Central European Journal of Operations Research (2020) 28:1315–1342
https://doi.org/10.1007/s10100-019-00647-8

S.I.: OR FOR SUSTAINABLE DEVELOPMENT

Oil prices and economic activity in BRICS and G7 countries

Erdem Kilic[1] · **Serkan Cankaya**[2]

Published online: 29 August 2019

Abstract

The effect of oil prices on countries' economic activity has been the center of attention for decades. The empirical link between oil prices and economic activity has been steadily investigated during this time period but the measured outcomes have revealed mixed results and been inconsistent. This study examines the effect of oil prices on economic activity for Brazil, Russia, India, China, and South Africa (BRICS) and Group of Seven (G7) countries in both short-run and long-run relationships by estimating a maximum likelihood structural vector autoregression model. The model shows that a positive shock to oil prices tends to affect the monetary aggregate in Brazil, Canada, France, Germany, and Russia. The effect on interest rate spread is most significant in India and Russia. Impulse response functions display almost no effect on the gross domestic product in the US and China. A positive response on the consumer price index is observed mostly for developed countries. The response of real exchange rate reveals a positive effect on all countries in varying degrees, with the exception of the US and South Africa. Finally, Granger causality tests were conducted with proper allowance for the non-stationarity of the data. The findings illustrate that the Russian economy is among the economies that are most significantly affected by oil price fluctuations for almost all the selected variables. The models also reveal that the effect of oil price shocks on the US's and China's economic activities is only limited to the effect on real exchange rates. Other variables show no or limited reactions to oil prices. We also used the Markov switching maximum likelihood vector autoregression models, which reveals similar results.

Keywords Oil price shocks · Macroeconomic fluctuations · Structural vectorautoregression model (SVAR) · Markov switching model (MS VAR)

✉ Erdem Kilic
kilice@mef.edu.tr

1 MEF University, Istanbul, Turkey

2 Istanbul Commerce University, Istanbul, Turkey

1 Introduction

The relationship between oil prices and the macroeconomy has been the center of attention for decades. The decline in oil prices over the last few years has generated renewed interest in this ongoing debate. Some argue that oil prices have a major effect on macroeconomic asymmetries, whereas others argue that oil prices no longer have that kind of power over macroeconomic activity due to changes in countries' economic structures. Several academic studies have been conducted to assess this connection. Some studies choose multiple variables that are believed to represent the macroeconomy in general, such as inflation, exchange rates, industrial production, interest rates, and the monetary aggregate or gross domestic product (GDP). Alternatively, studies choose to focus on a single variable such as stock market activities. Another distinction among studies is the country set that is selected. The US has been the center of most of the research in the last century; other developed nations are followed in individual capacity or in the form of well-known groupings such as G7. In recent times, emerging stock markets have been given much importance.

In this paper, we examine the effects of oil prices on economic activity for BRICS and G7 countries in both short-run and long-run relationships by estimating vector autoregression models. We robustified our results by implementing Markov switching vector autoregession models (MS VAR) using the same variables and motivation. We aimed to create a combined structure by using selected macroeconomic indicator variables and included both developed and developing nations in the analysis. One of our main objectives was to identify the major differences in oil price effects between developed economies and emerging economies. Different countries present varying macroeconomic characteristics with regard to oil price shocks. The level of economic development undoubtedly plays a significant role; however, we believe that other factors such as the country's oil-importing versus oil-exporting status, should be included in the analysis. Wang et al. (2019) investigated the relation between oil prices and the stock markets of oil-importing and oil-exporting countries. The results showed that there is a strong link between the two based on whether the country is an oil importer or exporter. Another finding of this study was on the level of importance of oil to the national economy and that the driving forces of oil price changes played an important role. Furthermore, the effects of aggregate demand uncertainty on stock markets in oil-exporting countries were found to be more robust than that of oil-importing countries. In the present study, we analyze the effects of oil price shocks on selected macroeconomic indicators for G7 and BRICS countries between 1993 and 2016. We have compared the developed nations' economic activity dynamics with that of five major emerging economies.

The acronym "BRIC" was first used in 2001 by Goldman Sachs in a paper in which it was projected that Brazil, Russia, India, and China would be among the largest economies in the world in the next 50 years. The formal gathering of the countries took place in 2006, and in 2009, South Africa joined the group. BRICS represent 43% of world population, 30% of world GDP, and 17% of world trade. G7 countries comprise 10% of the world population, 39% of world GDP, and 32% of world trade. The OPEC World Oil Outlook 2016 report states that there will be significant changes in the distribution of the global economic pie. As the power behind world economic

Table 1 Oil consumption of BRICS and G7 countries

Oil consumption (1000 barrels daily)	1993	2016	Growth (%)	Share of total 1990 (%)	Share of total 2016 (%)
Brazil	1589	3018	89.93	2.35	3.13
Russia	3928	3203	− 18.46	5.81	3.32
India	1313	4489	241.89	1.94	4.65
China	3013	12,381	310.92	4.46	12.82
South Africa	376	560	48.94	0.56	0.58
BRICS total	10,219	23,651	131.44	15.11	24.49
Canada	1697	2343	38.07	2.51	2.43
France	1926	1602	− 16.82	2.85	1.66
Germany	2881	2394	− 16.90	4.26	2.48
Italy	1906	1232	− 35.36	2.82	1.28
Japan	5367	4037	− 24.78	7.94	4.18
UK	1789	1597	− 10.73	2.65	1.65
USA	17,236	19,631	13.98	25.49	20.33
G7 total	32,802	32,836	0.10	48.52	34
Total BRICS and G7	43,021	56,487	31.30	63.63	59
Total world	67,609	96,558	42.82	100	100

Data is obtained from BP Statistical Review of World Energy, 2017

growth changes, the demand for energy will eventually follow. Table 1 presents the change in oil consumption of BRICS and G7 countries between 1993 and 2016. In 1990, 15% of world oil consumption was by BRICS countries, and by 2016, this figure had increased to 25%. During this period, the share of G7 oil consumption decreased to 34% from 48%. On a country basis, the most significant increase is observed in China, which showed a 439% increase in oil consumption. The only exception in BRICS countries is Russia's performance of 36%. All G7 countries, with the exception of Canada and the US, showed negative growth performance from 1990 to 2016. We believe that as emerging economies continue growing, they will gain a larger influence on the world economy. We aim to contribute to academic literature by not only focusing on developed nations but also including developing countries by employing a comparative perspective.

To understand the relation between oil price shocks and economic activity, the empirical literature needs to be observed carefully. Several studies show that the relation between oil prices and economic activity has diminished (Tang et al. 2010; Naccache 2010; Alvarez-Ramirez et al. 2010).

Numerous scholars have explored oil price dynamics, and several analytical methods have been used to understand the pricing structure in oil markets.[1] Studies have revealed that there have been differing policy responses among countries with regard to oil market uncertainties over time (Hooker 1996; Hamilton 1996; Ratti and Vespig-

[1] See Leopold, (2016) for a comprehensive literature survey about supply chain management of oil utilization.

nani 2013b). Ratti and Vespignani (2013b) found a dramatic influence of oil prices on commodity markets in BRICS countries. Studies have revealed that the short-run and long-run dynamics display different patterns. In the short run, oil prices and the economy exhibit an asymmetric relationship (Lee et al. 1995; Huang et al. 2005; Rahman and Serletis 2010; Alvarez-Ramirez et al. 2010). Another stream of research revealed that depending on the selected country or time period, the causality between oil prices and economic growth is unclear (Narayan and Smyth 2007; Cologni and Manera 2009; Benhmad 2012; Ratti and Vespignani 2013a). A recent study by Ratti and Vespignani (2016) also confirms that money and industrial production and processes are cointegrated by employing a global factor-augmented error correction model. Further, their study proposes an answer to the question "which economies drive the global economy?" The first finding confirms China's place as one of the major players in the world economy. They found that the interest rate in the China Granger impacts the global interest rate and vice versa at all lag lengths. Their results indicate that the US and China have the most extensive influence on global variables of interest rate, liquidity, industrial production, and consumer prices. In terms of Granger causality, the US and China effect the global interest rate, global M2, global industrial production, and global CPI. The Euro area influences the global interest rate, industrial production, and CPI. Japan affects global M2 and industrial production. India affects global industrial production and CPI. In summary, all five economies influence global industrial production, and there is a degree of linkage between China and the global economy that is similar to the connection between the global economy and the US, the Euro area, or Japan. Tiwari (2013) applies a continuous wavelet model to analyze the relationship between the oil price returns, inflation rate, and industrial production in the German economy. The results show that in 1978–1990, 1991–1994, and 2004–2009, there is a phase relationship, indicating positive covariance between oil price returns and inflation, and oil price returns is the leading variable. However, in 1994–2004, the phase difference is an anti-phase relationship, indicating negative covariance between oil price returns and inflation, and inflation is the leading variable. Wang et al. (2019) implemented a regime-switching model to identify the effects of price regulations on China's macroeconomy in different price regimes. They found that price regulations can reduce oil price volatility and can contribute to reducing macroeconomic volatility but is more effective in a mild-fluctuation regime. Bjørnland et al. (2018) analyzed the role of oil price volatility in reducing US macroeconomic instability. Interestingly, oil price shocks are recurrent sources of economic fluctuations. The most important factor reducing overall variability is a decline in the volatility of structural macroeconomic shocks; a change to a more responsive monetary policy regime also played a role. Considering a panel of 120 countries between 1980 and 2013, Antonietti and Fontini (2019) used cointegration analysis to show that oil price and energy consumption for economic activities are linked by a mutual relationship in the long-run. Although there is a clear effect of oil price on energy consumption for all countries, the analysis revealed that the opposite effect (i.e., of energy consumption on oil price) occurs for some countries.

The next section describes the data and the methodology. Section 3 presents the main empirical results of the paper. The concluding remarks are discussed in Sect. 4.

Table 2 Bai–Perron test of multiple structural breakpoints

Break test	F-statistics	Critical value
Sup F(1|0)	3.0788	8.58
Sup F(2|1)	3.12625	10.13
Sup F(3|2)	0.500680	11.14
Sup F(4|3)	0.48713	11.83

All values are significant at the 0.05 level

2 Data and methodology

In this section, we introduce the data and methodology used to study oil price effects on macroeconomic variables. We present the estimation procedure used to implement our estimation methods in the context of oil price movements and macroeconomic activity. We applied structural vector autoregession models and robustified our results by implementing Markov switching models.

2.1 Data description

The data spans the period from January 1993 to January 2016 on a quarterly basis for 12 countries: Brazil, Canada, China, France, Germany, India, Italy, Japan, Russia, South Africa, United Kingdom, and the US. The data sources are Haver Analytics, Economic Monitor, and World Bank Database. The sample period was motivated by an empirical effort to analyze long-run and short-run oil price effects across different countries. The selected time period incorporates many crises and oil price changes. These changes, including massive oil price changes, are identified by the Bai–Perron tests (see Table 2).

The choice of variables is based on macroeconomic activity and their ability to determine the general equilibrium in the economy motivated by IS-LM and AS-AD models. From this perspective, we were able to observe the effects of oil price dynamics on general macroeconomic activity. Using these theoretical relationships, certain outcomes can be predicted, especially the increasing effects on the price level of a positive oil price shock.

Besides crude oil prices, our data sample contains major macroeconomic activity variables including interest rate spread derived from domestic short-term 3-month interest rates as the difference of lagged interest rates spread, $i_t - i_{t-1}$, consumer price index, GDP, monetary aggregate M1, and real exchange rate (indirect quotation). The variables are expressed in logarithmic returns except for interest rates, which are introduced in the form of differentials. The descriptive statistics for the included variables are reported in Table 5 of "Appendix".

The unit roots in the logarithms of the studied variables are tested within least-square estimation using unit root tests: Philips–Perron (PP) in Eq. (1) as given in Phillips and Perron (1988) and Augmented Dickey–Fuller (ADF) in Eq. (2) as described in Greene (2012).

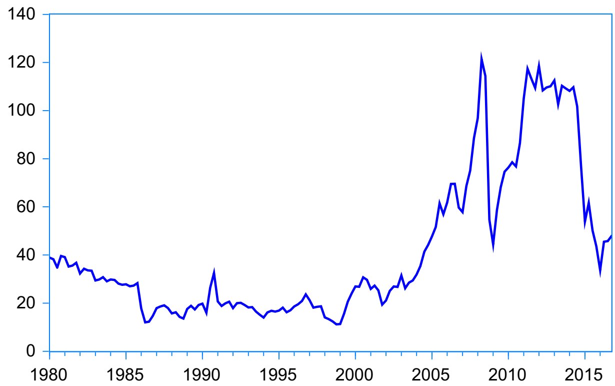

Fig. 1 Crude oil price measured in USD during 1990–2016

$$\Delta y_t = \alpha + \gamma y_{t-1} + \varepsilon_t \tag{1}$$

$$\Delta y_t = \alpha + \gamma y_{t-1} + \sum_{j=1}^{p} (\delta_j \Delta y_{t-j}) + \varepsilon_t \tag{2}$$

where, y_t denotes independent and also the dependent variable in period t, $\triangle y_t$ is the first difference of y_t for two subsequent periods α, γ and δ are the regression coefficients, j and p describe the index for the differences of y_t in the past periods, and ϵ_t shows the error term in the regression. In Table 6 of "Appendix", the test results of the unit roots tests reject the unit root hypothesis in first difference form without a trend.

As observed in Fig. 1, the crude oil price has experienced several structural breakpoints, resulting in highly volatile periods during the analysis period. We applied the Bai–Perron test to identify potential structural breaks in the oil prices (Bai and Perron 1998). The applied estimation method for detecting multiple breaks in time series data is based on a global optimization procedure, where the sum of squared residuals of an auxiliary regression are minimized. The null hypothesis that there are a certain number of breaks beginning from a single break was tested versus the alternative that there is no break until the null hypothesis is rejected. Some related alternative tests for stationarity and structural breaks can be found in recent research on energy markets (Apergis et al. 2010; Hasanov and Telatar 2011; Mishra and Smyth 2014). The results for the Bai–Perron SupF(L + 1|L) test presented in Table 2 reveal four structural breaks. The related break dates are estimated as 1999Q1, 2004Q1, 2008Q3, and 2013Q1. These breakpoints were used to construct a dummy series to capture the outliers indicating turbulent periods and crises in the crude oil price.

2.2 VAR model frameworks

We applied a vector autoregession model approach because contemporaneous effects can be captured in a multivariate estimation by building a simultaneous equations model, where empirical estimation results can be found. Further, exogenous and endogenous variables can be modeled explicitly, policy evaluations can be made, and a lag order of the independent variables can be specified. In the proposed methodology, we perceived oil price dynamics as endogenous in the economic framework. This treatment enabled us to determine the effect of oil price on the involved macroeconomic variables accurately. We specify a structural vector autoregression model (VAR) to show the relation between oil prices and macroeconomic variables. To achieve identification and to formulate our research interest, we imposed restrictions into the model by making use of structural innovations. The VAR methodology in Eq. (3) estimated by maximum likelihood as described in Hamilton (1994) contains all related variables, namely, interest rate spread, consumer price index, GDP, monetary aggregate M1, and real exchange rate as indicated by X. In addition, we introduced a dummy variable into the VAR model to account for structural breakpoints, which are indicated by d.

$$\Delta X_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta X_{t-1} + d_t + e_t \tag{3}$$

where, X_t denotes the independent and also the dependent variable in period t, $\triangle X_t$ is the first difference of X_t for two subsequent periods, α and β are the regression coefficients, i and p describe the index for differences of X_t in the past periods, e_t shows the error term in the regression, and d_t is a binary variable, indicating structural breakpoints for the relevant periods.

To achieve a specification and identification of a short-run relationship, we assume restrictions on B_0^{-1} in $e_t = B_0^{-1}\varepsilon_t$ that the structural innovations follow the structure, such as:

$$\begin{bmatrix} e^{oil} \\ e^{REER} \\ e^{price} \\ e^{GDP} \\ e^{ir\_spread} \\ e^{M} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 \\ b_{61} & 0 & b_{63} & 0 & b_{65} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon^{oil} \\ \varepsilon^{REER} \\ \varepsilon^{price} \\ \varepsilon^{GDP} \\ \varepsilon^{ir\_spread} \\ \varepsilon^{M} \end{bmatrix}. \tag{4}$$

The structural impulse response based on B_0^{-1} are responses to one-standard deviation shocks. Oil price shocks are expected not to respond to other shocks, whereas all other shocks respond to oil price shocks.[2] The remaining shocks follow a decreasing order of exogeneity. The indexes i and t indicate the order of different independent variables and the periods on a monthly basis.

In addition to the VAR model, the vector error-correction (VEC) model contains the error-correction term that captures the long-term cointegrated relationship between all the variables. The applied VEC Model is described by Eq. (5) as given in Pesaran and Smith, (2000):

[2] Compare Kilian (2008) for similar identification scheme.

$$\Delta X_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta X_{t-i} + \delta EC_{t-1} + d_t + e_t . \tag{5}$$

where X_t denotes the independent and also the dependent variable in period t, $\triangle X_t$ is the first difference of X_t for two subsequent periods, α, β and δ are the regression coefficients, i and p describe the index for differences of X_t in the past periods, EC_t indicates the error correction term,e_t shows the error term in the regression, and d_t is a binary variable indicating structural breakpoints fro the relevant periods. For the construction of the VEC model augmented by the dummy variable, we used Pesaran et al.'s (2000) approach and applied two tests about the presence of a cointegrating relationship: trace statistics and the maximum eigenvalue statistics. The related results are reported in Table 3. The results suggest rejecting the null hypothesis of no cointegration relationship among the model variables at a 5% significance level. As a pattern in the result, it can be stated that G7 countries have a lower number of lags (1–2) in the cointegrating relationships than the BRICS countries (2–4). The number of cointegrating vectors is nearly identical, with the exception of the US and Russia. We considered potential causality of oil price shocks on the analyzed macroeconomic variables by the application of Granger causality tests in Table 4.

2.3 MS VAR frameworks

We applied Markov switching vector autoregression models (MS VAR) in order to compare our previous findings with an alternative estimation technique. The application of MS VAR allowed the analysis of macroeconomic dynamics under different states or regimes in the economy through explicitly modeling the interaction of macroeconomic variables. Because macroeconomic activity is characterized by business cycles, a changing variance should build a profound model specification to capture such dynamics. In other words, asymmetries and nonlinearities in economic activity can be modeled in this way. The use of MS VAR in a macroeconomic context started with the pioneering work of Hamilton (1989). For a detailed description of MS VAR estimation using macroeconomic variables, compare Artis et al. (2004), Boldin (1996), Filardo (1994), Goodwin (1993), and Krolzig (1996). An identification of oil price effect nonlinearities on the related macroeconomics variables was established using Markov switching models. The maximum likelihood implemented model specification is given in Eqs. (6) and (7).

$$Y_t = \sum_{i=1}^{p} C_{i,S_t} \bigotimes X_{t-1} + \sum_{j=1}^{q} \beta_j X_{t-1} + \varepsilon_t$$

$$\varepsilon_t \sim N\left(0, \Sigma_{S_t}\right) \tag{6}$$

$$\Sigma_{S_t} = \begin{pmatrix} \sigma^2_{1,S_t} & \sigma_{1,2,S_t} \\ \sigma_{1,2,S_t} & \sigma^2_{2,S_t} \end{pmatrix} \tag{7}$$

where X_t denotes the independent variable in period t, the Y_t denotes the dependent variable in period t, β are regression coefficients, p and q describe the index for values

Table 3 Cointegration analysis

		Canada	France	Germany	Italy	Japan	UK	USA
No. of lags		2	1	1	2	1	2	1
No. of cointegrating vectors		2	2	2	2	2	2	1
H_0	H_1	Trace statistics						
$r = 0$	$r = 1$	141.9683*	130.2157*	170.7506*	127.5170*	152.2600*	141.1529	216.5093*
$r \leq 1$	$r = 2$	91.0310*	86.7125*	105.0332*	81.3120*	90.1073	80.2357	99.7261*
$r \leq 2$	$r = 3$	48.7129	52.2849	59.6684	54.7811*	54.1664	47.8970	50.2020
$r \leq 3$	$r = 4$	14.2014	26.4674	30.3147	33.3415	25.9241	23.1728	14.6284
$r \leq 4$	$r = 5$	6.1408	8.8123	12.8564	15.5167	6.1676	6.4855	5.4660
$r \leq 5$	$r = 6$	1.2344	0.3385	4.6162	0.8464	0.1114	0.2624	0.1859
H_0	H_1	Max-eigenvalue statistics						
$r = 0$	$r = 1$	50.9372*	43.5030	65.7173*	46.2049*	62.1526*	60.9171	116.7832*
$r \leq 1$	$r = 2$	42.3180*	34.4276	45.3647*	26.5308	35.9408	32.3387	49.5241*
$r \leq 2$	$r = 3$	34.5115	25.8174	29.3536	21.4396	28.2423	24.7242	35.5735*
$r \leq 3$	$r = 4$	8.0605	17.6551	17.4583	17.8248	19.7564	16.6872	9.1623
$r \leq 4$	$r = 5$	4.9064	8.4737	8.2402	14.6703*	6.0562	6.2231	5.2801
$r \leq 5$	$r = 6$	1.2344	0.3385	4.6162	0.8464	0.1114	0.2624	0.1859

		Brazil	Russia	India	China	South Africa
No. of lags		2	4	3	3	3
No. of cointegrating vectors		2	3	2	2	2
H_0	H_1	Trace statistics				
$r = 0$	$r = 1$	141.9235*	148.3798*	144.1399*	373.1777*	160.6150*
$r \leq 1$	$r = 2$	90.2676*	95.6334*	92.4343*	101.3118*	94.7650*
$r \leq 2$	$r = 3$	56.0302*	55.2231*	48.9774	54.0095	49.4137
$r \leq 3$	$r = 4$	30.5935	23.8909	31.2867	18.2071	20.9394
$r \leq 4$	$r = 5$	10.1983	10.0759	13.8882	7.7581	8.3073
$r \leq 5$	$r = 6$	2.2197	3.0556	5.2484	1.3341	2.8667
H_0	H_1	Max-eigenvalue statistics				
$r = 0$	$r = 1$	51.6559*	52.7464*	51.7055*	271.8659*	65.8500*
$r \leq 1$	$r = 2$	34.2373*	40.4102*	43.4569*	47.3022*	45.3513*
$r \leq 2$	$r = 3$	25.4367	31.3321	17.6907	35.8024*	28.4742
$r \leq 3$	$r = 4$	20.3951	13.8150	17.3985	10.4490	12.6321
$r \leq 4$	$r = 5$	7.9786	7.0202	8.6397	6.4239	5.4405
$r \leq 5$	$r = 6$	2.2197	3.0556	5.2484	1.3341	2.8667

*Indicates significance at 1% level

of X_t in the past periods, e_t shows the error term in the regression, the parameter C gives the estimated state-dependent coefficients for switching variables, and $S_t = 1, 2$ is the state vector. $S = 1$ indicates a bull market with a positive trend in the variable

Table 4 Granger causality

Dependent variable	Oil price does not Granger cause M1			Oil price does not Granger cause IR spread			Oil price does not Granger cause GDP		
	χ^2	*df*	Prob.	χ^2	*df*	Prob.	χ^2	*df*	Prob.
Brazil	4.905	3	0.178	8.09	3	0.044	4.592	3	0.204
Canada	11.144	3	0.01	2.34	3	0.503	11.296	3	0.01
China	1.592	3	0.8102	1.821	4	0.768	1.0745	4	0.898
France	13.859	2	0.001	1.0317	2	0.597	2.0026	2	0.3674
Germany	4.752934	2	0.0929	4.680356	2	0.0963	0.909679	2	0.6345
Japan	6.233	2	0.0443	1.788709	2	0.4089	2.1450	2	0.3421
Italy	2.997928	3	0.3919	5.615902	3	0.1319	5.597320	3	0.1329
India	5.2236	4	0.2651	13.206	4	0.0103	7.81204	4	0.0987
Japan	6.233	2	0.0443	1.7887	2	0.4089	2.14503	2	0.3421
Russia	23.866	5	0.0002	17.1532	5	0.0042	36.415	5	0.0000
South Africa	0.034884	2	0.9827	3.4139	2	0.1814	6.2010	2	0.0450
UK	2.6722	3	0.445	5.3155	3	0.1501	10.42923	3	0.0152
USA	3.3723	2	0.1852	0.3643	2	0.8334	1.388035	2	0.4996

Dependent variable	Oil price does not Granger cause CPI			Oil price does not Granger cause REER		
	χ^2	*df*	Prob.	χ^2	*df*	Prob.
Brazil	0.73	3	0.864	0.89	3	0.827
Canada	12.313	3	0.0102	12.313	3	0.0006
China	8.819	4	0.0658	11.174	4	0.0247
France	0.56	2	0.75	1.942	2	0.378
Germany	10.00247	2	0.0067	3.459039	2	0.1774
Japan	1.5274	2	0.4659	2.58003	2	0.2753
Italy	0.389530	3	0.9424	20.19239	3	0.0002
India	1.856485	4	0.7621	6.1982	4	0.1848
Japan	1.5274	2	0.4659	2.5800	2	0.2753
Russia	8.7389	5	0.1199	13.40522	5	0.0199
South Africa	3.6833	2	0.1586	5.4976	2	0.0640
UK	18.85	3	0.003	1.19942	3	0.7531
USA	6.01485	2	0.0494	5.1515	2	0.0761

return $S = 2$ indicates a bear market with a negative trend in the variable return.[3] The indicies i, j and t indicate the order of different switching and non-switching independent variables and further the time periods on a monthly basis. The switching variables are chosen as the constant intercept and the logarithmic difference of the oil price returns. The remaining macroeconomic variables are chosen as non-switching variables in the MS VAR models. We assume regime-varying variance as given in Eq. (7) because volatility in boom periods is presumed to be different from volatility

[3] Alternatively, we applied 3-state MS VAR models. Similar results were obtained, revealing significant oil price effects on the related model variables. The results are available on request.

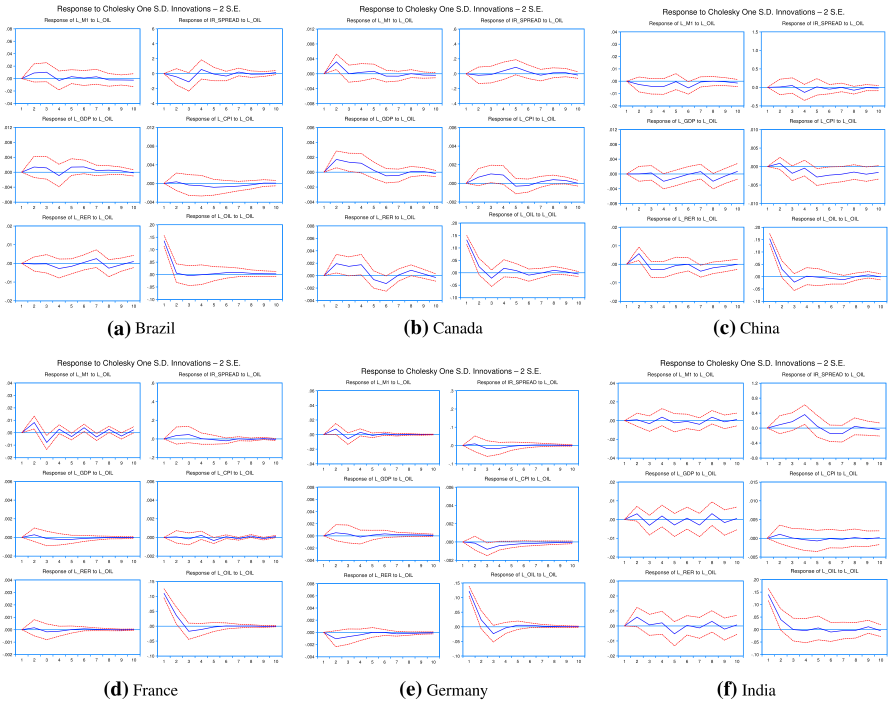

Fig. 2 Impulse response functions of each country to an oil price shock with median response confidence levels in **a**–**l**

in economic slowdown periods. The elements in the first column indicate the variance in the first state and the second element in the first column a shift from the first to the second state. The elements in the second column indicate the variance in the second state and the second element in the second column indicates a shift from the second to the first state.

The smoothed probabilities of the state-dependent regime switches are given in Eq. (8) as described by Hamilton (1989):

$$P(S_t = i|Z^T; \theta) \tag{8}$$

where θ is the estimated parameter vector, the Z vector represents the independent model variables, and $S_t = 1, 2$ is the state vector as defined in Eq. (7). In Tables 7a, b, 8a, b, 9a, b, 10a, b, 11a, b and 12a, b of "Appendix",the results are presented for the related data sample as per monthly basis.

3 Empirical analysis

We first present the empirical estimation results from the VAR models. Our analysis provides short-run and long-run perspectives. The impulse responses based on the

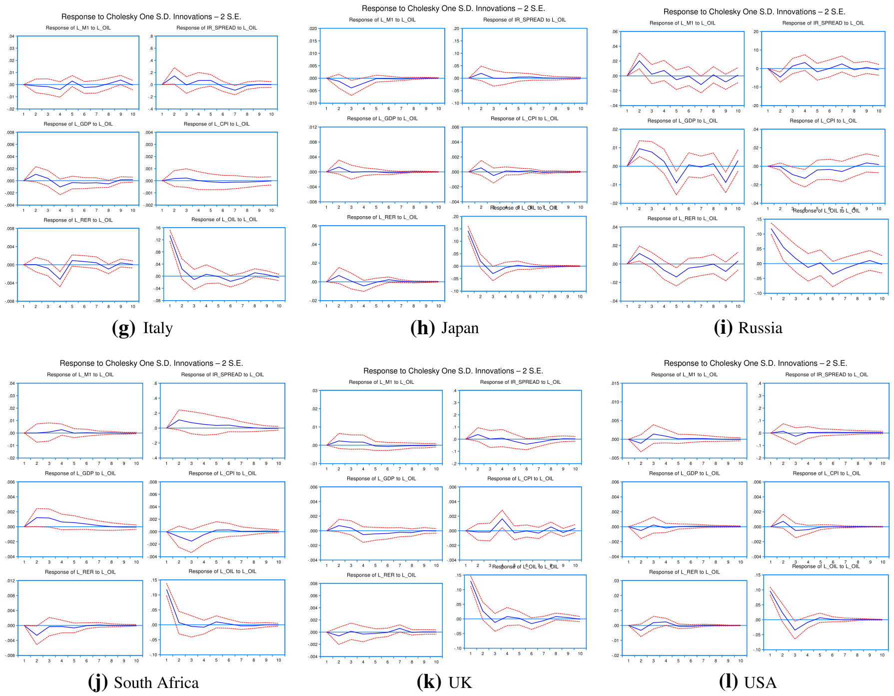

Fig. 2 continued

models in Sect. 2.2 are presented in the subsections below. The impulse responses of monetary aggregate, consumer price index, GDP, interest rate, and real exchange rate to oil price shock are presented in Fig. 2a–l. The impulse response figures show the effect of an oil price shock as a response of the mentioned variables to an orthogonalized one-standard deviation innovation set (see Pesaran and Shin 1998). The impulse response functions capture the effect of a one-time oil price shock to one of the innovations on the endogenous variables. This means that an oil price shock is transmitted to all the other endogenous variables through the dynamic lag structure of the VAR. The 95% confidence intervals are presented by short-dashed lines.

The impulse response of an oil price shock to M1 causes an increase in monetary aggregate M1 for one quarter in Canada, France, Germany, Russia, and the UK. A relatively stronger three-quarter positive effect is observed in Brazil. In contrast, Japan, China, and Italy show a strong negative response. The remaining countries show a weak response in the short-run. These results resemble those of Japan, France, Germany, the UK, and Canada in Cologni and Manera's work (2009).

The effect on interest rate spread reveals an increase for one quarter in France, Italy, Japan, South Africa, and the UK. The strongest effect is found in India by two quarters. Canada, China, Germany, and the US present almost no response. Relatively stronger responses are identified for Russia and Brazil.

Except for the US and China, the countries in the analysis give a positive response to an oil price shock on GDP in varying degrees. Russia and Canada show the strongest one-quarter positive response followed by Brazil, Italy, and India with slightly weaker one-quarter responses. France, Germany, Japan, South Africa, and the UK show a marginally positive response. The responses in developed economies, especially in the case of the US, are consistent with Hooker's findings (Hooker (1996)). Oil price shock effects after the OPEC price shock in 1979 had a significant effect but were internalized and became endogenous to the economies of the developed countries. In addition, Narayan and Smyth (2007) observe that shocks to per capita energy consumption are fleeting or transitory, which implies that following a global oil price shock, per capita energy consumption will return to its original equilibrium over a short period of time.

Oil price effects on CPI can be classified according to the following patterns. A one-quarter slightly positive effect can be observed for Brazil, China, France, Germany, Italy, Russia, and the UK. Positive responses are found for India, Japan, Canada, and the US, where the effects for Canada and the US are comparatively stronger. The only two-quarter response is examined for South Africa. These results are supported by Ratti and Vespignani (2016) who observed a global increase in interest rate, money stock, and CPI. Cologni and Manera (2009) observed an instantaneous response of inflation rate to an oil price shock for most G7 countries.

Considering the responses of real exchange rate, Canada, China, India, and Russia reveal a one-quarter positive response. France, Japan, Germany, Italy, the UK, and Brazil reveal a comparably stable effect. In contrast, the US and South Africa show a negative effect. The results for China and India should be seen from the perspective of long-run depreciation resulting from terms of trade effects.

When we analyzed long-run VEC model results, we observed a long-run cointegrating relationship among the variables. The detailed results of the cointegration framework can be found in Table 3. Trace statistics and max-eigenvalue statistics reveal the number of cointegrating vectors for all countries included in the analysis.

In sequel, we present the results obtained from the MS VAR models and compare these to the VAR model results. The results from the MS VAR models are presented in Tables 7a, b, 8a, b, 9a, b, 10a, b, 11a, b and 12a, b of "Appendix". The most affected variables are interest rate spread, real exchange rate, and CPI throughout the data sample. Monetary variables are more sensitive to oil price shocks. This is a reasonable result when considering that monetary authorities react with better designed policies to deal with oil price shocks (see Cologni and Manera 2009). Therefore, it turns out that monetary variables show significant response to oil price dynamics. When we compare these results with those from the VAR model, we can observe the following. The MS VAR models in the case of the real exchange rate support the VAR results for Brazil, Canada, France, Germany, Italy, Japan, Russia, and the US. In these results, oil price induces a significant effect on the real exchange rate by creating a state-dependent regime switch of the real exchange rate. Concerning the CPI, Brazil, China, Germany, Italy, India, France, the UK, and the US, the VAR results support the findings about oil price effects in the same way. In the case of the monetary policy variable M1, the results for Germany, Italy, France, and the UK are consistent with the VAR results. We can observe that for MS VAR models in the case of GDP, China, France, India, Japan, South Africa, the UK, and the US, the VAR results support the results. Similarly, the results for the interest rate spread are consistent with the VAR results for Italy, India, Japan, France, South Africa, and the UK.

4 Conclusion

This study aimed to contribute to the literature by comparing the effect of oil prices on economic activity for the BRICS countries and G7 countries in both short-run and long-run relationships by estimating structural vector autoregression models and Markov switching vector autoregression models. We empirically explored the short-run and long-run relationship between oil prices and selected macroeconomic variables-short term interest rate, consumer price index, GDP, monetary aggregate M1, and real exchange rate for developed and developing nations-by using the mentioned vector autoregressive models. The results indicate that oil price shocks have varying reaction characteristics for different countries and time periods. Significant oil price effects can be seen in both type of models on the presented monetary macroeconomic variables. In particular, a positive effect on monetary aggregate is observed for Brazil, Canada, France, Germany, Russia, and the UK. Japan, China, and Italy revealed a negative effect. From the Markov switching model, it can be seen that monetary policy variables are significantly sensitive to oil price movements. The effect on interest rate spread is most significant in India followed by France, Italy, Japan, South Africa, and the UK. Impulse response functions display almost no effect on GDP for the US or China. These results are also supported by Narayan and Smyth (2007), Cologni and Manera (2009), and Ratti and Vespignani (2013b): countries react more efficiently by monetary policy to counteract oil price effects on the their macroeconomic status. Almost all countries exhibit a positive response on CPI. The response of real exchange rate reveals a positive effect on all countries with varying degrees, with the exception of the US and South Africa. Furthermore, the long-run VEC model results reveal a cointegrating relationship among macroeconomic variables to oil price shocks as well. Finally, the findings illustrate that the exposure of the US's economic activity to oil prices seems to be limited. A clear pattern of differences in the macroeconomic variables for G7 and BRICS cannot be identified. Although there are certain exceptions generally in the VAR model results, the findings point to some relatively moderate overexposure of emerging nations to innovations on oil prices. Ratti and Vespignani (2013b) identify similar results concerning the higher sensitivity for BRICS countries to oil price movements compared with G3 countries. Developed nations reveal less sensitivity on oil price shocks. Based on our presented results, as a further research path, we suggest a potential extension of the study by modeling general equilibrium models with a specified competition structure of the international oil price markets, accounting for oil price effects on the macroeconomic performance and sector specific responses.

Appendix

See Tables 5, 6, 7, 8, 9, 10, 11 and 12.

Table 5 Descriptive Statistics

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	
(a) Brazil						
Mean	0.0269	– 0.1949	0.0159	0.0057	0.0156	
Median	0.0262	– 0.1000	0.0152	0.0076	0.0288	
Maximum	0.2891	21.6600	0.0603	0.0394	0.0687	
Minimum	– 0.2301	– 20.9700	– 0.0035	– 0.0417	– 0.1047	
Std. Dev.	0.1141	4.9740	0.0092	0.0128	0.0412	
Skewness	0.0637	0.7668	1.6605	– 0.7267	– 1.0881	
Kurtosis	2.6336	13.3307	9.2533	4.4293	3.2499	
Jarque–Bera	0.5203	377.2240	173.3805	14.3724	16.5944	
Probability	0.7709	0.0000	0.0000	0.0007	0.0002	
Sum	2.2401	– 16.1800	1.3222	0.4784	1.2981	
Sum Sq. Dev.	1.0692	2028.738	0.0069	0.0134	0.1393	
Observations	83	83	83	83	83	
	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(b) Canada						
Mean	0.0199	– 0.0903	0.0075	0.0058	0.0005	0.0014
Median	0.0201	– 0.0157	0.0064	0.0064	0.0006	0.0113
Maximum	0.0647	3.2439	0.0321	0.0246	0.0204	0.5007
Minimum	– 0.0308	– 3.6165	– 0.0095	– 0.0231	– 0.0359	– 0.7378
Std. Dev.	0.0151	0.9215	0.0073	0.0076	0.0080	0.1535
Skewness	0.0222	– 0.0474	1.2339	– 0.6652	– 0.7558	– 0.9720
Kurtosis	4.4576	7.1024	5.2514	4.1347	5.5869	7.1453
Jarque–Bera	13.0254	103.1385	68.3546	18.7302	54.9883	128.4010
Probability	0.0014	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	2.9347	– 13.2755	1.1158	0.8529	0.0747	0.2102
Sum Sq. Dev.	0.0334	123.9897	0.0078	0.0084	0.0093	3.4414
Observations	147	147	147	147	147	147
	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(c) China						
Mean	0.04360	– 0.0515	0.0118	0.0251	0.0064	0.0014
Median	0.0428	0.0000	0.0092	0.1123	0.0609	0.0113
Maximum	0.2011	2.6000	0.0853	0.1805	0.2403	0.5007
Minimum	– 0.0898	– 3.7239	– 0.0381	– 0.3784	– 0.3544	– 0.7378
Std. Dev.	0.0430	0.9029	0.0215	0.1729	0.1450	0.1535
Skewness	0.4140	– 0.3728	0.6419	– 1.1821	– 0.9444	– 0.9720
Kurtosis	4.6602	6.2254	3.9100	2.6380	2.5897	7.1453
Jarque–Bera	21.0824	67.1274	15.1678	35.0392	22.8841	128.4010
Probability	0.000026	0.000000	0.000509	0.000000	0.000011	0.000000

Table 5 continued

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
Sum	6.4105	− 7.5757	1.7380	3.6985	0.9532	0.2102
Sum Sq. Dev.	0.2703	119.0419	0.0680	4.3667	3.0701	3.4414
Observations	147	147	147	147	147	147

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(d) France						
Mean	0.0176	− 0.0194	0.0051	0.0039	− 0.0019	0.0014
Median	0.0152	0.0000	0.0042	0.0041	− 0.0014	0.0113
Maximum	0.1252	0.3591	0.0233	0.0266	0.0271	0.5008
Minimum	− 0.1522	− 1.8957	− 0.0059	− 0.0458	− 0.0324	− 0.7378
Std. Dev.	0.0361	0.2127	0.0047	0.0089	0.0088	0.1535
Skewness	− 0.6343	− 6.0481	1.0134	− 1.3089	− 0.3306	− 0.9721
Kurtosis	8.0733	50.2875	5.0499	9.0695	5.5589	7.1453
Jarque–Bera	167.5106	14592.39	50.9037	267.6183	42.7866	128.4010
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	2.5966	− 2.8621	0.7474	0.5857	− 0.2925	0.2102
Sum Sq. Dev.	0.1901	6.6085	0.0032	0.0118	0.0114	3.4414
Observations	147	147	147	147	147	147

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(e) Germany						
Mean	0.0144	− 0.0642	0.0071	0.0043	0.0002	0.0014
Median	0.0125	0.0000	0.0054	0.0043	− 0.0008	0.0113
Maximum	0.1171	1.2089	0.0385	0.0157	0.020663	0.5007
Minimum	− 0.1105	− 3.3705	− 0.0050	− 0.0171	− 0.0106	− 0.7378
Std. Dev.	0.0453	0.4781	0.0083	0.0048	0.0057	0.1535
Skewness	− 0.3930	− 2.8526	1.6412	− 0.8425	1.1593	− 0.9721
Kurtosis	2.6693	19.9216	5.7311	6.2508	4.8109	7.1453
Jarque–Bera	4.4542	1953.219	111.6810	82.1179	53.0153	128.4010
Probability	0.1078	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	2.1251	− 9.4375	1.0548	0.6333	0.03232	0.2102
Sum Sq. Dev.	0.3006	33.37412	0.0100	0.0034	0.0048	3.4415
Observations	147	147	147	147	147	147

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(f) India						
Mean	0.0310	− 0.0667	0.0146	0.0162	0.0072	0.0202
Median	0.0381	0.0000	0.0159	0.0092	0.0078	0.0390
Maximum	0.1211	2.9000	0.0549	0.1611	0.1392	0.3160
Minimum	− 0.0812	− 3.0000	− 0.0401	− 0.0756	− 0.0775	− 0.7378

Table 5 continued

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
Std. Dev.	0.0405	1.0406	0.0145	0.0609	0.0562	0.1648
Skewness	− 0.0821	− 0.1456	− 0.4385	0.4766	0.2340	− 1.5227
Kurtosis	3.1416	3.9045	5.0698	2.4318	2.1986	7.9577
Jarque–Bera	0.1411	2.7085	15.15961	3.6952	2.5838	101.5580
Probability	0.9319	0.2581	0.0005	0.1576	0.2747	0.0000
Sum	2.2328	− 4.8000	1.0509	1.1645	0.5187	1.4552
Sum Sq. Dev.	0.1163	76.8800	0.0149	0.2638	0.2243	1.9272
Observations	72	72	72	72	72	72

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(g) Italy						
Mean	0.0182	− 0.1079	0.0112	0.0028	0.0052	0.0014
Median	0.0140	− 0.0550	0.0079	0.0028	0.0038	0.0113
Maximum	0.1688	2.560000	0.051534	0.024216	0.048760	0.500775
Minimum	− 0.098828	− 2.7433	− 0.0040	− 0.0294	− 0.0223	− 0.7378
Std. Dev.	0.0541	0.7676	0.0112	0.0071	0.0115	0.1535
Skewness	0.4623	− 0.2603	1.6917	− 0.6203	1.0021	− 0.9721
Kurtosis	3.4156	4.8144	5.6582	6.4361	5.0447	7.1453
Jarque–Bera	6.2946	21.8265	113.3998	81.7450	50.2124	128.4010
Probability	0.0429	0.000018	0.000000	0.000000	0.000000	0.000000
Sum	2.6824	− 15.8733	1.6513	0.4229	0.7714	0.2102
Sum Sq. Dev.	0.4277	86.0363	0.0185	0.0074	0.0195	3.4414
Observations	147	147	147	147	147	147

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(h) Japan						
Mean	0.0141	− 0.0405	0.0022	0.0049	0.0002	0.0014
Median	0.0121	0.0000	0.0013	0.0046	− 0.0038	0.0113
Maximum	0.1336	1.1480	0.0313	0.03105	0.1934	0.5007
Minimum	− 0.0349	− 1.0133	− 0.01257	− 0.0496	− 0.1421	− 0.7378
Std. Dev.	0.0164	0.2421	0.0067	0.0108	0.0463	0.1535
Skewness	2.8964	0.3468	1.2587	− 0.7570	0.5371	− 0.9721
Kurtosis	22.0681	11.0148	5.7687	6.5757	4.8904	7.1453
Jarque–Bera	2432.553	396.4072	85.7724	92.3538	28.9592	128.4010
Probability	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000
Sum	2.0853	− 5.9597	0.3263	0.7348	0.0350	0.2102
Sum Sq. Dev.	0.0394	8.5591	0.0065	0.0171	0.3132	3.4414
Observations	147	147	147	147	147	147

Table 5 continued

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(i) Russia						
Mean	0.0570	− 1.1289	0.0353	0.0094	0.0354	0.0114
Median	0.0456	− 0.4000	0.0235	0.0478	0.0663	0.0225
Maximum	0.2222	65.0000	0.3371	0.1097	0.1953	0.3160
Minimum	− 0.1463	− 130.0000	0.0011	− 0.2231	− 0.2008	− 0.7378
Std. Dev.	0.0768	19.6826	0.0441	0.0952	0.0976	0.1602
Skewness	0.0191	− 2.7594	4.8120	− 1.1034	− 0.7798	− 1.3796
Kurtosis	2.7237	25.6632	30.3086	2.7752	2.5281	7.5677
Jarque–Bera	0.2689	1881.600	2899.419	17.0192	9.1832	98.4861
Probability	0.8742	0.0000	0.0000	0.0002	0.0101	0.0000
Sum	4.7336	− 93.7000	2.9311	0.7824	2.9396	0.9480
Sum Sq. Dev.	0.4839	31767.25	0.1596	0.7444	0.7813	2.1034
Observations	83	83	83	83	83	83

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(j) South Africa						
Mean	0.0265	− 0.1056	0.0137	0.0071	0.0120	0.0203
Median	0.0234	0.0000	0.0136	0.0079	0.0095	0.0469
Maximum	0.1103	1.2000	0.0334	0.0177	0.0505	0.3160
Minimum	− 0.0467	− 2.6000	− 0.0132	− 0.0156	− 0.0077	− 0.7378
Std. Dev.	0.0304	0.7645	0.0086	0.0060	0.0107	0.1659
Skewness	0.0811	− 1.2272	0.0939	− 0.9423	0.9303	− 1.5151
Kurtosis	2.9776	4.9609	3.3984	4.7694	4.3028	7.8541
Jarque–Bera	0.0792	29.1968	0.57407	19.7711	15.2635	96.8684
Probability	0.9611	0.0000	0.7504	0.0001	0.0005	0.0000
Sum	1.8839	− 7.5000	0.9760	0.5091	0.8524	1.4463
Sum Sq. Dev.	0.0647	40.9177	0.0053	0.0025	0.0080	1.9271
Observations	71	71	71	71	71	71

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(k) UK						
Mean	0.0246	− 0.0455	0.0064	0.0054	0.0014	0.0112
Median	0.0213	0.0000	0.0057	0.0057	0.0007	0.0239
Maximum	0.1533	0.6066	0.0441	0.0239	0.0207	0.5008
Minimum	− 0.0282	− 2.5200	− 0.0070	− 0.0228	− 0.0155	− 0.7378
Std. Dev.	0.0247	0.3476	0.0071	0.0063	0.0073	0.1573
Skewness	2.0528	− 4.1871	1.6636	− 1.2248	0.2911	− 0.9296
Kurtosis	10.9131	27.2996	8.9136	7.8229	2.6869	7.1191

Table 5 continued

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
Jarque–Bera	400.6778	3330.508	232.1056	147.5254	2.2029	102.9700
Probability	0.000000	0.000000	0.000000	0.000000	0.332381	0.000000
Sum	2.9874	− 5.5108	0.7806	0.6625	0.1725	1.3616
Sum Sq. Dev.	0.0736	14.4991	0.0061	0.0048	0.0065	2.9687
Observations	121	121	121	121	121	121

	L_M1	IR_SPREAD	L_CPI	L_GDP	L_REER	L_OIL
(l) USA						
Mean	0.014612	− 0.084643	0.006780	0.006694	0.000226	0.001898
Median	0.013350	− 0.010000	0.007333	0.007160	0.002704	0.013641
Maximum	0.076687	1.203300	0.017217	0.022558	0.080112	0.500775
Minimum	− 0.018200	− 3.359970	− 0.023167	− 0.021352	− 0.049987	− 0.737837
Std. Dev.	0.015398	0.550700	0.005039	0.006580	0.023862	0.156471
Skewness	0.817722	− 1.900498	− 1.695875	− 0.948737	0.179627	− 0.973834
Kurtosis	4.746421	11.52332	11.41198	6.063911	2.888878	6.965169
Jarque–Bera	33.39385	508.0519	479.8811	75.76309	0.824901	113.8432
Probability	0.000000	0.000000	0.000000	0.000000	0.662026	0.000000
Sum	2.045717	− 11.85000	0.949268	0.937123	0.031704	0.265703
Sum Sq. Dev.	0.032958	42.15459	0.003530	0.006018	0.079144	3.403145
Observations	140	140	140	140	140	140

	L_OIL
(m) Oil price	
Mean	0.0014
Median	0.0113
Maximum	0.5008
Minimum	− 0.7378
Std. Dev.	0.1535
Skewness	− 0.9721
Kurtosis	7.1453
Jarque–Bera	128.4010
Probability	0.000000
Sum	0.2102
Sum Sq. Dev.	3.4415
Observations	147

Table 6 Unit root tests

	d(M1)	d(IR_SPREAD)	d(CPI)	d(GDP)	d(REER)	d(OIL)
PP						
Brazil	– 20.1192***	– 17.9859***	– 4.7927***	– 14.0241***	– 13.0845***	– 9.1553***
Canada	– 5.2430***	– 9.5775***	– 8.1370***	– 7.1644***	– 9.8431***	– 9.1553***
China	– 14.5248***	– 13.2540***	– 8.5581***	– 23.8829***	– 37.7313***	– 9.1553***
France	– 19.1480***	– 9.9120***	– 9.2950***	– 6.6638***	– 6.7907***	– 9.1553***
Germany	– 12.4025***	– 6.9841***	– 8.5165***	– 9.8395***	– 13.0573***	– 9.1553***
Italy	– 18.5519***	– 10.109***	– 6.0569***	– 7.1607***	– 12.4481***	– 9.1553***
India	– 13.5979***	– 7.9553***	– 9.7174***	– 14.2453***	– 21.1550***	– 9.1553***
Japan	– 6.1669***	– 9.0556***	– 13.862***	– 11.1636***	– 12.5953***	– 9.1553***
Russia	– 12.9616***	– 15.3927***	– 5.6742***	– 14.5418***	– 16.5885***	– 9.1553***
South Africa	– 13.4801***	– 4.4896***	– 6.1920***	– 6.4701***	– 11.2717***	– 9.1553***
UK	– 9.8765***	– 6.7881***	– 13.7612***	– 6.3615***	– 12.6240***	– 9.1553***
USA	– 4.4212***	– 7.3021***	– 9.3199***	– 8.4769***	– 8.6599***	– 9.1553***
ADF						
Brazil	– 2.6092*	– 5.8926***	– 3.7130***	– 4.4565***	– 2.6529*	– 9.7849***
Canada	– 2.4821	– 9.6916***	– 8.1538***	– 7.1499***	– 10.3203***	– 9.7849***
China	– 0.0745	– 7.3458***	– 3.2084**	– 0.3754	– 3.4064**	– 9.7849***
France	– 1.9248	– 9.9120***	– 2.8647*	– 6.7054***	– 9.7849***	– 9.7849***
Germany	– 2.6330*	– 7.0407***	– 7.8291***	– 9.7404***	– 13.0646***	– 9.7849***
Italy	– 3.0549**	– 10.0957***	– 2.5600	– 7.1607***	– 3.0763**	– 9.7849***
India	1.0277	– 7.9564***	– 2.0635	– 2.1119	– 4.9302***	– 9.7849***
Japan	– 6.2424***	– 8.4950***	– 3.6651***	– 11.1360***	– 12.6047***	– 9.7849***
Russia	– 2.1695	– 6.6448***	– 5.5491***	– 3.2150**	– 2.9483**	– 9.7849***
South Africa	– 3.0626**	– 4.7685***	– 3.4260**	– 6.4799***	– 3.5562***	– 9.7849***
UK	– 3.0201**	– 6.8056***	– 3.4997***	– 6.4909***	– 12.5470***	– 9.7849***
USA	– 4.5685***	– 7.0975***	– 9.4691***	– 8.2674***	– 8.5799***	– 9.7849***

*Significant at the 10%; **Significant at the 5%; ***Significant at the 1%. MacKinnon (1996) one-sided *p* values. Test specifications are underlying a constant term for PP and ADF tests

Table 7 MS VAR results

	GDP	M1	IR-Spread	CPI	REER
(a) Brazil					
Constant (regime 1)	– 0.010513	– 0.116049	0.018064***	0.013218***	0.005497
	0.026866	0.718077	0.001098	0.003001	0.008476
Constant (regime 2)	0.076546	0.228204	0.019949***	0.001998	– 0.019173
	0.029218	2.2852	0.005451	0.005921	0.019851
Oil (regime 1)	– 0.083570	– 1.478072	0.003822	0.031087***	0.056129***
	0.062863	3.847251	0.005707	0.007816	0.021041
Oil (regime 2)	– 0.113536	1.507957	0.070501	0.103393	– 0.096793
	1.2853	2.3852	0.072453	0.068748	0.206472

Table 7 continued

	GDP	M1	IR-Spread	CPI	REER
Variance (regime 1)	0.006601***	18.467404	0.000050***	0.000116***	0.000813***
	0.001214	2.6852	0.000011	0.000011	0.000125
Variance (regime 2)	0.014624	27.887233***	0.000126***	0.000162	0.001744
	1.4545	5.878761	0.000047	1.00323	1.5545
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9917	0.0528			
Regime 2	0.0083	0.9472			
Duration of regimes	18.00	11.08			
Log likelihood:	562.135	Notes: The values below each coefficient value indicate the related standard error terms			
(b) Canada					
Constant (regime 1)	0.016348***	0.013751	0.0063000***	0.004419*	−0.008005***
	(0.002584)	0.178457	0.000964	0.002335	0.001754
Constant (regime 2)	−0.018368	−0.245019	0.002419	0.009220**	−0.010540
	(0.045618)	0.957296	0.007497	0.039063	0.013544
Oil (regime 1)	−0.012458	0.042518	0.006548**	−0.006850	0.016540***
	(0.008687)	1.711612	0.002605	0.005092	0.004340
Oil (regime 2)	−0.269161	−0.381935	−0.031436	−0.042177	0.071486
	(0.892180)	17.107825	0.149472	0.868341	0.263793
Variance (regime 1)	0.000081***	0.110515***	0.000008***	0.000024***	0.000025***
	(0.000019)	0.020713	0.000001	0.000004	0.000004
Variance (regime 2)	0.000138	0.161445	0.000019	0.000045	0.000081
	1.3285	3.2232	3.7845	1.2232	0.9322
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9847	0.0248			
Regime 2	0.0153	0.9752			
Duration of regimes	65.64	40.31			
Log likelihood: 1261.0755					

Table 8 MS VAR results

	GDP	M1	IR-Spread	CPI	REER
(a) China					
Constant (regime 1)	0.022102	−0.111782	0.008916	0.020724***	−0.016956***
	0.000000	0.000000	0.00000	0.00000	0.000000
Constant (regime 2)	−0.205227	0.176279	−0.090327	−0.046764***	0.020255***
	0.0000	0.0000	0.0000	0.0000	0.0000
Oil (regime 1)	0.050070	0.146325	−0.000616	−0.106637***	0.051633***
	0.0000	0.000	0.0000	0.0000	0.0000

Table 8 continued

	GDP	M1	IR-Spread	CPI	REER
Oil (regime 2)	− 0.038766	− 0.274447	0.022513	− 0.106003***	− 0.101004***
	0.0000	0.0000	0.0000	0.0000	0.0000
Variance (regime 1)	0.000718***	1.069468***	0.000062***	0.001370***	0.000483***
	0.000000	0.000000	0.000000	0.000000	0.000000
Variance (regime 2)	0.000828***	1.375655***	0.000000***	0.036089***	0.000377***
	0.000000	0.000000	0.000000	0.000000	0.000000
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9977	0.0238			
Regime 2	0.0023	0.9762			
Duration of regimes	548.21	40.65			
Log likelihood:	752.7443				
(b) France					
Constant (regime 1)	0.007423	− 0.102067	0.001863***	0.004816***	− 0.003364***
	0.008658	0.106043	0.000688	0.000703	0.000501
Constant (regime 2)	− 0.023669**	0.016880	0.006049***	− 0.000354	0.000625
	0.013330	0.7632	0.000949	0.001575	0.000962
Oil (regime 1)	− 0.043085	0.877327***	0.010479***	0.004724	− 0.006005***
	0.032953	0.371530	0.002693	0.00342	0.002167
Oil (regime 2)	0.131224**	− 0.834438	0.007296	0.004618***	0.001171
	0.049354	0.754821	0.005735	0.007347	0.003927
Variance (regime 1)	0.001593***	0.213129**	0.000012***	0.000018***	0.000007***
	0.000255	0.103084	0.000002	0.000006	0.000001
Variance (regime 2)	0.002496***	0.470538***	0.000018*	0.000030***	0.000015***
	0.000875	0.095294	0.000010	0.000013	0.000005
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9760	0.0270			
Regime 2	0.0240	0.9730			
Duration of regimes	41.44	36.02			
Log likelihood:	1525.254				

Table 9 MS VAR results

	GDP	M1	IR-Spread	CPI	REER
(a) Germany					
Constant (regime 1)	0.009241	− 0.0520	0.0034***	0.0028*	− 0.0021
	0.006096	0.0500	0.0004	0.001384	0.0013
Constant (regime 2)	− 0.015180	− 0.0774	0.0032***	0.0044*	− 0.0032
	0.014641	0.0902	0.0008	0.0025	0.0021
Oil (regime 1)	0.016795	0.720749***	0.012148***	− 0.013122***	0.012186**
	0.027930	0.209236	0.002218	0.006627	0.005861

Table 9 continued

	GDP	M1	IR-Spread	CPI	REER
Oil (regime 2)	0.000273	− 0.776886	0.002611	0.019585	− 0.012182
	0.005842	0.476418	0.005944	0.015041	0.010930
Variance (regime 1)	0.000762	0.044920***	0.000006***	0.000041***	0.000032***
	0.7372	0.010386	0.000001	0.000009	0.000005
Variance (regime 2)	0.002533***	0.079636	0.000010***	0.000072	0.000049
	0.000849	0.3942	0.000002	0.55942	1.4542
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9788	0.0278			
Regime 2	0.0212	0.9722			
Duration of regimes	47.13	35.98			
Log likelihood:	1190.2635				
(b) Italy					
Constant (regime 1)	0.005454	− 0.172866*	0.007168***	0.002013***	− 0.003203***
	0.007354	0.093771	0.000850	0.000687	0.001185
Constant (regime 2)	− 0.009483	0.117346***	0.034054***	− 0.010397***	− 0.003081***
	0.028350	0.046883	0.005062	0.003309	0.003179
Oil (regime 1)	0.024685	0.919607***	0.010530*	− 0.003522***	− 0.008027***
	0.032187	0.414252	0.004969	0.003603	0.005697
Oil (regime 2)	− 0.055636	− 0.912358	0.106485**	0.004330	− 0.028326***
	0.094926	1.585332	0.046567	0.6643	0.016272
Variance (regime 1)	0.002656***	0.449623***	0.000074	0.000034***	0.000086***
	0.000328	0.055809	0.44772	0.000006	0.000016
Variance (regime 2)	0.004060***	0.780063***	0.000164	0.000056	0.000146
	0.001331	0.238548	0.000134	0.87964	0.88454
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9797	0.0259			
Regime 2	0.0203	0.9741			
Duration of regimes	50.28	37.34			
Log likelihood:	1612.7194				

Table 10 MS VAR results

	GDP	M1	IR-Spread	CPI	REER
(a) India					
Constant (regime 1)	0.033456***	− 0.073999***	0.019503***	0.007725***	− 0.005417
	0.000000	0.000000	0.0000	0.00000	0.0000
Constant (regime 2)	0.223488****	0.083150***	0.019321***	− 0.315704***	0.045303
	0.000000	0.00000	0.0000	0.0000	0.0000
Oil (regime 1)	− 0.024370***	0.646327***	0.001879***	− 0.010514***	0.012978
	0.000000	0.00000	0.0000	0.00000	0.0000

Table 10 continued

	GDP	M1	IR-Spread	CPI	REER
Oil (regime 2)	0.039455***	− 0.687222***	0.072115***	0.000839***	0.011615
	0.00000	0.0000	0.0000	0.0000	0.0000
Variance (regime 1)	0.001104***	0.799431***	0.000132***	0.000209***	0.000197***
	0.000000	0.0000	0.0000	0.0000	0.00000
Variance (regime 2)	0.001789***	1.048851***	0.000292***	0.005798***	0.004795***
	0.0000	0.0000	0.0000	0.0000	0.00000
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9948	0.0245			
Regime 2	0.0052	0.9755			
Duration of regimes	189.47	40.58			
Log likelihood:	632.2822				
(b) Japan					
Constant (regime 1)	0.014349***	− 0.000920	− 0.000171	0.001680	− 0.004264
	0.001920	0.383322	0.000652	0.001301	0.006081
Constant (regime 2)	0.007811***	− 0.020239	0.025325***	− 0.021846*	0.018585
	0.76766	0.085519	0.005471	0.011825	0.33767
Oil (regime 1)	0.020363*	0.052499	0.006827*	0.007832	− 0.045278*
	0.011027	0.053059	0.003305	0.006878	0.023452
Oil (regime 2)	− 0.010982	− 0.065574	0.020730	− 0.044172	− 0.002726
	0.22288	0.886767	0.047604	0.090062	0.041945
Variance (regime 1)	0.000300***	0.005049***	0.000020***	0.000082***	0.001766***
	0.000045	0.000781	0.000004	0.000012	0.000254
Variance (regime 2)	0.000362	0.006088	0.000034	0.000117	0.002340
	0.46846	0.87874	0.12461	0.42261	0.32261
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9764	0.0451			
Regime 2	0.0236	0.9549			
Duration of regimes	42.29	22.18			
Log likelihood:	1056.2033				

Table 11 MS VAR results

	GDP	M1	IR-Spread	CPI	REER
(a) Russia					
Constant (regime 1)	0.035723	− 0.895142	0.018362***	− 0.002533	0.015522
	1.98941	4.562698	0.002733	0.23243	0.554354
Constant (regime 2)	− 0.025476	1.060741	0.168382	0.077604	− 0.069805
	2.36868	1.45451	0.435498	1.3438	0.047138
Oil (regime 1)	0.040112	− 8.527511	− 0.007618	− 0.025431	0.098246***
	0.040935	13.454636	0.011347	0.021061	0.021251

Table 11 continued

	GDP	M1	IR-Spread	CPI	REER
Oil (regime 2)	0.052240	8.514183	− 0.158072	− 0.266526	0.020784
	3.36543	7.2303	0.95230	1.9803	2.6340
Variance (regime 1)	0.002901***	290.536675	0.000223***	0.000739***	0.000858***
	0.000431	1211.9803	0.000045	0.000176	0.000186
Variance (regime 2)	0.006779	435.840231	0.002924	0.008661	0.008266
	0.79387	1827.3232	0.332398	0.465401	0.18762
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9949	0.0468			
Regime 2	0.0051	0.9532			
Duration of regimes	37.00	18.56			
Log likelihood:	369.2046				
(b) SA					
Constant (regime 1)	0.039293***	− 0.209560***	0.018011***	0.010702***	0.005682***
	0.000000	0.000000	0.000000	0.000000	0.000000
Constant (regime 2)	− 0.042277***	0.088921***	− 0.047157***	− 0.046184***	− 0.032746
	0.000000	0.000000	0.00000	0.000000	0.00000
Oil (regime 1)	0.023043***	− 0.306051***	0.018814***	0.017752	− 0.008117
	0.000000	0.000000	0.00000	0.000000	0.000000
Oil (regime 2)	− 0.024499***	0.083012***	− 0.010232***	− 0.027131	− 0.002843
	0.000000	0.000000	0.000000	0.000000	0.000000
Variance (regime 1)	0.001033***	0.451478***	0.000046***	0.000022***	0.000098***
	0.000000	0.000000	0.000000	0.000000	0.000000
Variance (regime 2)	0.001643***	0.618293***	0.000116***	0.000061***	0.000178***
	0.000000	0.000000	0.000000	0.000000	0.000000
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9998	0.0228			
Regime 2	0.0002	0.9772			
Duration of regimes	5839.04	43.95			
Log likelihood:	973.7556				

Table 12 MS VAR results

	GDP	M1	IR-Spread	CPI	REER
(a) UK					
Constant (regime 1)	0.006012	− 0.093634	0.006940***	0.005349***	− 0.002222**
	0.005270	0.090797	0.001006	0.001089	0.000974
Constant (regime 2)	0.052328***	0.324508	0.011443***	− 0.002432	0.003564
	0.012144	0.224762	0.002478	0.003530	0.003296
Oil (regime 1)	− 0.025578	0.995360***	0.012060***	0.007043*	0.000585
	0.015116	0.290383	0.003707	0.003870	0.02232

Table 12 continued

	GDP	M1	IR-Spread	CPI	REER
Oil (regime 2)	− 0.215736***	− 1.188057	− 0.002294	0.013808	0.007491
	0.073653	1.226425	0.011946	0.021091	0.024864
Variance (regime 1)	0.000280***	0.114109***	0.000020***	0.000021***	0.000040***
	0.000065	0.022382	0.000003	0.000005	0.000006
Variance (regime 2)	0.000648***	0.184391	0.000037	0.000047	0.000052***
	0.000222	0.725353	0.000028	0.000030	0.000028
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9753	0.0400			
Regime 2	0.0247	0.9600			
Duration of regimes	40.66	23.58			
Log likelihood:	1151.4559				
(b) USA					
Constant (regime 1)	0.019742***	0.023575***	0.005216***	0.008491***	0.008495***
	0.000000	0.000000	0.000000	0.000000	0.000000
Constant (regime 2)	0.016974***	0.067765***	− 0.170381***	0.107403***	− 0.032242***
	0.00000	0.000000	0.000000	0.000000	0.00000
Oil (regime 1)	− 0.026899***	0.534194***	0.020827***	0.001125***	− 0.074867***
	0.000000	0.00000	0.000000	0.000000	0.000000
Oil (regime 2)	0.024181***	− 0.705861***	− 0.038628***	− 0.013916***	0.082016***
	0.000000	0.000000	0.000000	0.000000	0.000000
Variance (regime 1)	0.000213***	0.129965***	0.000011***	0.000030***	0.000320***
	0.000000	0.000000	0.000000	0.000000	0.000000
Variance (regime 2)	0.000006***	0.177729***	0.000817***	0.000000***	0.006133***
	0.000000	0.000000	0.000000	0.000000	0.000000
Transition probabilities	Regime 1	Regime 2			
Regime 1	0.9928	0.0228			
Regime 2	0.0072	0.9772			
Duration of regimes	140.12	43.88			
Log likelihood:	1092.4367				

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