***	-6.634(1)***		
lcpi	3.519(1)	-0.999(1)	-5.694(1)***	-6.281(1)***
lexp	0.545(12)	-2.143(12)	-5.196(6)***	-5.012(6)***
limp	-0.317(12)	-2.082(12)	-4.610(5)***	-4.823(5)***
lfex	1.021(3)	-1.532(3)	-2.114(3)**	-4.239(2)***
lipi	-1.772(2)	-1.768(2)	-9.069(2)***	-8.127(2)***

Notes: ***, and ** shows the significance at the 1% and 5% level, respectively.

China and PPI in Russian appear stationary in levels, while all the other country-specific variables are integrated of order one, stationary in first differences. The order of integration of each variable helps us in applying a transformation method when estimating the FAVAR model to extract the factors from the dataset.

4.2 Factor Estimation

To estimate the FAVAR given by equation (1), we first need to estimate the unobserved factors F_t. Given the size of our dataset, we extract two factors only for each country. The dataset used to extract these factors, X_t, consists of two main parts, world-level macroeconomic variables and country-specific macroeconomic variables. We treat the first part (world indicators) as common for all countries, whereas the second part is unfixed and changed according to each country's domestic variables. It should be noted that the extracted factors therefore have no structural interpretation. It is interesting to know to the extent to which both extracted factors provide similar information in the large dataset, X_t. To answer this question, we estimate correlation coefficients for each country. The estimated correlation coefficients are very low and are statistically insignificant, providing evidence that the factors are not correlated.[13] In order to provide some preliminary evidence on the role of factors and information they convey, we examine the correlation between the extracted factors and the other variables included in the dataset. Specifically, we select first the world indicators and country-specific variables based on correlations between the variables and each extracted factor for each country.

We then regress each of the highest correlated macroeconomic variables on each of the factors separately, to estimate the share of total variation explained by each factor. The estimation results are given in Table 5. The estimated values of R^2 reveal that the common extracted components (factors) explain a significant portion of the variance of most of the variables for all countries. For example, in the case of Brazil, we obtain an R^2 of 62.3 per cent, 57.1 per cent, 46.7 per cent, and 37.5 per cent for CPI, PPI, the exchange rate between Australian dollar and US dollar (AUD/USD), and the exchange rate between UK pound and US dollar (GB/USD), respectively. Similarly, for China, the estimated value of R^2 is 72.8 per cent, 70.9 per cent, and 52.4 per cent for imports, exports, and the exchange rate between Australian dollar and US dollar (AUD/USD), respectively. In the case of Russia, the variables for which the extracted factors explain an important proportional of the variance are imports (57.6 per cent), exports (57.0 per cent), and the exchange rate between UK pound and US dollar (GB/USD) (37.7 per cent). For India, the obtained values of R^2 suggest that the exchange rate between UK pound and US dollar (GB/USD), the exchange rate between Australian dollar and US dollar (AUD/USD), imports and exports are highly correlated with the extracted factors. Further, we observe that a significant portion of the variance of gold prices and GDP of emerging economies are also explained by the extracted common factors for all the countries. However, we also observe that there are some variables for which the obtained R^2 is small (e.g. oil stocks), suggesting that the extracted factors do not significantly explain the variance of these variables. Overall, the estimates given in Table 5 suggest that both the extracted common factors significantly explain the portion of variance of both world-level macroeconomic indicators and country-specific variables.

Table 5: Share of explained variance of highly correlated series

Variable	*Factor 1* R^2	*Factor 2* R^2
Brazil		
aex	0.467	
bex	0.375	
gp	0.357	
gdpem	0.171	
exp	0.155	
cpi		0.623
ppi		0.571
gdpem		0.206
India		
bex	0.474	
aex	0.460	
fex	0.260	
gp	0.253	
gdpem	0.179	
exp		0.441
imp		0.354
ppi		0.218
gdpw		0.177
China		
exports	0.709	
imports	0.728	
gdpem	0.270	
gdpw	0.130	
oilst	0.087	
austus		0.524
gbus		0.363
gold		0.358
Russia		
imports	0.5761	
exports	0.5706	
austus	0.2367	
cpi	0.2192	0.3148
gdpem	0.2017	
gbus		0.3769
austus		0.3238

4.3 Analysing Oil Price Shocks

After confirmation of the order of integration of each series, and associations between the extracted factors and the other variables included in the dataset, we estimate the effects of oil price shocks on real stock prices. Specifically, we augment the VAR model by including the two common factors extracted from a relatively large dataset in order to overcome the omitted information problem of the standard VAR model. The obtained generalised impulse response results are illustrated in Figures 1-4. Specifically, the figures contain the estimates of

Figure 1: The Impulse Response of Stock Prices
to a shock in Oil Price: The Case of Brazil

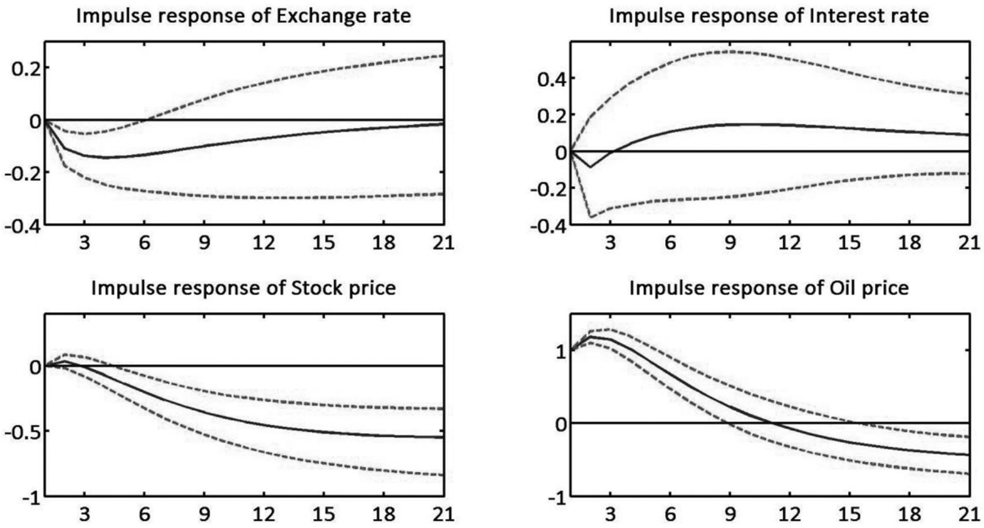


Figure 2: The Impulse Response of Stock Prices
to a shock in Oil Price: The Case of India

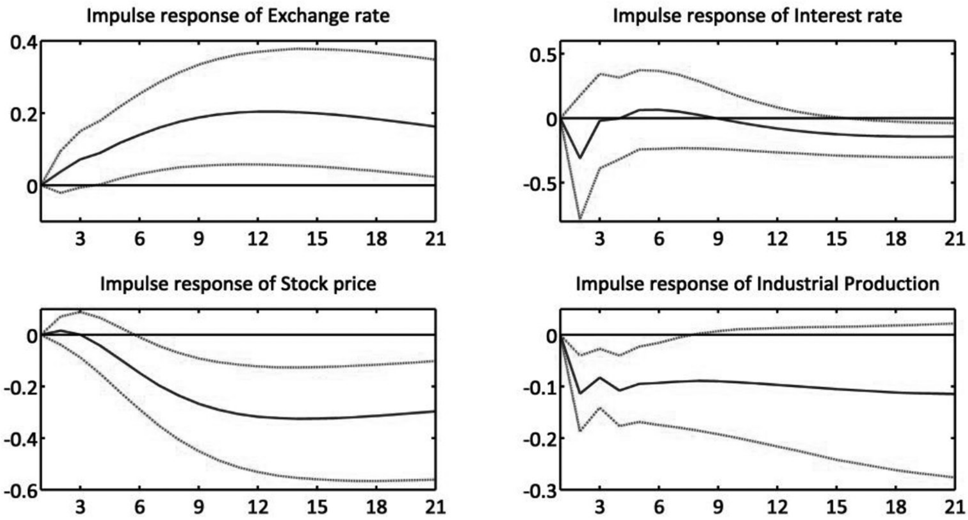


Figure 3: The Impulse Response of Stock Prices
to a shock in Oil Price: The Case of China

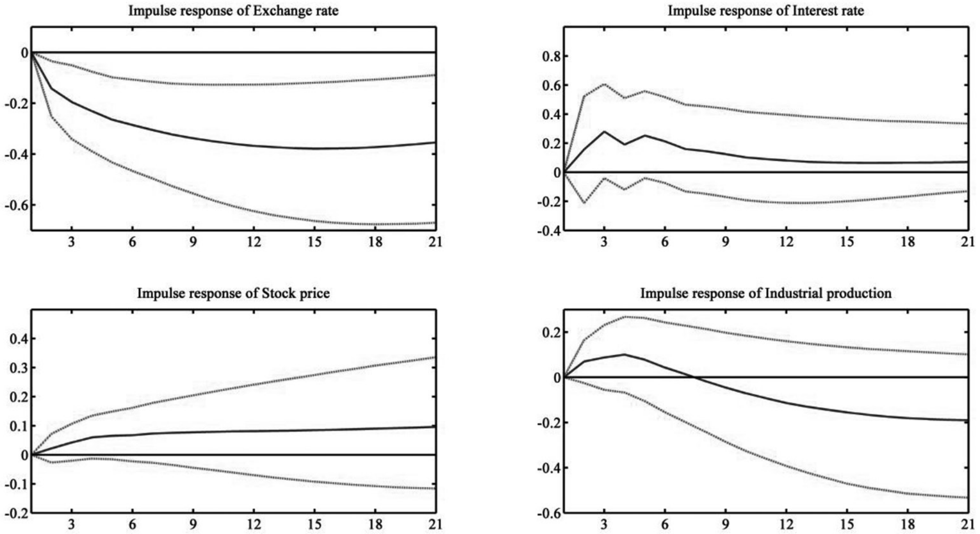
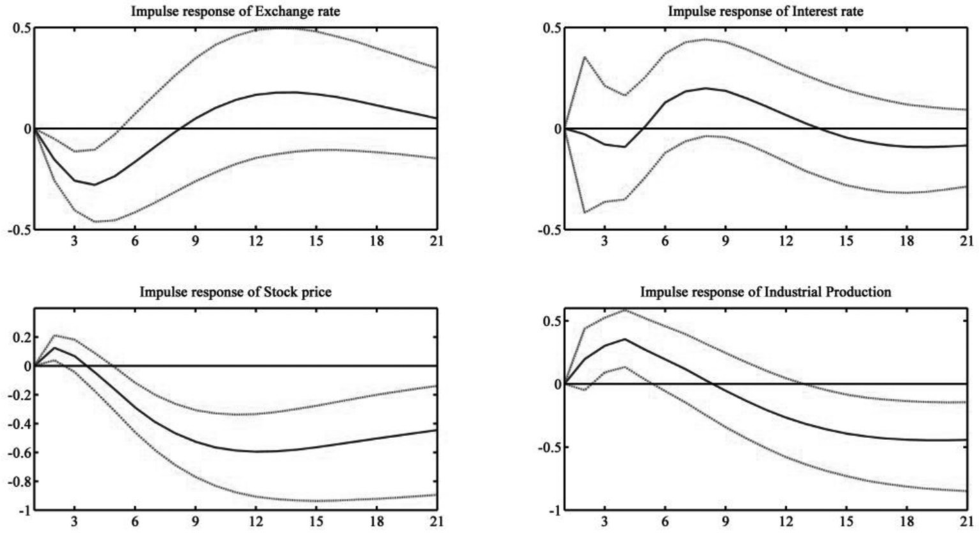


Figure 4: The Impulse Response of Stock Prices
to a shock in Oil Price: The Case of Russia



the impact of a one standard deviation shock on: stock prices, exchange rates, interest rates, and industrial production. Overall, the figures reveal that the impulse-response functions of real stock returns to oil price shock are statistically significant for each country with 95 per cent confidence bounds around each orthogonalised impulse response, which makes sense from theoretical point of view. However, the effects of oil price shocks differ considerably across the four BRICs. For example, the reactions of stock prices to oil price shocks in both Brazil and India are negative and appear highly persistent. In particular, they do not die off even after 20 months. This implies that oil price shocks have a significant and long-lasting effect on stock market performance. Further, the persistent nature of the responses suggest that the authorities of these emerging markets should take measures to remove the unfavourable effects of oil shocks on stock market performance. This is in line with the findings of Basher and Sadorsky (2006), who have analysed the impact of oil price changes on a large set of emerging stock market returns for the period 1992 to 2005. They propose that emerging economies are less able to reduce oil consumption, are more energy intense, and more exposed to oil price shocks than developed economies. Therefore, oil price changes are likely to have a greater impact on profits and stock prices in emerging economies.[14]

The impulse-response functions depicted in Figure 3 suggest that stock prices react positively to oil price shocks in China. Although this positive response is relatively slow, it seems permanent. Interestingly, stock prices in Russia initially respond positively to oil price shocks. However, after 4 months, the response becomes negative. This negative response is at its highest one year after the shock. However, after this it starts to decline. We also observe that stock prices react faster to oil price shocks in India and Russia than in Brazil and China. The figures also show that the effects of oil price shocks on stock market performance are larger for Brazil and Russia than the other two countries. In particular, this difference seems most pronounced 9 months after the oil price shock. Overall, the impulse-response functions indicate that stock prices respond significantly to oil price shocks in all of the BRICs. However, the effects of oil price shocks are asymmetric across the economies.

Although the main focus of this paper is to assess the effects of oil price shocks on stock prices, it is useful to look at the response of some of the other variables to oil price shocks. In particular, we observe the response of exchange rates, interest rates, and industrial production.[15] Similar to the case of stock prices, the responses of these variables are asymmetric across all four countries. The results suggest that the effects of oil price shocks on exchange rates are negative for Brazil and China, but positive in case of India. Nevertheless, the effects seem highly persistent and do not die off over the examined horizons for either India or China. In contrast, the response of the exchange rate in Brazil declines over the time and then almost completely dies off at a 20-month horizon. In the case of Russia, the impulse-response function of the exchange rate indicates an initial negative effect of oil price shocks on exchange rates (up to 8-months), then turning positive, but then dying off quickly.

The response of interest rates to oil price shocks is also asymmetric across the BRICs. In particular, the reaction of interest rates to oil price shocks in Brazil is negative up to three periods; however, after this it turns positive. On the other hand, in India and Russia, the interest rate reacts to oil price shocks negatively initially, then positively, but then it again responds negatively. In contrast to these cases, the reaction of the interest rate to oil price shocks is positive throughout the time horizon in the case of China. These responses are in line with theoretical expectations. It is also worth noting that the effects of oil price shocks on interest rates are smaller than the effects of oil price shocks on both stock prices and exchange rates. The results also suggest that the response of industrial production to oil price shocks is negative throughout the time horizon for India, whereas for China and Russia, the response of industrial production to oil price shocks is positive and statistically significant, but then it turns negative, suggesting that the impacts of oil price shocks on industrial production change over time.

Overall, we consider our results to be satisfactory. The impulse-response functions obtained are generally accurate and make sense from an economic point of view. We also think that we obtain consensual evidence on the impact of oil price shocks on stock price in the BRICs. Nevertheless, our empirical findings are naturally not free from problems. In particular, the results we present here could be improved by including more macroeconomic-level variables into the dataset. Country-specific-microeconomic-level variables could also be considered. Other econometric instruments such as variance decomposition could also be applied for a better and more precise interpretation of the results and for comparative purposes.

5. Conclusions and Policy Implications

There has been much interest in the recent energy economics literature on the response of stock prices to oil price/production shocks. Most prior studies have examined this issue within vector autoregression (VAR) frameworks. However, the documented findings are mixed at best. One question arises over whether the estimates of the response of stock prices to oil price shocks based on small-scale VAR models suffer from omitted information problems, as such models allow researchers to include only a limited number of variables in the specification. Another question of interest is whether the response of stock prices to oil shocks differs across emerging and rapidly growing countries. This paper aims at providing initial answers to these questions.

Specifically, to overcome the problem of omitted information in small-scale vector autoregression (VAR) models, in the present paper we combines the VAR methodology with dynamic factor analysis and examine the response of stock prices to oil shocks for four selected emerging economies, namely the BRICs of Brazil, China, India, and Russia. Our empirical analysis covers the period

January 1991–March 2011. We use a dataset that involves three common world oil market indicators, major currencies exchange rates, world CPI, gold prices, and percentage change in GDP of both world and emerging economies. In addition, we also take into account several country-specific variables, such as interest rates, consumer and producer price indices, exports and imports, and industrial production, for each country when estimating the response of stock prices to oil price shocks.

Using the factor augmented vector autoregressive (FAVAR) approach proposed by Bernanke *et al* (2005), we extract two factors which are significantly related to a large set of world-level and country-specific macroeconomic variables. We use the extracted factors as regressors in recursive VARs to assess the response of stock prices to oil price shocks. Unlike the standard VAR model, the FAVAR approach allows us to include larger dimensional datasets.

Our results suggest that the impulse responses of stock prices to oil price shocks are persistent and accurate, but asymmetric across the four BRICs. Specifically, we observe that stock prices in Brazil and India respond negatively to oil price shocks, whereas the response of stock prices to oil price shocks in China is positive. We also observe that stock prices in Russia initially respond positively, however, the response becomes negative after four months. Finally, the impulse response results reveal that the impact of oil price shocks on stock prices is smaller for China than for the other three countries. Overall, the FAVAR approach allows us to obtain more coherent evidence on the effects of oil price shocks on stock prices by obtaining relatively more precise responses and by increasing the understanding of such shocks from a theoretical point of view.

Accepted for publication: 22 July 2017

Appendix A: Description of the Dataset

The variables used in this study are obtained from the International Monetary Fund (IMF), except energy-related variables which are obtained from the US Energy Information Agency (EIA). All nominal prices are deflated using US-CPI: all urban, all products. Transformation to stationarity has been based on unit root test results. The Tcode column show the transformation method used for each variable, where; 1- at level, 2- log of level, 3- first difference of logs, 4- first difference of level.

Table 6: Dataset Description

No.	*Series Title*	*Unit*	*Tcode*
World macroeconomic factor			
1	Gold Price	US Dollars per onze	3
2	Total Crude Oil Stocks	Million Barrels	3
3	Crude Oil Production, World	Thousand Barrels per Day	3
4	Consumer Price Indices, World	Index	3
5	GDP Volume, % Change, for Emerging & Developing Economies	Per cent	3

6	GDP Volume, % Change, World	Per cent	3
7	Japanese Yen in terms of US Dollars	YEN/USD	3
8	Great Britain Pounds in terms of US Dollars	GB/USD	3
9	Australian Dollar in terms of US Dollars	AUD/USD	3
Country specific factor			
India			
10	National CPI	Index	3
11	Exchange rate	National Currency per US Dollars	3
12	Interest rate	Per cent per Annum	1
13	Share price	Index	3
14	Industrial production	Index	3
15	Producer price index (PPI)	Index	3
16	Total imports	Millions US Dollars	3
17	Total exports	Millions US Dollars	3
18	Foreign exchange		3
Brazil			
19	National CPI	Index	3
20	Exchange rate	National Currency per US Dollars	3
21	Interest rate	Per cent per Annum	4
22	Share price	Index	3
23	Industrial production	Index	3
24	Producer prices	Index	3
25	Total imports	Millions US Dollars	3
26	Total exports	Millions US Dollars	3
27	Foreign exchange	Millions US Dollars	3
China			
28	National CPI	Index	2
29	Exchange rate	National Currency per US Dollars	3
30	Interest rate	Per cent per Annum	4
31	Share price	Index	3
32	Industrial production	Index	3
33	Producer prices	Index	3
34	Total imports	Millions US Dollars	3
35	Total exports	Millions US Dollars	3
36	Foreign exchange	Millions US Dollars	3
Russia			
37	National CPI	Index	3
38	Exchange rate	National Currency per US Dollars	3
39	Interest rate	Per cent per Annum	4
40	Share prices	Index	3
41	Industrial production	Index	3
42	Producer price	Index	2
43	Total imports	Millions US Dollars	3
44	Total exports	Millions US Dollars	3
45	Foreign exchange	Millions US Dollars	3

Endnotes

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2. Wang *et al* (2013) argue that the magnitude, duration, and even direction of response by stock market returns to oil market shocks in a country depends on whether the country is a net importer or exporter in the world oil market.

3. For more information, see Ciner (2001), Nandha and Faff (2008), Miller and Ratti (2009), Chen (2010) and Filis (2010).

4. Several other studies, such as Ciner (2001), Nandha and Faff (2008), Miller and Ratti (2009), Chen (2010) and Filis (2010), have also shown a negative relationship between oil prices and stock returns.

5. The Gulf Cooperation Council (GCC) is an organisation of six oil-exporting countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates. It was formed in 1981 to foster economic, scientific and business cooperation among them.

6. Boivin and Giannoni (2008) and Mumtaz and Surico (2009) extended the econometric framework to include international factors.

7. The list of world and domestic variables used to extract factors are provided in Appendix A.

8. The principal component estimation allows for cross-correlation of the error terms that must vanish as N goes to infinity (Stock and Watson 2002a).

9. The sample for Russia runs from January 1998 to March 2011.

10. The industrial production index for Brazil is not available.

11. The complete list of the series, the sources and the choice of filtering are reported in Table 6 in Appendix A.

12. Primary stocks encompass crude oil stocks in refining and storage facilities of the industry, such as crude oil in export and import terminals, in distribution terminals, in refinery columns, and in specific large storage facilities.

13. Correlation estimates are not provided here to economise on space, but they are available from the authors on request.

14. A negative effect of positive oil price shocks on stock market returns has been confirmed by a number of authors for oil importing countries. Jiménez-Rodriguez and Sánchez (2005) argue that the negative effects for oil importing countries are reinforced because of intensive trade connections. M'henni *et al* (2011) have also found that large oil price changes have a positive impact on stock returns in oil-exporting countries.

15. Since data on the industrial production index for Brazil are not available, we observe the response of oil price instead of industrial production.

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