Zagreb International Review of Economics & Business, Vol. 27, No. 1, pp. 31-61, 2024

Faculty of Economics and Business, University of Zagreb and Sciendo. Printed in Croatia.
ISSN 1331-5609; UDC: 33+65
DOI: 10.2478/zireb-2024-0002

Do Exchange Rates Respond Asymmetrically to Crude Oil Market Shocks? Insights from BRICS and Pakistan

Abdul Rashid [*]
Zainab Jehan [+] [**]
Maria Tahira [***]
Amir Javed [****]

Abstract: *The shocks in the crude oil market are unlikely to have symmetric impacts on exchange rates, especially over various time periods. Furthermore, in low- and high-volatility regimes, exchange rates are predicted to respond differently to oil market shocks. By employing Markov-switching model and state-space model, this research empirically investigates whether oil market shocks exert asymmetric impacts on exchange rates, across the time and across different levels of volatility. In doing so, the study utilizes monthly data from January 1994-September 2017 for BRICS countries and Pakistan. The findings indicate that although oil supply shocks are mostly insignificant, oil price shocks appear statistically significant to affect the exchange rates whereas aggregate demand shocks are most volatile and are more likely to cause exchange rate fluctuations. The study concludes that various forms of oil shocks have a wide range of consequences on exchange rate determinations. Nonetheless, exchange rates' response to oil shocks differ dramatically through low- and high-volatility states, implying that oil shocks exert a time-varying impact on exchange rates. Finally, the findings provide credence to the phenomenon of asymmetry in exchange rate responses to oil market shocks.*

Keywords: Exchange rate fluctuations; Oil market shocks; Markov-switching model; state-space model; time-varying estimates

JEL Classification: C32, E23, Q41

[*] International Islamic University, Islamabad, Pakistan.
[+] Zainab Jehan is corresponding author. E-mail: zainabjehan.fjwu@gmail.com
[**] Fatima Jinnah Women University, Rawalpindi, Pakistan..
[***] International Islamic University, Islamabad, Pakistan
[****] Universita G. D`Annunzia di, Chieti-Pescara, Italy

Introduction

Over time, crude oil has undisputedly emerged the primary source of energy, holding a central position in global economic activities. The escalating demand of oil has exerted significant pressures on oil market, particularly impacting the movements of oil price (OP). The increasing fluctuations in oil prices and their broader implications on economy have enticed the attention of researchers and policy makers (Lee et al., 1995; Sadorsky, 1999; Park & Ratti, 2008; Apergis & Miller, 2009; Hamilton, 2009; Narayan et al., 2014; Narayan & Gupta, 2015; Ghosh & Kanjilal, 2016; Ahmadi et al., 2016; Kang et al., 2016; Lee et al., 2017, 2019; Lee & Lee, 2019; Zhang & Baek, 2022; Garzon Antonio´ & HierroLuis, 2022; K.S & Ray, 2023). Consequently, the empirical inquiries linking oil prices and exchange rates are extensive and diverse, yet, inconclusive. One contributing factor to these varied findings is that previous research largely assumed symmetric effects from different types of oil shocks, assuming these effects remained constant over time

The theoretical framework established reciprocal relationship between oil prices and the exchange rates, emphasizing various transmission mechanisms that intertwine the two. These mechanisms, such as the terms of trade (TOT) channel, the wealth effect channel, and the portfolio channel, elucidate distinct pathways through which fluctuations in oil prices affect exchange rates (Krugman, 1983; Golub,1983; Amano & Van Norden, 1998). To illustrate, the trade channel explains that the exchange rates are highly sensitive towards changes in tradable sectors. Hence, any variations in oil prices are instantly and significantly transmitted towards exchange rates. Conversely, the wealth effect channel and the portfolio channel, respectively, delineate the short-run and long-run implications of OP fluctuations on exchange rates. These channels elucidate that an upsurge in OP benefits exporters, enhancing the wealth of oil exporting countries (Benassy-Quere et al., 2007). Alternatively, higher oil prices relocate income from oil importing to oil exporting countries, subsequently altering the portfolio of the trading partners. Finally, the asset price channel explains how movements in exchange rates influence oil prices (Bloomberg & Harris, 1995; Chen et al., 2010).

Empirically, the initial assessments mainly focused on understanding the nature and the direction of the association amid oil prices and exchange rate. In this regard, three strands of empirical literature emerged; The first strand documented the impact of oil prices on exchange rates such as Bénassy-Quéré et al., (2007), Chen & Chen (2007), Narayan et al., (2008), Lizardo & Mollick (2010), Al-mulali & Sab (2012), Habib et al., (2016) among others. The second strand including Sadorsky (2000), Yousefi & Wirjanto (2004), Zhang et al.,(2008), Akram (2009) among others, explained the impact of exchange rate variations on oil prices. Another strand of literature provided the evidence of the absence of any relationship between the both (Aleisa & Dibooglu, 2002; Breitenfeller & Cuaresma, 2008). Hence, the research concerning the relationship of oil prices and exchange rates is at best inconclusive, attributed to variations in sample, time period, estimation techniques, and type of variables used. Notably, studies have documented that OP shocks impart varying effects on the exchange rates of oil-importing and oil-exporting countries. Specifically, in response to rising oil prices, the exchange rates of net oil-exporting (oil-importing) countries are reported to appreciate (depreciate) (Sadorsky, 2000; Chen & Chen, 2007; Lizardo & Mollick, 2010; Basher et al., 2016; Habib et al., 2016; Yang et al., 2017).

Crude oil shocks are categorized as: shocks originating from oil demand, oil supply, and oil price movements. The first type of shocks can further be broken down into precautionary and speculative oil demand shocks that mainly emerged due to uncertainties regarding future oil supply shortfalls (Chen *et al.,* 2016). Moreover, any change in precautionary demand influences the future oil supply and its price (Kilian, 2009). The second type of shock is largely stimulated by variations in oil production and supply (Hamilton, 2003). Whereas, OP shocks occur due to volatile and unpredictable oil prices, which are generally caused by uncertainty in oil demand and variations in oil supply (Kilian, 2008a).

Pioneering work by Hamilton (2003) identified oil shocks from oil prices. Subsequently, Kilian (2009) expanded on these shocks, differentiating between aggregate global demand shocks; oil specific demand shocks, and crude oil supply shocks. Following the framework provided by Kilian (2009), numerous studies reported significant impacts of different types of oil price shocks on the exchange rate (Atems et al., 2015; Basher et al., 2016; Habib et al., 2016) while others such as Atems et al., (2015) and Basher et al., (2016) stated an insignificant impact of supply shocks on exchange rates. Moreover, Habib et al., (2016) explained significant influence of both oil demand and the supply shocks on exchange rates. Yet, they reported that the impacts of former are stronger as compared to the latter. Recently, studies employing improved and updated approaches have shown that oil demand shocks significantly contribute to exchange rate fluctuations, while supply shocks seem less impactful, particularly in post-global financial crises (Ready, 2018; Malik & Umar, 2019). Additionally, these shocks affect oil-importing and oil-exporting countries differently, with varying effects observed in developed versus developing nations (Lin & Su, 2020; Jiang et al., 2020). Various studies highlight the sensitivity of exchange rates to time periods, sample sizes, methodologies, and shock measures (Beckmann et al., 2020) whereas some suggest an asymmetric response of exchange rates to oil price shocks and reported that unexpected changes in oil prices impart significantly higher influence on exchange rates (Huang et al.,2020).

Objectives of the Study

It is evident that prior research predominantly examined exchange rate response to OP shocks in a linear/symmetric framework. However, this study aims to depart from the existing literature by addressing the several key questions. Hence, the objectives of this study are multifold;

1. First, it seeks to explore whether oil market shocks exert varying impacts on exchange rates across different regimes. For this, a Markov-switching model is employed by assuming that the effect of all oil shocks on exchange rates are contingent upon the prevailing regime. Putting differently, the study aims to ascertain whether exchange rate movements in appreciations or depreciations respond asymmetrically to oil market shocks.
2. Secondly, the study intends to investigate whether the impacts of oil market shocks on exchange rates change over time. While previous empirical investigations often assumed a static relationship between oil prices and exchange rates, however, advancements in trading mechanisms in both oil and foreign exchange markets, regulatory reforms, changes in the flow and cost of information suggest potential variation in this relationship across different time periods. Therefore, to build the understanding on time-varying link, a state-space mode is employed which allows the coefficient(s) of interest to vary over time. This exploration is of significant relevance for firm managers and investors.
3. Third, the study aims to determine if different categories of shocks within the oil market have similar effects on exchange rates. Initially, a structural vector autoregressive regression (SVAR) is used to identify distinct categories of oil shocks, including oil supply shocks, aggregate oil demand shocks, and oil-specific demand shocks. Subsequently, the study examines the extent to which these diverse shocks impact exchange rates differently.

In addressing the above-mentioned questions and to achieve the objectives, the study focuses on a sample comprising BRICS and Pakistan.

The late 1990s saw the emergence of several emerging economies notably, Brazil, China, India, Russia, and South Africa (BRICS) in both economic and demographic terms owing to the Russian and Asian financial markets' crises. These countries have shown remarkable growth trends asserting their significance in the global economy (Dumrongrittikul & Anderson, 2016). Moreover, Chen et al., (2016) predicted that by 2050, BRICS countries will contribute to 50% of total world GDP. According to world population ranking 2017, BRICS countries are among the top ten most populous economies of world, except South Africa that holds 25th position. This immense population size requires huge amount of oil to satisfy their needs. Consequently, higher imports generate high import bills that ultimately put upward pressure on foreign exchange and resulting in appreciation of their respective currencies. Moreover, higher import bills relative to export earnings distort balance of payments. Among the selected sample, China, India, South Africa and Pakistan are the oil importing countries whereas Brazil and Russia are oil-exporting countries. The empirical inquiry is established by using time series data ranging from January 1994- September 2017

The remainder of the paper is organized as follows. Section 2 critically analyses the related research on oil market fluctuations and exchange rate. The econometric techniques and data used for empirical analysis is discussed in section 3. Section 4 and 5 describe the empirical findings of the research and conclusion, respectively.

Literature Review

Voluminous research have investigated the association amid oil prices and macroeconomic variables (GDP, exchange rates, interest rates, and inflation). Hamilton (1983) revealed that oil prices exert significantly adverse influences on US economy. Similarly, Sadorsky (1999) empirically reported that shocks in oil prices maintain an inverse relationship with macroeconomic variables in the USA. Further, Dawson (2006) illustrated that the link concerning oil prices and exchange rate is observed as insignificant in Dominican Republic, whereas, Azam Aziz (2011), based on co-integration technique, estimated the long-run interaction between oil prices, interest rates, and the exchange rate. The findings revealed that both the interest rate and oil prices positively influence the exchange rate. Similarly, Hasanov (2010) found significant positive associations amongst oil prices and exchange rates in Azerbaijan.

Another study by Ono (2011) examined whether oil prices are associated to real stock returns in BRICS countries and provided evidence of the significant impact of OP fluctuations in the case of China, Russia, and India. Moreover, by using three different econometric techniques, Reboredo (2012) measured the co-movements of exchange rates with oil market changes. The analysis revealed a weak interdependence amid oil prices and exchange rates. Kin & Courage (2014) established that oil prices substantially affect the nominal exchange rate. Similarly, Kaushik *et al*., (2014) & Ghosh (2011) explored the linkage between Indian exchange rate and oil prices. The findings showed that any rise in crude oil prices depreciates Indian currency with respect to US dollars. Fowowe (2014) studied the responsiveness of South African exchange rate to OP shocks. The results showed that exchange rates and oil prices are insignificantly linked with each other, in the long run. However, in the short run, increased oil prices significantly depreciate the South African exchange rate. The study of Shair *et al*., (2015) analyzed the association amid exchange rate and oil prices in Pakistan and reported a depreciation of Pakistani rupee against the US dollar in response to an escalation in oil prices. Atems *et al*., (2015) scrutinized the effect of oil supply and demand shocks on the US exchange rate and showed that increased oil prices and higher demand shocks result in depreciations of US exchange rate, whereas, the supply shocks do not affect the US exchange rate. Additionally, Ji *et al.*, (2015) analyzed the crude oil market performance and its influence on the stock exchange, industrial sector and commodity price level in BRICS countries. The findings showed that supply shocks have significant impacts on said variables in case of Russia, whereas, aggregate demand shocks appeared significant in case of other countries.

An important contribution is made by Chen *et al.*, (2016), who explained that the exchange rate irregularities under oil shocks depend mainly on the type of a shock as the exchange rate showed different behavior under different shocks. Furthermore, Basher *et al.*, (2016) scrutinized the nonlinearities in crude oil markets of oil importing and oil exporting countries. They explained that the role of oil production (supply-side) shocks appeared insignificant in determining the exchange rate. In contrast, both oil demand and price shocks significantly affect exchange rates. Pershin *et al.*, (2016) studied the association of oil prices with exchange rates in Botswana, Kenya, and Tanzania and suggested that the reaction of exchange rate to OP shocks differs in all three of these countries.

Another research by Antonakakis *et al.*, (2017) explained the existence of volatility in exchange rate and oil prices in oil-importing and oil-exporting nations. The analysis showed that demand side shocks mainly affected the exchange rate, whereas, the supply side shocks remained insignificant in the selected countries. By using a cross-correlation approach, Hussain *et al.,* (2017) explained the co-movements amid exchange rates and oil prices in ASEAN countries and reported that oil prices and Chinese exchange rate show a negative cross-correlation. Mensah *et al.,* (2017) showed a significant long-run relationship between oil prices and exchange rates in Russia, India, South Africa, Ghana, and Nigeria. Rouband & Arouri (2018) reported significant interrelations among exchange rates, stock markets, and oil prices. Delgado et al., (2018) empirically tested the relationship between oil prices, exchange rates, and stock market index in Mexico. They reported an adverse and significant impact on stock market index with respect to the movements in exchange rates while higher oil prices appreciate the exchange rate. Castro & Jiménez-Rodríguez (2018) examined the time varying relationship between US exchange rate and OP shock by utilizing monthly data from 1974-2017. The results reported differential response of exchange rate towards oil prices shocks not only in long-and-short run but also across different time regimes. Nouira *et al.,* (2019) tested the influence of OP fluctuations on the exchange rates of MENA countries and found evidence of significant volatility spillovers from oil prices towards exchange rates.

Malik & Umar (2019) employed the methodology of Ready (2018) and reported significant roles of oil demand shocks in exchange rate variations, although supply shocks are reported as insignificant. They further highlighted a stronger link between OP shocks and exchange rates in the post-global financial crisis. Kumar (2019) investigated the causality between oil prices, exchange rate, and stock prices in India by employing nonlinear Granger Causality and nonlinear NARDL techniques. The findings revealed bidirectional causality between oil prices and exchange rate, and OPs and stock prices. Moreover, the results reflected asymmetric impacts of OPs on both exchange rate and stock market. Specifically, positive shocks in OPs have stronger impacts on both variables as compared to negative OP shocks.

The recent surge in the empirical literature explored the asymmetric and varying impact of oil market shocks on exchange rates across different times and regimes. For instance, Lin & Su (2020) explained that OP shocks delivered differential impact on oil-importing and oil-exporting countries. Moreover, they reported that the responsiveness of exchange rate to OP shocks is higher for high frequency data. Jiang et al., (2020) explained that OP shocks have differential impacts on developed and developing countries. Beckmann et al., (2020), based on a survey study, explained that the response of exchange rate towards OP shocks is highly sensitive to time period, sample size, methodology, and measure of shocks. However, largely, empirical studies established that the link between OP shocks and exchange rate is stronger in the long run. Huang et al., (2020) examined the association amid OP shocks and exchange rate in different countries with different exchange rate setups. They provided the evidence of asymmetric response of exchange rate towards OP shocks and also examined the response of exchange rates in a time varying perspective. Moreover, they reported that unexpected changes in OPs impart significantly higher influence on exchange rates. Youssef & Mokni (2020) examined the exchange rate response towards OP fluctuations along with financial contagion. The results, derived from the Markov-regime switching quantile regression model, revealed varying effects of OP fluctuations on exchange rates over different regimes. Furthermore, the study highlighted that this impact is stronger for high volatility regimes. Lin & Su (2020) evaluated the consequence of OP shocks on exchange rates. By taking two categories of oil market shocks and three types of exchange rate series, the results based on ARDL and VAR techniques explained that two oil prices shocks have different impacts for oil-importing and oil-exporting BRICS countries. Moreover, the findings stated that exchange rate respond to OP shocks only under high frequency data. Notably, the study highlighted that China's response to OP shocks remained insignificant.

Kisswani & Elian (2021) examined the asymmetric impact of oil price shocks, economic policy shock, and geopolitical risk on bilateral exchange rate of selected economies namely, UK, China, Canada, Japan, and Korea. The findings, based on the NARDL technique, exhibit a strong evidence of asymmetric relationship for some economies, however, the nature of asymmetry varies for short and long run time frame. The findings suggest investors and policy makers to monitor oil price fluctuations in order to make better hedging strategies and policy directives, respectively. Zhang & Baek (2022) explained that oil prices exert an asymmetric impact on exchange rate, in the short and long run, of selected Asian countries where positive shocks appears more stronger as compared to the negative ones. Hashmi, Chang, Huang, & Uche (2022) analyzed the relationship between stock returns, oil prices and exchange rate for Pakistan by employing a quantile ARDL technique. The study concluded that oil prices impact exchange rate equally through different quantiles and the impact remains same across different states of currency market namely bullish, bearish, and normal. Moreover, Garzon Antonio´ & Hierro Luis (2022) documented an appreciation in exchange rate in response to higher oil price in euro area. Baek (2022) explained that the impact of oil prices on exchange rate turns asymmetric only when COVID-19 is taken into analysis. In absence of the covid-19 phenomenon, the impact of oil prices is symmetric for exchange rate in case of South Korea. Finally, K.S & Ray(2023) employed asymmetric framework to examine the dynamic relationship between international gold and oil prices, exchange rate and stock market for UAE. Based on ARDL technique, the study concludes that the dynamicity of these markets is better explained in an asymmetric framework as the symmetric analysis does not capture any co-integrating relationship among the selected variables.

The existing literature has mainly emphasized on investigating the symmetric impact on macroeconomic factors under oil market shocks. Departing from the existing studies, our study expands the literature on several grounds. Firstly, we target the asymmetric behavior of oil market and the exchange rate of the selected countries. Secondly, we employ Markov-switching regime and the state space model to capture the time-varying relationship and nonlinearities in the associations of oil market shocks and exchange rate. In addition to this, we measure the volatility and persistence of each regime. Notably, we select BRICS countries and Pakistan not only because these countries have extreme dependence on crude oil but they also have large share in global economic activity. Our analytical framework and econometric methods enable us to study whether the responsiveness of exchange rates to oil shocks is different in different regimes and in different time periods.

Methodology and Data

We follow a two-step strategy in which we first construct shocks concerning oil-demand and oil-supply in the crude oil market by adopting the Kilian and Park (2009) identification technique. Then, we empirically assess how and to what extent these shocks affect exchange rates in the selected countries.

Structural VAR Model

Structural VAR models have extensively been utilized to ascertain the dynamic association between oil prices and the macroeconomic factors (Wang *et al.*, 2013). In order to discern three structural shocks namely, oil supply shock, aggregate demand shocks, and oil specific demand shocks, a global oil market model is employed by adopting Kilian & Park (2009) approach. Specifically, we use world crude oil production, Brent crude oil prices and inflation rate to measure above stated shocks in the oil market. This approach is meaningful to understand the dynamic of exchange rate market, and the underline phenomenon of oil market. Moreover, it helps in measuring the varying impact of oil prices across different time periods. As oil prices are used in hedging, and for maintaining international portfolio, symmetric analysis do not provide in depth insights, hence asymmetric analysis is critical for firms and policy makers.

To construct simple switching model, we first focus on SVAR model, which can be described as

$$\boldsymbol{y_t} = A_\circ^{-1} A(L) \boldsymbol{y_{t-1}} + A_\circ^{-1} \boldsymbol{\varepsilon_t} \tag{1}$$

where $\boldsymbol{y}_t$ includes world crude oil production, crude oil prices, and the rate of inflation, while $\boldsymbol{\varepsilon}_t$ represents structural innovations. We impose restrictions on A_0^{-1} in $\boldsymbol{e}_t = A_0^{-1} \boldsymbol{\varepsilon}_t$ to obtain the structural innovations.

The structural shocks of three types are attributed as: $\boldsymbol{e}_{1t}$ denotes world crude oil supply shocks. These shocks are from production side as instabilities of oil production bring variabilities in oil supply (see for instance, Basher *et al*., 2016; Antonakakis *et al*., 2017). ε_{2t} represents aggregate demand (AD) shocks that are determined through the rate of inflation. Previously, Huang and Feng (2007) and Ji *et al*., (2015) have used inflation rate as measure of aggregate demand shocks. The third and last type of oil shocks are oil specific demand shocks (market specific demand shocks termed as oil price shocks) represented by ε_{3t}. (see for instance, Hamilton, 1983; Castro & Jiménez-Rodríguez, 2018; Nouira *et al*., 2019 among others), A_0^{-1} identification is captured by using the restrictions as follows:

$$e_t = \begin{pmatrix} e_{1t}^{wcp} \\ e_{2t}^{CPI} \\ e_{3t}^{OP} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_{1t}^{s} \\ \varepsilon_{2t}^{d} \\ \varepsilon_{3t}^{od} \end{pmatrix} \tag{2}$$

where WCP is world crude oil production, CPI is the rate of inflation, OP is Brent oil price, 's' shows supply shocks, 'd' denotes AD shocks and 'od' is oil specific demand shocks.

Markov Switching Model

After attaining the SVAR results and computing oil market shocks (supply shocks, AD shocks, and oil specific demand shocks), we move to our next step i.e. to investigate the exchange rate behavior under crude oil shocks. In doing so, we have employed Markov switching model as follows:

$$\Delta fx_t = \beta_{\circ,s_t} + \beta_{1,s_t}\varepsilon_t^s + \beta_{2,s_t}\varepsilon_t^d + \beta_{3,s_t}\varepsilon_t^{od} + \beta_{4,s_t}\Delta fx_{t-1} + \mu_t \tag{3}$$

where log of the first differenced exchange rate is denoted by Δfx_t. The terms ε^s, ε^d, ε^{od} are the oil market shocks which are calculated by the SVAR model as explained in 2. ε^s (oil supply shock), ε^d (AD shocks), ε^{od} (oil specific demand shock/OP shock) are introduced in the Markov switching model for investigating the exchange rate behavior under crude oil shocks. It is pertinent to mention that we have formulated the model by assuming the exogeniety of oil shocks.

The Markov-switching model explains that oil market shocks induce changes in exchange rate and this impact is also conditional on a state (S_t). The likelihood of switching from one state (1) at time period 't' to another state (m) at time period 't+1' is only determine by the state at time period 't' and not any other state.

Notably, Markov switching is conditionally linear inside each regime, while the switching between regimes is fundamentally stochastic. Furthermore, the switching between regimes is thought to be stochastic, based on a time-varying transition probability matrix. The intercept, variance, three oil shocks, and one period lag of the dependent variable in our model all influence changes in the transition probability matrix. Here $S_t = 0,1$ denote markovian state variable. The $S_t = 0$ for t = 1, …, T_0 and $S_t = 1$ for t = , T_0 +1, … , T.

Let S_t be a state variable that is unobservable and is driven by a first-order Markov chain with the transition matrix.

$$P = \begin{bmatrix} IP(S_t = 0|S_{t-1} = 0) & IP(S_t = 1|S_{t-1} = 0) \\ IP(S_t = 0|S_{t-1} = 1) & IP(S_t = 1|S_{t-1} = 1) \end{bmatrix} \tag{4}$$

$$P = \begin{bmatrix} P_{00} & P_{01} \\ P_{10} & P_{11} \end{bmatrix} \tag{5}$$

So that Y_t are jointly determined by ε_t and S_t. Markov Switching model explains that the universe is divided into m states denoted by $S_t = 0, \dots, m$. In other words, we assume that some unobserved variable $S_t = 0$ switches the exchange rate regimes. This unobserved variable could take any integer value. We also assume that 'm' (number of states) will either be '0' or '1'. So, it is obvious that when = 0, the exchange rate shows that at time 't' it is in regime '1' (the low-volatility regime), and when S_t = 1 the exchange rate switch to regime '2'(high-volatility regime). The exchange rate switching in different states are governed by Markov process.

State Space Model

For time-varying analysis of crude oil shocks with respect to exchange rate, we employ the following Gaussian state-space model in which coefficients also vary over time (Koop *et al*., 2009; Kang *et al*., 2015).

$$y_t = \beta_t z_t + \varepsilon_t \tag{6}$$

$$\beta_t = \beta_{t-1} + \pi_t \tag{7}$$

Equation (6) is measurement equation in which y_t is dependent variable is (exchange rates). The term β_T represents the time varying coefficients ($\beta_t = \beta_1, \beta_2, \beta_3$ … … … βt, The explanatory variables are denoted by z_t (supply shocks, AD shocks and oil specific demand shocks) whereas, ε_t and π_t are error terms of measurement equation and state equation, respectively, with zero mean and σ^2 variance.

The more specific model is

$$logREX_t = \beta_\circ + \beta_{1t}\varepsilon_t^s + \beta_{2t}\varepsilon_t^d + \beta_{3t}\varepsilon_t^{od} + \varepsilon_t \tag{8}$$

$$\beta_{1t} = \beta_{1t-1} + u_1 \tag{9}$$

$$\beta_{2t} = \beta_{2t-1} + u_2 \tag{10}$$

$$\beta_{3t} = \beta_{3t-1} + u_3 \tag{11}$$

Following the standard literature, we assume that the unknown parameters follow the first order autoregressive process. The measurement equation (8) allows parameter to be time dependent while transition determines the movement of the parameters. β_t is an unobserved time varying parameter of specific country (denoted by 'i') which is estimated by the dependent variable and stochastic error term ε_t. Equations (9)-(11) are transition equations that show the development of state variables, as being driven by stochastic innovation process.

Data

For doing empirical analysis, we use the monthly data on real exchange rates, consumer price index, world crude oil production, and Brent oil prices. We define exchange rate as domestic currency per unit of the foreign currency. Inflation rate is the annual percentage change in Consumer Price Index (CPI). World/global crude oil production are expressed in barrels per day while global crude oil prices are expressed in per barrel form

The time duration of the study ranges from January 1994 to September 2017. The real effective exchange rate data are accessed from International Financial Statistics (IFS). The data of CPI for BRICS countries are obtained from the Federal Reserve Economic Data (FRED) while for Pakistan, the data is taken from IFS. World crude oil production per barrel and oil prices in US dollar are accessed from Energy Information Administration (EIA). All variables are expressed in logarithmic form except inflation rate.

Discussion of Empirical Results

The Unit Root Test

To assess the unit root attributes of selected series, the augmented Dickey-Fuller (ADF) unit root test is employed. Further, to determine the optimal lag length, we utilized Schwarz Information Criterion (SIC). Table 1 displays the unit root statistics for all selected series, both at the level and at the first difference. The results indicate that the inflation rate and world crude oil production are stationary at level, while oil prices and the exchange rate are stationary at first difference.

Table 1: Unit Root Tests

Country	Variables	ADF at level		ADF at 1st difference
		Without Trend	With Trend	Without Trend
Brazil	CPI	-7.00***		
	OP	-1.75	-1.98	-13.65***
	WCP	-0.89	-3.97***	
	REX	-2.27	-2.33	-13.21***
Russia	CPI	-4.86***		
	OP	-1.75	-1.98	-13.65***
	WCP	-0.89	-3.97***	
	REX	-2.5	-2.95	-11.65***
India	CPI	-3.10**		
	OP	-1.75	-1.98	-13.65***
	WCP	-0.89	-3.97***	
	REX	-2.40	-3.53**	
China	CPI	-5.73***		
	OP	-1.75	-1.98	-13.65***
	WCP	-0.89	-3.97***	
	REX	-2.04	-2.47	-12.29***
South Africa	CPI	-11.54***		
	OP	-1.75	-1.98	-13.65***
	WCP	-0.89	-3.97***	
	REX	-2.60*		
Pakistan	CPI	-6.31***		
	OP	-1.75	-1.98	-13.65***
	WCP	-0.89	-3.97***	
	REX	-1.34	-1.51	-12.21o***

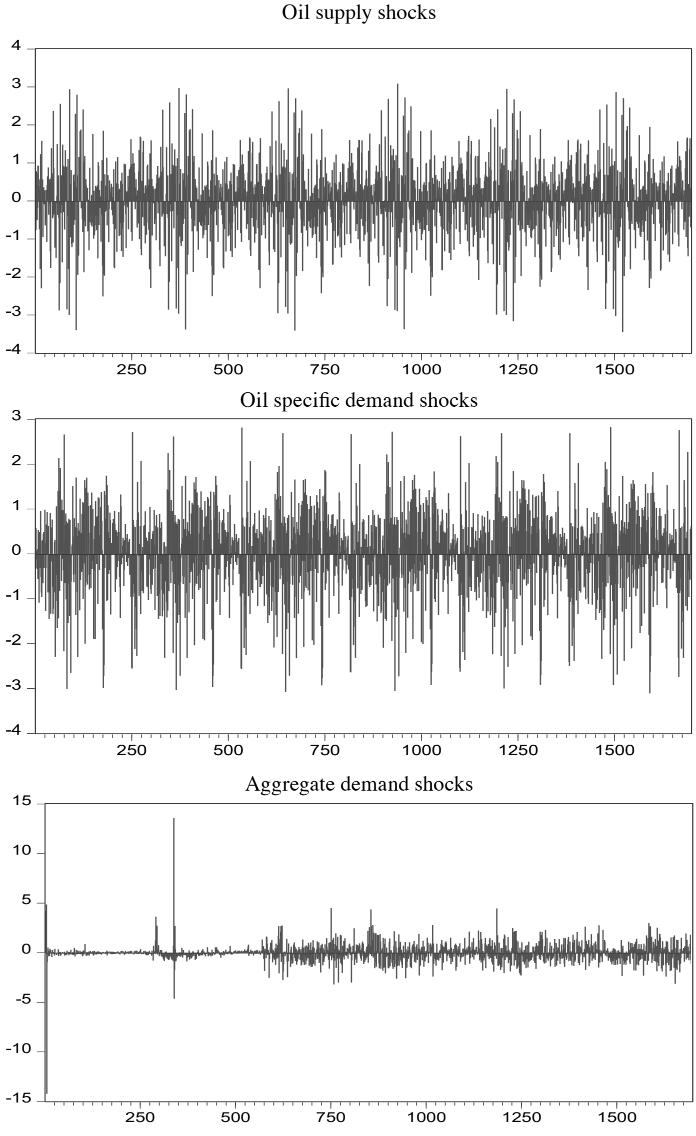
Source: Authors' own calculation

Structural VAR Test

The study used SVAR model for the calculation of the shocks. We introduce restrictions in the model by assuming that in the short run, the supply of oil is inelastic implying that it does not change in response to variations in the oil market in extremely short time period (within a month), due to high adjustment and extraction cost of oil production. Moreover, the inflexible supply response may be attributed to monopolistic control by OPEC and government regulations of oil production and supply. As a result, short-run crude oil supply curve becomes vertical. Next, the rate of inflation responds to innovations after at least one-month delay. Finally, the real OP responds to the rate of inflation and oil production innovation during the same period (month). This assumption is plausible because unexpected movements in the crude oil market or in an economy directly affect the prices of oil.

Next, to establish an optimal lag length, we executed a lag length selection test using alternate information criterion such as Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Hannan-Quinn Information Criterion. According to the Schwarz Information Criterion, two lags are taken as the optimum numbers of lags. Therefore, 2 lagged SVAR model is used to obtain shocks by Cholesky factor method. Figure 1 depicts oil supply shocks, oil specific demand shocks, and AD shocks. The figure shows that oil specific demand shocks are more volatile.

Figure 1: Oil market shocks



Interpretation of Markov Switching Model

Table 2 shows estimates of Markov-switching regression. Through this exercise, we achieve one of the objectives i.e. to assess whether exchange rates respond asymmetrically to crude oil market shocks. It can be observed from the table that these shocks deliver relatively asymmetric impacts on the exchange rates of different countries.

The lagged exchange rate has a significant impact in both regimes for all countries, showing that regime change does not affect the impact of lagged exchange rate. We discuss the results in detail.

Table 2: Impact of Oil Shocks on Real Exchange Rate – Markov Switching Regime Model

Country	State	Intercept	Supply	Demand	Oil price	Log REX(-1)	Sigma	LL
Brazil	S1	0.0287* (1.4628)	0.0010 (1.2304)	0.001455** (2.176661)	0.0016* (1.819710)	0.9857*** (96.6726)	1.0505*** (-18.7749)	809.586
	S2	0.3680*** (2.5737)	-0.0133 (-1.9218)	0.003957 (0.198115)	0.0011 (0.2797)	0.7915*** (9.9022)	3.09*** (9.1835)	
Russia	S1	0.0185* (1.7251)	0.0004 (0.8663)	0.00843*** (7.994629)	8.24E-05 (0.1444)	0.9922*** (176.2682)	0.571*** (5.5025)	914.700
	S2	0.1257*** (2.8156)	0.0009 (0.3439)	-0.0127*** (-8.277832)	0.0055*** (2.2670)	0.9330*** (39.0018)	2.168*** (4.4537)	
India	S1	0.4656*** (6.5651)	0.0002 (0.1994)	0.001714 (1.509311)	0.0002 (0.2177)	0.7689*** (21.4348)	0.8911*** (10.7473)	771.095
	S2	0.8150*** (7.426983)	-0.0001 (-0.1785)	4.15E-05 (0.0411)	0.0009 (0.8752)	0.5817*** (10.3969)	0.963*** (4.2278)	
China	S1	0.010753 (1.223888)	0.0002 (0.8042)	0.0033*** (9.0434)	-0.0005 (-1.5949)	0.9945*** (24.7045)	0.502*** (10.3792)	1086.65
	S2	0.0251*** (3.5202)	9.22E-0 (0.1576)	0.0024*** (3.5060)	-0.0050*** (-8.1575)	0.9896*** (27.7995)	0.285*** (5.5310)	
South Africa	S1	0.0136 (0.6275)	0.0011 (1.5984)	0.0017*** (2.0964)	0.0005 (-0.7638)	0.9935*** (17.8468)	0.955*** (4.1923)	846.972
	S2	0.0428 (0.3129)	0.0020 (0.4962)	-0.0085* (2.7225)	-0.0102*** (2.9327)	0.9739*** (13.8317)	1.93*** (6.4161)	
Pakistan	S1	0.0429*** (4.9765)	0.0003 (0.8348)	0.0011*** (2.8216)	-0.0017*** (-3.5953)	0.9791*** (29.9103)	0.461*** (4.068)	1036.93
	S2	0.02098 (0.3147)	0.0018 (1.2659)	9.43E-05 (0.0598)	-0.0007 (-0.4494)	0.9883*** (29.9145)	1.091*** (3.7400)	

Dependent variable is monthly real exchange rate. Supply shows world oil production shocks, Demand shows CPI shocks of each country and oil price denotes global oil price shocks. Log REX (-1) is the one period lagged value of real exchange rate. *, **, *** is the significance at 10%, 5% and 1 % respectively. LL refers to log likelihood value. Sigma measures the regime volatility through standard deviation of exchange rate.

Source: Authors' own calculations

Estimates of Oil Supply Shocks

The supply shocks originate because of disruptions in production mainly instigated by extreme weather conditions, wars, or any variations/adjustments in exporting countries' production quota.

The results in Table 2 indicate that the supply shocks portray an insignificant impact on the real exchange rate in either state for all countries. This finding implies that unexpected variations in supply of crude oil neither appreciate nor depreciate the exchange rates of the sample countries. This result corroborates with the findings of Kilian (2009), and Kilian & Park (2009), Atems *et al*., (2015), and Basher *et al*., (2016). The empirical findings in these studies also established that oil supply shocks are relatively less important as compared to aggregate demand and oil-specific demand shocks. This finding is quite surprising, especially for oil-exporting countries in our sample, namely Brazil and Russia. Our time period ranges from 1994 to 2017 which includes many production shocks like 2001 World Trade Centre attack, and 2003 Iraq war etc. Despite these production shocks, exchange rates of Russia and Brazil do not respond to these shocks, which is quite surprising and unexpected results. One of the possible reasons can be that these countries manage their exchange rates in very effective ways and any shocks related to oil supply does not have any significant influence on the value of domestic currency. Another possible reason of this behavior is that to offset the impact of production quota change or military conflicts and to maintain dominancy in exporting countries, Russian and Brazil governments promote investment in exploration of new crude oil fields. We believe that these new oil fields reduce the disruptions in the oil supply and make oil supply shocks insignificant for their respective exchange rates.

The results also suggest that the exchange rates of oil-importing countries, namely India, China, Pakistan, and South Africa are also not significantly affected by any oil supply shocks. This finding makes sense as these countries mainly do not export oil and therefore, domestic currencies of these countries may not be significantly affected by any oil supply shocks. Basher *et al*., (2016), Antonakakis *et al*., (2017), and Malik & Umar (2019) also explained that the role of oil production (supply-side) shocks appeared insignificant in determining the exchange rate of both oil-exporting and oil-importing countries.

Estimates of Aggregate Demand Shocks

Aggregate demand shocks have important implications for both producers and consumers. Global demand shocks affect the economy of an exporting country through OP change. The change in oil prices further fluctuates the prices of industrial products may create Dutch disease effect. The global demand of oil in Brazil portrays a significant and favorable impact on the real exchange rate in regime 1 which indicates appreciation pressure.

Interestingly, the findings reveal that for Brazil, the shocks have only significant impacts on exchange rates in first state. Whereas, in case of Russia, the exchange rate significantly responds to aggregate demand shocks in both states. This finding suggests that Russian exchange rate is affected by aggregate demand shocks in both low- and high-volatile states. On the contrary, the exchange rate of Brazil only significantly responds to oil demand shocks in the case of low-volatility state. It is pertinent to note that there is a positive effect on exchange rate of Russia by oil specific demand shocks in periods when the exchange rate is relatively less volatile, whereas, it is negatively and significantly affected by the shocks in episodes of high volatility. Understanding these nuances can help policymakers formulate more effective strategies to manage exchange rate fluctuations and leverage favorable impact of oil market shocks for the benefit of Russian economy

In case of oil-importing countries, Pakistan, China and South Africa, aggregate demand shocks appear to deliver a significant bearing on the exchange rates of these countries. Yet, the effects are state dependent. For example, for South Africa, we observe a statistically significant impacts of aggregate demand shocks in both low- and high-volatility states. Yet, the effects appear as positive in low-volatility state, whereas, they turn negative in high-volatility state. In contrast, for China, the effects are positive and significant regardless of the level of volatility. In case of Pakistan, AD shocks have only significant and positive effects on the exchange rate in low-volatility state. Hence, these findings suggest that the impact of AD shocks is conditional on the state of the volatility of exchange rate. The asymmetric response of the exchange rate towards shocks in aggregate demand is largely determined by the degree of exchange rate volatility.

Finally, the estimation results indicate that AD shocks do not carry any significant impacts on exchange rate determination in India. This finding holds in both low- and high-volatility states. One should note that both India and China are fast growing emerging economies. However, the responsiveness of exchange rate to AD shocks are quite dissimilar in both the economies. This differential response mainly is attributed to differences in economic structure in both countries. China is undoubtedly one of the largest economies of the world with significant trade shares. Similarly, China has relatively more direct and indirect investments in the world than India. Further, both countries have quite different economic and social issues and thus, requires designing quite different nature of fiscal and monetary policies. Therefore, it is expected that the exchange rate of both countries may respond differently to any internal and external shocks. Antonakakis *et al*., (2017), Malik & Umar (2019) also documented that demand side shocks are significant contributor towards exchange rates variations.

Estimates of Oil Price Shocks

Speculations about the shortage of future oil supply bring more uncertainties and stimulate fluctuations in international oil prices. The exporting countries (Russia and Brazil) in our sample show a positive and significant impact of oil specific demand shocks on exchange rates at least in one regime. This indicates that oil specific demand shocks (any upsurge in the cost of oil) creates appreciation in real exchange rate in exporting countries. This finding is similar to previous studies that provide evidence that OP shocks appreciate the exporting country's currency (Habib *et al*., 2016, and Fratzscher *et al*., 2014). Nevertheless, it is worth mentioning that the effects of

OP shocks or oil specific demand shocks are different in different states of exchange rate volatility. For instance, the shocks affect Brazil's exchange rates in low-volatility state, whereas, the Russian exchange rate is affected in high-volatility state. These findings suggest that different countries should have different policies to curb the variations of exchange rate caused by OP shocks.

We can say that higher oil prices negatively affect an oil importing country by depleting its trade balance and foreign exchange reserves. One of the major reasons is that rising oil prices increase oil-specific as well as overall import bills which in turn increase the demand for dollars and ultimately puts pressure on foreign exchange market. The rising oil prices further transmit adverse impact on the net importer's economy. For instance, rising oil prices not only decrease the purchasing power of importing country in international market, but also reduces domestic confidence on the currency. In the long run, higher oil prices decrease the real output of oil importing country. This verifies Hamilton's (2003) findings that higher oil prices affect trade and industrial activities adversely. Moreover, OP shocks not only create inflationary pressures but also a depreciation in real exchange rate. Hence, the OP shocks increase the fragility of oil importing countries.

It is well evident that China and India are fast growing economies among BRICS countries and are heavily dependent on oil but interestingly for both countries' OP shocks appear as insignificant in regime 1. Indian and Chinese capital markets impose strict regulations and limits on capital mobility as compared to rest of the world, which makes their stock markets independent and stable. One of the important reasons for insignificant oil specific demand is that the favorable effect of expectation is counterpoise by adverse effect of precautionary demand. Moreover, Chinese government also introduces alternative energy sources to minimize oil demand. These measures help reduce dependence on oil and improve the shock absorption capacity of the foreign exchange market. However, the results suggest that in low-volatility state, OP shocks deliver significantly negative effects on the exchange rate, in China. This finding is in accordance with Hussain *et al.,* (2017) who explained the co-movements amid exchange rates and oil prices in ASEAN countries and reported that oil prices and Chinese exchange rate show a negative cross-correlation. Nouira *et al.,* (2019) also found evidence of significant volatility spillovers from oil prices towards exchange rates. Kumar (2019) investigated the causality between oil prices and exchange rate in India and revealed asymmetric impacts of OPs on exchange rate with positive shocks having stronger impacts as compared to negative OP shocks. Kisswani &Elian (2021) exhibit a strong evidence of asymmetric relationship for some economies while reporting that the nature of asymmetry varies for short and long run time frame.

The results concerning South Africa indicate that oil specific demand shocks have no contribution in the exchange rate determination specifically, in periods when there are relatively less variations in exchange rate. However, OP shocks formulate significant negative effects of exchange rate in periods of high volatility of exchange rate. These findings suggest that when exchange rates are already highly volatile, then the authorities may consider OP shocks seriously and use effective measures to abate the adverse effects of all kinds of shocks on exchange rate. Fowowe (2014) showed that in the short run, increased oil prices significantly depreciate the South African exchange rate while they are insignificantly linked with each other, in the long run. Mensah *et al.,* (2017) showed a significant long-run relationship between oil prices and exchange rates in Russia, India, South Africa, Ghana, and Nigeria. Finally, the estimation results for Pakistan indicate that the effects of OP shocks are significant only in low-volatility state. Hashmi, Chang, Huang, & Uche (2022) concluded that, in case of Pakistan, oil prices impact exchange rate equally through different quantiles and the impact remains same across different states of currency market namely bullish, bearish, and normal.

Volatility of Regimes

Table 2 (Column 8) also presents the volatility of each regime measured through standard deviation, sigma, which shows the volatility of each regime. Higher value of sigma shows higher volatility and vice versa for low values of sigma. It can be observed that Brazil in state 2 is the most volatile among all the countries while China in state 2 is least volatile. By following Ang and Bekaert (2002), the regime classification measure (RCM) is computed as under:

$$RCM = 100\left[1 - \frac{k}{k-1}\frac{1}{T}\sum_{k=1}^{N}\left(p_{i,t} - \frac{1}{k}\right)^2\right] \quad (5.1)$$

where k shows the number of regimes, T denotes number of observation and $p_{i,t}$ is smooth probabilities. The value of RCM ranges from 0 (perfect classification of regime) to 100 (failure to notice any classification). Table 3 shows that China has the smallest RCM value which means that Markov model is best fitted model for China whereas, for Pakistan, it is the least fit among selected countries.

The transition probabilities P11 and P22 show that first regime is persistent as value of its probability is higher as compared to second regime for all countries. This can also be confirmed by duration to remain in one regime i.e. DU1 (time period of first regime in months) and DU2 (time period of second regime in months). The time period of first regime is higher than the second indicating that first regime is more persistent. Furthermore, computed probabilities P12 [Prob ($s_t = 1|s_t = 2$)] and P21 [Prob ($s_t = 2|s_t = 1$)] show that the probability is higher in regime 2.

Table 3: Transition Probabilities and Expected Duration in Each Regime

	P11	P12	P21	P22	DU1	DU2	RCM
Brazil	0.9637	0.0362	0.2089	0.7910	27.5524	4.7857	23.76
Russia	0.9352	0.0647	0.1853	0.8146	15.4347	5.3949	24.52
India	0.7234	0.2765	0.1464	0.8535	3.6162	6.8280	21.69
China	0.9300	0.0699	0.3125	0.6874	14.3007	3.1999	15.84
South Africa	0.9005	0.0994	0.5158	0.4841	10.0531	1.9387	25.21
Pakistan	0.9238	0.0761	0.2676	0.7323	13.1284	3.7362	26.12
P11, P12, P21, P22 are transition probabilities. DU1 and DU2 are the expected duration of being in state 1 and 2. The first regime in case of all countries is more persistent as compared to the second regime.							

Authors' own calculations

Time Varying State Space Model

To study whether the effects of different types of oil shocks on exchange rates vary over time, we estimate state space models and the estimated value of the s (smooth state estimates) is presented in Figure 2. Figure 2 shows the time varying coefficients' results of oil supply shocks, AD shocks and oil specific demand shocks on the exchange rate of BRICS and Pakistan. The estimated values strongly support the time varying impact of crude oil shocks on the exchange rates of selected countries. The plots shows significance of findings based on the (+/- 2) standard deviation upper and lower bounds.

The plotted estimates clearly illustrate that the impacts of all three types of oil shocks are reasonably diverse in different time periods for Brazil. The supply shock coefficients are mostly positive, yet its value remains around zero. It shows slightly negative response (disruptions in supply) from 2001 to 2003, the period of World Trade Centre attack and Iraq war, which slightly disturbs the supply pattern of oil. The reaction of Brazilian exchange rate to OP shocks shows increasing behavior. It starts from a negative impact and slowly moves towards positive impact on the exchange rate. We may claim that as Brazil was an oil importer in the beginning, therefore, an increase in OP has had a negative influence on its exchange rate. However, after the discoveries of the oil reserves, an upsurge in OP has had a beneficial impact on its exchange rate. On the other hand, the oil demand shocks' behavior varies continuously between positive and negative, which makes the impact of oil specific demand shocks on exchange rate more unstable and volatile.

The plots of the estimates provide strong evidence of the time-varying response of Russian exchange rate to oil supply shocks. At beginning of the sample period, the influence of supply shocks on exchange rates was positive, which turned to negative in 2000. However, it became again positive in 2012. The figure provides clear evidence that the influence of oil supply shocks on exchange rates changes over the course of time. Specifically, we observed that the supply shocks are negative during the years 1999, 2000, 2004 and 2005. Afterwards, it becomes positive but does not show large variations. The responses to OP shocks appear negative from 1996 to 2001. Afterwards, they turn positive and exhibit direct association with exchange rate. The response of Russian exchange rate to oil specific demand shocks also significantly changes over time. At the beginning, it was negative. However, it becomes positive during 2000 and remains almost positive for remaining years of the study.

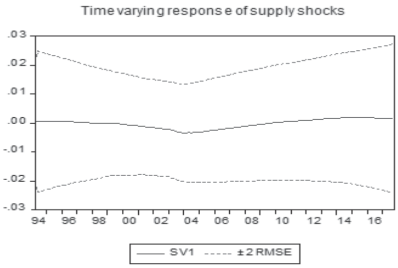
As it can be observed from the figure that the responsiveness of Indian exchange rate to oil supply and aggregate demand shocks does not vary much during the examined periods. The response to oil supply shocks is negative through the examined periods. Similarly, the effects of aggregate demand shocks fluctuate around zero during the sample period. Finally, we can observe from the figure that although the response of Indian exchange rate to oil specific demand shocks remains positive throughout the sample period, there is a significant variation in the magnitude of estimated coefficient. This finding provides evidence that the effects of oil specific demand shocks on exchange rate determinations are different in different time periods. The results are consistent with our supposition that the effects of oil shocks on exchange rates are time heterogeneous. This implies that the nature of the effect as well as its size both differ across times.

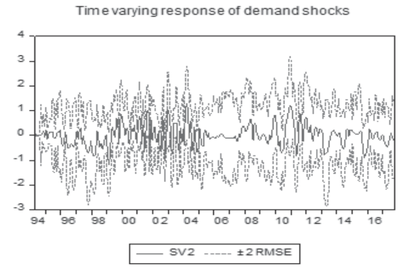
Turning to the case of China, we observe that the Chinese exchange rate's response to both oil supply shocks and aggregate shocks are quite similar to the behavior of Indian exchange rate. However, the impact of oil specific demand shocks are quite different form India and quite variable over time. Specifically, the estimates show that the effects of oil supply shocks are mostly stable and have negligible variations over time. In contrast to this, the effects of aggregate demand shocks on exchange rate determination significantly fluctuate during the sample period. The effects of oil specific demand are quite different in different periods in terms of magnitude. At begging, the negative effects are very strong, specifically, during 1994 to 2000. During the period 2001-2005, the effects are very close to zero. Yet, during 2006, they become positive and afterwards turn to again negative and start to become stronger. The findings provide enough support of the time-varying behavior of exchange rates towards oil shocks.

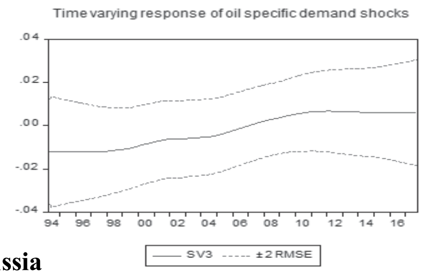
As the plotted estimates indicate, the effects of oil shocks on exchange rate are quite time varying in nature for South Africa. The positive value of the coefficient of oil supply shocks increases with time. Similarly, the effects of aggregate demand shocks on exchange rate are also quite different in different time periods. Initially, they are positive, then become negative and finally again become positive and remain positive for the remaining years of the sample period. The size and sign of coefficient of oil specific demand shocks also significantly changes across time. At begging of the sample period, the response of exchange rate to oil specific shocks was negative, then gradually becomes positive. Yet, during 2004 and 2005, once again, the response of exchange to oil specific demand shocks becomes negative, whereas for remaining years of the sample, it is positive. These findings are in line with our hypothesis that the effects of all three types of oil shocks on exchange rate are different in different time periods.

Figure 2: Graphs of State Space Model

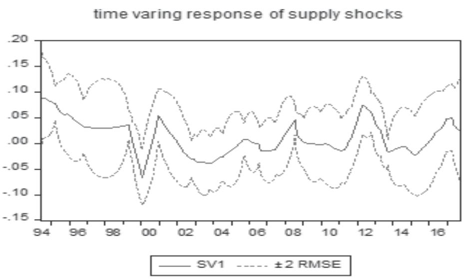
Plots for Brazil

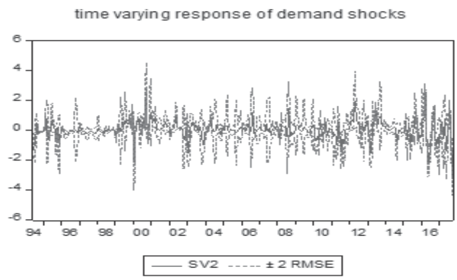


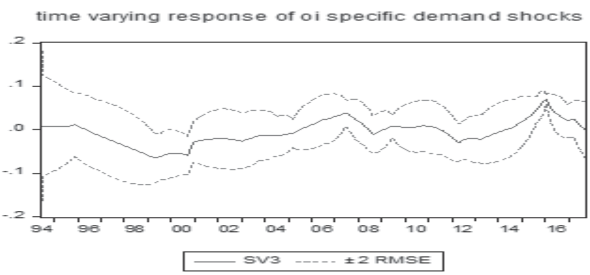




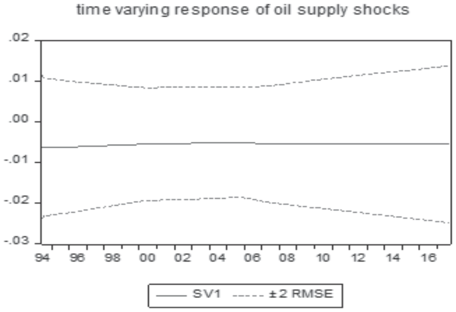
Plotes for Russia

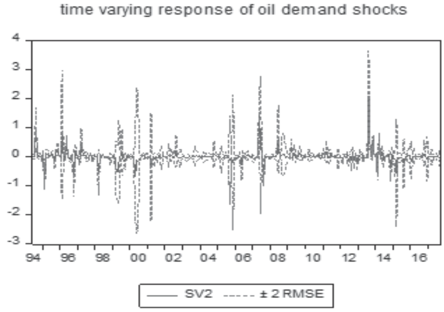


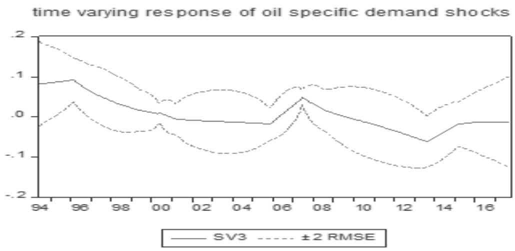




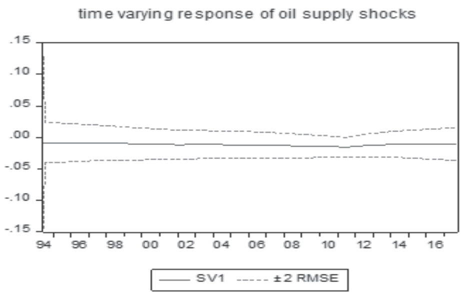
Plotes for India

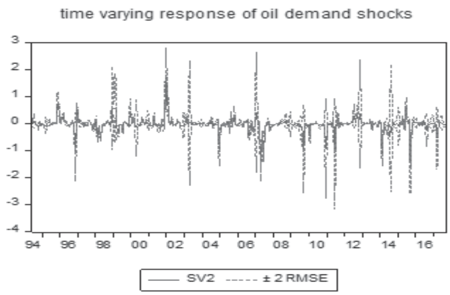


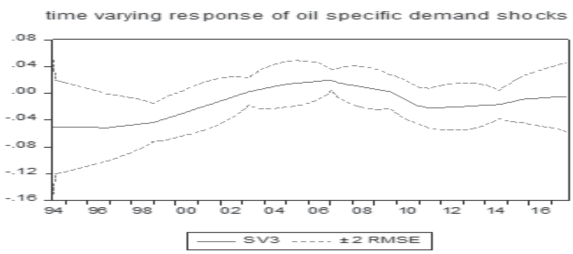




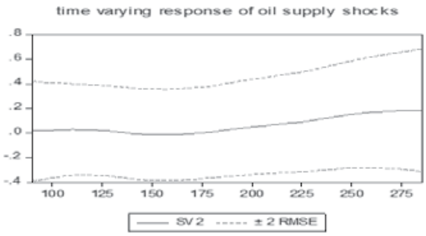
Plotes for China

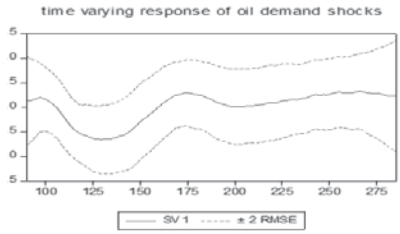


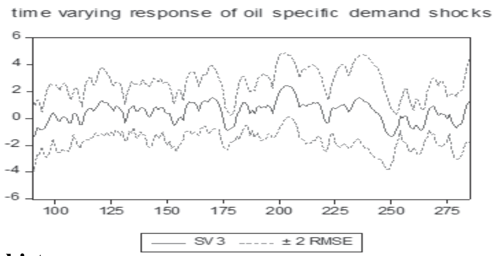




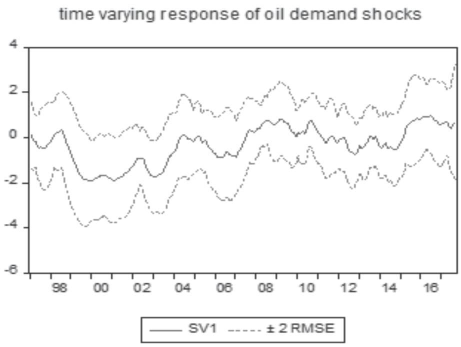
Plots for South

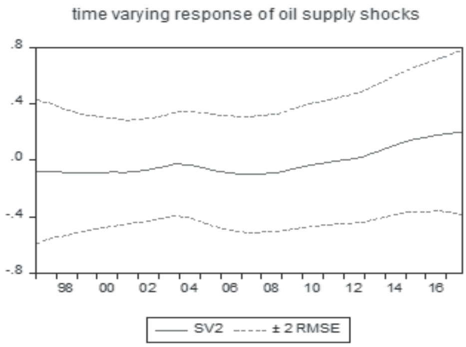


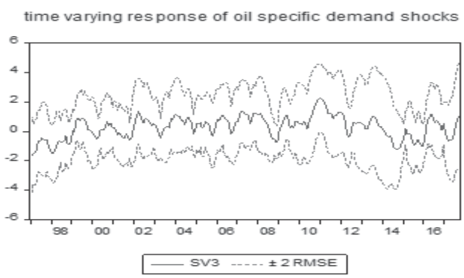




Plots of Pakistan







In the case of Pakistan, the exchange rate effects of oil market shocks are significant but quite different in different periods. Before 2004, the effects of oil supply shocks were negative, whereas after that, they become positive and stronger with time. Likewise, the effects of aggregate demand shocks on exchange rates were positive, whereas, they become positive and stronger in the later years of the sample. As far as the oil specific demand shocks' effects are concerned, the estimates show that they are very much different in different time periods both in terms of sign and size. In early periods of the sample, they were negative and small. However, in latter years of the sample, they appear positive and strong.

Summary of Empirical Findings

In sum, the findings presented provide strong evidence of the heterogeneous behavior of the exchange rate in response to oil market shocks, conditional on the type of oil shocks and on the level of exchange rate volatility. Specifically, the findings suggest that each category of selected shocks: supply shocks, AD shocks, and oil specific demand shocks has quite differential impacts on the exchange rate of each examined country. Further, the influence of these shocks on exchange rates are country specific. The exchange rate of different countries is influenced by oil shocks quite differently. Further, we demonstrated that size and significance of the impact of all three categories of shocks on exchange rates are conditional on level of volatility. In a low-volatility state, the impacts of oil shocks on exchange rates are significantly different from those in a high-volatility state. These findings suggest that business firms and policymakers should give a serious attention to asymmetries in exchange rate response to oil shocks while making different policies and applying different strategies to minimize exchange rate risks.

Conclusions and Policy Recommendations

This research reveals several considerable findings on the asymmetric influence of various forms of oil market shocks on exchange rates. First, the findings recommend that shocks from oil production side (supply shocks) have insignificant or negligible implications on the exchange rate in all the examined countries. Secondly, the exchange rate is directly related with OP shocks in oil-exporting countries, whereas the effects are either negative or statistically insignificant in case of the oil-importing countries. This shows that the existence of asymmetry in the exchange rates' response towards fluctuations in OPs. Finally, aggregate demand shocks are more volatile and are responsible to bring variations in the exchange rate.

The findings also advocate that the impact of shocks concerning oil market are conditional on volatility regimes. Specifically, we show that the responses of the exchange rate of all sample countries to all three categories of oil shocks are quite different in low- and high-volatility state. Last, but not the least, the results of the state space models provide strong evidence of the time-varying nature of the response of exchange rates to different types of oil shocks. Taken together, we may conclude that the different types of exchange rate shocks have quite different effects on exchange rates. Further, the effect on exchange rates concerning each type of oil shock varies across examined countries. Next, we explain that the effects of oil market shocks are also subject to the level of exchange rate volatility. Finally, there are significant evidences of the time-varying behavior of exchange rates towards different types of oil market shocks.

As crude oil uncertainties affect emerging economies differently, it is essential for the countries of BRICS and Pakistan to adopt different strategies in order to tackle the unanticipated shocks from crude oil market. Further, our findings indicate that the demand side disruptions in the oil market are highly significant for both sets of economies. Therefore, BRICS countries and Pakistan need to design their policies to minimize the adverse effects of oil market shocks. The results of the paper also suggest that corporate firms and policymakers both should give a careful consideration to asymmetries in the responsiveness of exchange rate for oil shocks conditional on types of shocks, volatility levels, and across time while designing policies and implanting different strategies to hedge exchange rate risks, specifically caused by unexpected fluctuations in oil market.

Based on the findings of the study, it is implied that the importing countries can explore alternate sources of energy i.e., coal, hydro, wind, solar and nuclear energy. Moreover, countries like China, India, and Pakistan which are fast growing economies and heavily rely on oil imports, may focus on diversification of oil import origins, develop efficient energy consumption strategies for industries and households. Pakistan along with these steps may also focus on investing in financial instruments such as futures contracts to hedge against oil market fluctuations. China may focus on increasing the domestic oil production to reduce its dependence on oil imports. As far as oil exporting countries in the sample are concerned, they may focus on building alternative oil resources by investing in renewables which not only reduce the reliance on oil market but also helps in reducing the adverse implications of oil market fluctuations. Moreover, the exporting countries may maintain strategic oil reserves, for stabilizing the prices during oil market instabilities. The exporting countries may also adopt flexible monetary policy to counter the inflationary impact of higher oil prices and consequent exchange rate fluctuations. Hence, by adopting multi-faced approaches that focuses on reducing oil dependence, improving energy efficiency, and diversifying energy sources and trade partners, BRICS and Pakistan can insulate their economies from the adverse effects of oil market shocks.

Declarations

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest/Competing interests

There is no conflict of interest/Competing interests.

Availability of data and material

The data that support the findings of this study are openly available in the website of World Bank (www.worldbank.org) published by World Bank, EIA, IFS published by IMF

Code Availability

The computer program results are shared through the tables in the manuscript.

Authors' Contributions

Abdul Rashid (Conceptualization, Supervision, Methodology)
Zainab Jehan (Write-up, Review and Editing)
Maria Tahira (Initial Write-up, Estimation, References)
Amir Javed (Methodology, Estimation)

REFERENCES

Ahmadi, M., Behmiri, N. B., & Manera, M. (2016). How is volatility in commodity markets linked to oil price shocks?. Energy Economics, 59(C), 11-23. DOI: 10.1016/j.eneco.2016.07.006

Akram, Q. F. (2009). Commodity prices, interest rates and the dollar. Energy economics, 31(6), 838-851. DOI:10.1016/j.eneco.2009.05.016

Aleisa, E. A., & Dibooĝlu, S. (2002). Sources of real exchange rate movements in Saudi Arabia. Journal of Economics and Finance, 26(1), 101-110. DOI: 10.1007/BF02744455

Al-mulali, U., & Che Sab, C. N. B. (2012). Oil prices and the real exchange rate in oil-exporting countries. OPEC Energy Review, 36(4), 375-382. DOI: 10.1111/opec.2012.36.issue-4

Amano, R. A., &Van Norden, S. (1998). Oil prices and the rise and fall of the US real exchange rate. Journal of international Money and finance, 17(2), 299-316.DOI: 10.1016/s02615606(98)00004-7.

Ang, A., & Bekaert, G. (2002). Regime switches in interest rates. Journal of Business and Economic Statistics, 20(2), 163-182. https://doi.org/10.1198/073500102317351930

Antonakakis, N., Chatziantoniou, I., & Filis, G. (2017). Oil shocks and stock markets: Dynamic connectedness under the prism of recent geopolitical and economic unrest. International Review of Financial Analysis, 50(3), 1-26. DOI: 10.1016/j.irfa.2017.01.004

Antonio J, G., & Luis A, H. (2022). Inflation, oil prices and exchange rates. The Euro's dampening effect. Journal of Policy Modeling, 44(1), 130-146. DOI:10.1016/j.jpolmod.2021.12.001

Apergis, N., &Miller, S. M. (2009). Do structural oil-market shocks affect stock prices?. Energy economics, 31(4), 569-575. DOI:10.1016/j.eneco.2009.03.001

Atems, B., Kapper, D., & Lam, E. (2015). Do exchange rates respond asymmetrically to shocks in the crude oil market? Energy Economics, 49(3), 227-238. DOI: 10.1016/j.eneco.2015.01.027

Azman Aziz, M. I., & Bakar, A. (2011). Oil price and exchange rate: A comparative study between net oil exporting and net oil importing countries. European Journal of Economics, Finance and Administrative Sciences, (42), 13-28.

Baek, J. (2022). Does COVID-19 play any role in the asymmetric relationship between oil prices and exchange rates? Evidence from South Korea. Economic Analysis and Policy, 74, 553-559. DOI: 10.1016/j.eap.2022.03.015

Basher, S. A., Haug, A. A., & Sadorsky, P. (2016). The impact of oil shocks on exchange rates: A Markov-switching approach. Energy Economics, 54(2), 11-23. DOI: 10.1016/j.eneco.2015.12.004

Beckmann, J., Czudaj, R. L., & Arora, V. (2020). The relationship between oil prices and exchange rates: Revisiting theory and evidence. Energy Economics, 88(2020), 1-12,104772. DOI: 10.1016/j.eneco.2020.104772

Bénassy-Quéré, A., Mignon, V., & Penot, A. (2007). China and the relationship between the oil price and the dollar. Energy policy, 35(11), 5795-5805.DOI:10.1016/j.enpol.2007.05.035

Blomberg, S. B., and Harris, E. S. (1995). The commodity-consumer price connection: fact or fable?. Economic Policy Review, 1(3),21–38.

Breitenfellner, A., & Cuaresma, J. C. (2008). Crude oil prices and the USD/EUR exchange rate. Monetary Policy and the Economy, 4(2008), 102-121.

Chen, H., Liu, L., Wang, Y., & Zhu, Y. (2016). Oil price shocks and US dollar exchange rates. Energy, 112(10), 1036-1048. DOI: 10.1016/j.energy.2016.07.012

Chen, S. S., & Chen, H. C. (2007). Oil prices and real exchange rates. Energy economics, 29(3), 390-404. DOI: 10.1016/j.eneco.2006.08.003

Chen, Y. C., Rogoff, K. S., & Rossi, B. (2010). Can exchange rates forecast commodity prices?. The Quarterly Journal of Economics, 125(3), 1145-1194. https://doi.org/10.1162/qjec.2010.125.3.1145

Dawson, J. C. (2006), The Effect of Oil Prices on Exchange Rates: A Case Study of The Dominican Republic. The Park Place Economist, 14(2), 1-9.

Delgado, N. A. B., Delgado, E. B., & Saucedo, E. (2018). The relationship between oil prices, the stock market and the exchange rate: evidence from Mexico. The North American Journal of Economics and Finance, 45, 266-275. DOI: 10.1016/j.najef.2018.03.006

Dumrongrittikul, T., & Anderson, H. M. (2016). How do shocks to domestic factors affect real exchange rates of Asian developing countries? Journal of Development Economics, 119(3), 67-85. DOI: 10.1016/j.jdeveco.2015.10.004

Fowowe, B. (2014). Modelling the oil price–exchange rate nexus for South Africa. International Economics, 140, 36-48. DOI: 10.1016/j.inteco.2014.06.002

Fratzscher, M., Schneider, D., & Van Robays, I. (2014). Oil prices, exchange rates and asset prices (Working paper series no 1689). European Central Bank, Frankfurt, Germany. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2277448

Ghosh, S. (2011). Examining crude oil price–Exchange rate nexus for India during the period of extreme oil price volatility. Applied Energy, 88(5), 1886-1889. DOI: 10.1016/j.apenergy.2010.10.043 .

Ghosh, S., & Kanjilal, K. (2016). Co-movement of international crude oil price and Indian stock market: Evidences from nonlinear cointegration tests. Energy Economics, 53, 111-117. DOI: 10.1016/j.eneco.2014.11.002.

Golub,S.(1983).Oil price and exchange rates. Econ Journal,93,576–593.https://doi.org/10.2307/2232396.

Habib, M. M., Butzer, S., & Stracca, L. (2016). Global exchange rate configurations: Do oil shocks matter? IMF Economic Review, 64(3),443–470. DOI: 10.1057/imfer.2016.9.

Hamilton, J. D. (1983). Oil and the macro economy since World War II. Journal of Political Economy, 91(2), 228-248. DOI: 10.1086/261140.

Hamilton, J. D. (2003). What is an oil shock? Journal of Econometrics, 113(2), 363-398. DOI 10.1016/S0304-4076(02)00207-5

Hamilton, J. D. (2009). Causes and Consequences of the Oil Shock of 2007-08 (No. w15002). National Bureau of Economic Research. Working Paper 15002. DOI:10.3386/w15002.

Hasanov, F. (2010). The impact of real oil price on real effective exchange rate: The case of Azerbaijan. MPRA Paper No. 33493, University Library of Munich, Germany. https://mpra.ub.uni-muenchen.de/33493/1/MPRA_paper_33493.pdf

Hashmi, S. M., Chang, B. H., Huang, L., & Uche, E. (2022). Revisiting the relationship between oil prices, exchange rate, and stock prices: An application of quantile ARDL model. Resources Policy, 75(2022), 102543. DOI: 10.1016/j.resourpol.2021.102543

Huang, S., An, H., & Lucey, B. (2020). How do dynamic responses of exchange rates to oil price shocks co-move? From a time-varying perspective. Energy Economics, 86(2020),1-14, 104641. DOI: 10.1016/j.eneco.2019.104641

Huang, Y., & Feng, G. U. O. (2007). The role of oil price shocks on China's real exchange rate. China Economic Review, 18(4), 403-416.DOI: 10.1016/j.chieco.2006.02.003

Hussain, M., Zebende, G. F., Bashir, U., & Donghong, D. (2017). Oil price and exchange rate co-movements in Asian countries: Detrended cross-correlation approach. Physica A: Statistical Mechanics and its Applications, 465, 338-346. DOI: 10.1016/j.physa.2016.08.056

Ji, Q., Liu, M. L., & Fan, Y. (2015). Effects of structural oil shocks on output, exchange rate, and inflation in the BRICS countries: A structural vector auto regression approach. Emerging Markets Finance and Trade, 51(6), 1129-1140. https://doi.org/10.1080/1540496X.2015.1080505

Jiang, Y., Feng, Q., Mo, B., & Nie, H. (2020). Visiting the effects of oil price shocks on exchange rates: Quantile-on-quantile and causality-in-quantiles approaches. The North American Journal of Economics and Finance, 52(C),1-32, 101161. DOI:10.1016/j.najef.2020.101161

Kang, W., Ratti, R. A., & Vespignani, J. (2016). The impact of oil price shocks on the US stock market: A note on the roles of US and non-US oil production. Economics Letters, 145, 176–181. DOI: 10.24149/gwp249

Kang, W., Ratti, R. A., & Yoon, K. H. (2015). Time-varying effect of oil market shocks on the stock market. Journal of Banking and Finance, 61(2), S150-S163. DOI: 10.1016/j.jbankfin.2015.08.027

Kaushik, N., Nag, R., & Upadhyaya, K. P. (2014). Oil price and real exchange rate: The case of India. The International Business and Economics Research Journal (Online), 13(4), 809-814. DOI https://doi.org/10.19030/iber.v13i4.8688

Kilian, L. (2008). A comparison of the effects of exogenous oil supply shocks on output and inflation in the G7 countries. Journal of the European Economic Association, 6(1), 78-121. DOI: 10.1162/JEEA.2008.6.1.78

Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. American Economic Review, 99(3), 1053-69. DOI:10.1257/aer.99.3.1053

Kilian, L., & Park, C. (2009). The impact of oil price shocks on the US stock market. International Economic Review, 50(4), 1267-1287.

Kin, S., & Courage, M. (2014). The impact of oil prices on the exchange rate in South Africa. Journal of Economics, 5(2), 193-199.DOI: 10.1080/09765239.2014.11884996

Koop, G., Leon-Gonzalez, R., & Strachan, R. W. (2009). On the evolution of the monetary policy transmission mechanism. Journal of Economic Dynamics and Control, 33(4), 997-1017. DOI: 10.1016/j.jedc.2008.11.003

Krugman, P.(1983). Oil shocks and exchange rate dynamics. In: 3. NBER Chapters, in: Exchange Rates and International Macroeconomics, pages 259-284, National Bureau of Economic Research.

Kumar, S. (2019). Asymmetric impact of oil prices on exchange rate and stock prices. The Quarterly Review of Economics and Finance, 72, 41-51. DOI: 10.1016/j.qref.2018.12.009

Lee, C. C., & Lee, C. C. (2019). Oil price shocks and Chinese banking performance: Do country risks matter?. Energy Economics, 77(C), 46-53. DOI:10.1016/j.eneco.2018.01.010

Lee, C. Y., & Huh, S. Y. (2017). Forecasting the diffusion of renewable electricity considering the impact of policy and oil prices: The case of South Korea. Applied energy, 197, 29-39. DOI: 10.1016/j.apenergy.2017.03.124

Lee, J. H., Byun, H. S., & Park, K. S. (2019). How does product market competition affect corporate takeover in an emerging economy?. International Review of Economics and Finance, 60, 26-45. DOI: 10.1016/j.apenergy.2017.03.124

Lee, K., Ni, S., & Ratti, R. A. (1995). Oil shocks and the macroeconomy: the role of price variability. The Energy Journal, 16(4),39-56. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol16-No4-2

Lin, B., & Su, T. (2020). Mapping the oil price-stock market nexus researches: A scientometric review. International Review of Economics and Finance, 67(2020), 133–147. https://doi.org/10.1016/j.iref.2020.01.007.

Lin, B., & Su, T. (2020). Does oil price have similar effects on the exchange rates of BRICS?. International Review of Financial Analysis, 69(2020), 101461. DOI: 10.1016/j.irfa.2020.101461

Lizardo, R. A., & Mollick, A. V. (2010). Oil price fluctuations and US dollar exchange rates. Energy Economics, 32(2), 399-408.DOI: 10.1016/j.eneco.2009.10.005

Malik, F., & Umar, Z. (2019). Dynamic connectedness of oil price shocks and exchange rates. Energy Economics, 84(2019), 104501. https://doi.org/10.1016/j.eneco.2019.104501.

Mensah, L., Obi, P., & Bokpin, G. (2017). Cointegration test of oil price and us dollar exchange rates for some oil dependent economies. Research in International Business and Finance, 42, 304-311. DOI: 10.1016/j.ribaf.2017.07.141

Narayan, P. K., & Gupta, R. (2015). Has oil price predicted stock returns for over a century?. Energy Economics, 48, 18-23. DOI: 10.1016/j.eneco.2014.11.018

Narayan, P. K., Narayan, S., & Prasad, A. (2008). Understanding the oil price-exchange rate nexus for the Fiji islands. Energy Economics, 30(5), 2686-2696. DOI:10.1016/j.eneco.2008.03.003

Narayan, P. K., Sharma, S., Poon, W. C., & Westerlund, J. (2014). Do oil prices predict economic growth? New global evidence. Energy economics, 41, 137-146. DOI: 10.1016/j.eneco.2013.11.003

Nouira, R., Amor, T. H., & Rault, C. (2019). Oil price fluctuations and exchange rate dynamics in the MENA region: Evidence from non-causality-in-variance and asymmetric non causality tests. The Quarterly Review of Economics and Finance, 73, 159-171. DOI: 10.1016/j.qref.2018.07.011

Ono, S. (2011). Oil price shocks and stock markets in BRICs. The European Journal of Comparative Economics, 8(1), 29-45.

Park, J., & Ratti, R. A. (2008). Oil price shocks and stock markets in the US and 13 European countries. Energy economics, 30(5), 2587-2608.DOI:10.1016/j.eneco.2008.04.003

Pershin, V., Molero, J. C., & de Gracia, F. P. (2016). Exploring the oil prices and exchange rates nexus in some African economies. Journal of Policy Modeling, 38(1), 166-180. DOI: 10.1016/j.jpolmod.2015.11.001

Ready, R. C. (2018). Oil prices and the stock market. Review of Finance, 22(1), 155–176. DOI:10.1093/rof/rfw071

Reboredo, J. C. (2012). Modelling oil price and exchange rate co-movements. Journal of Policy Modeling, 34(3), 419-440. DOI: 10.1016/j.jpolmod.2011.10.005

Roubaud, D., and Arouri, M. (2018). Oil prices, exchange rates and stock markets under uncertainty and regime-switching. Finance Research Letters, 27, 28-33. DOI: 10.1016/j.frl.2018.02.032

Castro Rozo, C., & Jiménez-Rodríguez, R. (2018). Time-varying relationship between oil price and exchange rate. MPRA Working paper No. 87879. https://mpra.ub.uni-muenchen.de/87879/1/MPRA_paper_87879.pdf

Sadorsky, P. (1999). Oil price shocks and stock market activity. Energy economics, 21(5), 449-469.

Sadorsky, P. (2000). The empirical relationship between energy futures prices and exchange rates. Energy Economics, 22(2), 253–266.

Shair, G., Ali, A., & Siraj, W. (2015). Crude oil prices and Pakistani Rupee-US dollar Exchange Rate: An analysis of Preliminary Evidence. European Journal of Business and Management, 7(7), 442-447

Sujit, K. S., & Ray, S. (2023). Linear and nonlinear asymmetric relationship in crude oil, gold, stock market and exchange rates: An evidence from the UAE. Resources Policy, 83, 103633. DOI: 10.1016/j.resourpol.2023.103633

Wang, Y., Wu, C., & Yang, L. (2013). Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries. Journal of Comparative Economics, 41(4), 1220-1239. DOI: 10.1016/j.jce.2012.12.004

Yang, L., Cai, X. J., & Hamori, S. (2017). Does the crude oil price influence the exchange rates of oil-importing and oil-exporting countries differently? A wavelet coherence analysis. International Review of Economics and Finance, 49, 536-547. DOI: 10.1016/j.iref.2017.03.015

Youssef, M., & Mokni, K. (2020). Modeling the relationship between oil and USD exchange rates: Evidence from a regime-switching-quantile regression approach. Journal of Multinational Financial Management, 55, 100625. DOI: 10.1016/j.mulfin.2020.100625

Yousefi, A., & Wirjanto, T. S. (2004). The empirical role of the exchange rate on the crude-oil price formation. Energy Economics, 26(5), 783-799. DOI:10.1016/j.eneco.2004.06.001

Zhang, X., & Baek, J. (2022). The role of oil price shocks on exchange rates for the selected Asian countries: Asymmetric evidence from nonlinear ARDL and generalized IRFs approaches. Energy Economics, 112, 106178. DOI: 10.1016/j.eneco.2022.106178

Zhang, Y. F., Fan. Y., Tsai, H.T., & Wei, Y.M. (2008). Spillover effect of US dollar exchange rate on oil prices. Journal of Policy Model, 30(6),973–991. DOI: 10.1016/j.jpolmod.2008.02.002