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Abstract

The aim of this paper is to investigate the exchange rate consequences of oil-price fluctuations and to test for the dynamics of oil price volatility by examining interactions between oil market and exchange rate in selected MENA countries (Egypt, Jordan, Morocco, Qatar, Saudi Arabia, Tunisia, and UAE). Using daily time series data covering the period from January 1, 2001 to December 29, 2017, we implement the test for asymmetric non-causality of Hatemi-J (2012), the asymmetric generalized impulse response functions of Hatemi-J (2014), and the test for non-causality-in-variance of Hafner and Herwartz (2006) to examine the presence of volatility spillover between oil prices and exchange rates return series. The econometric investigation reveals in particular that i) when prices are rising in Tunisia and Saudi Arabia, oil prices cause change in exchange rates, and ii) there is significant evidence of volatility spillovers from oil markets to exchange rate markets in the selected MENA countries. These findings have important implications both from the investor's and from the policy-maker's perspective.

Keywords: oil price shocks, exchange rate volatility, asymmetric causality test, asymmetric generalized impulsion functions, causality-in-variance tests, MENA countries.

JEL-Codes: F310, G010, Q430.

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1. Introduction

Oil is one of the most important forms of energy and is a significant determinant of global economic performance. Since the oil price shocks of the 1970s, the price of crude oil and its consequences on various economic magnitudes have continued to attract interest from economists and policy makers. Such a topic has a great interest in international economics and is still debated.

In this context, several studies have focused on the oil price impacts on macroeconomic performance. Hamilton (2000, 2011), Hooker (2002), Dogrul and Soytas (2010) confirmed the oil price fluctuations impact on inflation. In particular, the exchange rate is considered as the primary channel through which the fluctuations of oil prices traded in US dollars are transmitted to the real economy and financial markets (Reboredo, 2012). Indeed, an oil price increase has an effect on a nation's wealth as it leads to a transfer of income from oil importing to oil exporting countries through a shift in the terms of trade. Through a shift in the balance of trade, exchange rates are also expected to change.

Furthermore, the consequence of oil prices on exchange rate movements has been emphasized by Amano and Van Norden (1998) and recently has been renewed by several authors, as Kin and Courage (2014), Oriavwote and Eriemo (2012), Basher *et al.* (2011), Aziz (2009). Such studies argue that increases in the oil price of the oil-exporter (oil importer) lead to an increase (decrease) in the relative price of commodities. This entails an appreciation (depreciation) of exchange rate (Chaudhuri and Daniel, 1998).

Other studies underlined that a rise in the oil price can lead to either an appreciation or a depreciation of the exchange rate (Benassy-Quere *et al.*, 2007). Indeed, the effect of an oil price increase depends on the oil intensity of tradable and non-tradable sectors in the country: if the non-tradable sector is less (more) energy intensive, then the exchange rate will depreciate (appreciate).

Besides, the literature showed that a nonlinear relationship can exist between open price and exchange rate. In this sense, Akram (2004) finds that fluctuations of oil price affect the Norwegian exchange rate in a negative non-linear way, especially when oil prices are below 14 USD. Other works (for instance, Cooper, 1994; Benhmad, 2012; and Brahmasrene 2014) found an opposite direction of causation.

Although oil imports represent a significant fraction of the trade balance for energy-dependant economies, the literature concerning the impact of oil prices on exchange rates is mostly available for oil-producers, neglecting small open emerging countries and oil-importers. Indeed, oil exporters should consider the role that the choice of foreign exchange regime can play in the adjustment process" (McCown *et al*., 2006).

In particular, the causality relation between oil prices and exchange rates has been widely examined in the literature using Granger's causality tests (Chen and Chen, 2007; Lizardo and Mollick, 2010; Tiwari *et al.*, 2013). Several authors also have adopted nonlinear frameworks when assessing this relationship (Chen et al., 2004; Diks and Panchenko, 2006). Moreover, several studies (Jammazi et al., 2015; Aloui and Jammazi, 2015) highlighted the asymmetric relationship between oil prices and exchange rates. Recently, Jawadi *et al.* (2016) investigated the instantaneous intraday linkages between oil price and US$/euro volatilities. It should be noted, that, while the relation between oil price and exchange rate has been widely investigated, there has been less interest in the determinants of oil price volatility. Indeed, the volatility of oil prices can affect the behavior of exchange rate volatility, which implies in this case that both oil prices and exchange rates are interrelated with respect to volatility.

Furthermore, and in spite of the general acknowledgment that oil plays a significant role in most MENA countries, which is particularly sensitive to those changes in oil prices (both oil producers and dependent on petroleum as consumers), little evidence exists on the effects of oil price shocks on exchange rate fluctuations in the MENA context. In fact, over the past decades, the MENA region has experienced several inflationary shocks. To reduce price volatility and inflation, many MENA countries have chosen the policy of fixed exchange rates as the preferred policy anchor. Indeed, by pegging their national currencies to a strong currency (as the US dollar) they could avoid exchange rate volatility damaging to their economic activity, escape speculative attacks and reduce the risk premiums and the cost of international financing. But, in the last decades, some MENA countries as Egypt, Morocco, Tunisia and Turkey have moved towards greater exchange rate flexibility.

Given these considerations our paper contributes to the literature by reassessing the exchange rate dynamic consequences of oil-price fluctuations for selected MENA countries (including both commodity importers and exporters) using daily time series data covering the period from January 1, 2001 to December 29, 2017, and test for the existence of possible asymmetric volatility. Specifically, our econometric strategy is composed of three steps. First, since the traditional Granger non-causality testing approach is unable to uncover a nonlinear causal relationship between oil prices and exchange rates, we implement the test for asymmetric non-causality developed by Hatemi-J (2012). Second, following Hatemi-J (2014) we calculate generalized impulse response functions to investigate the dynamic response of each exchange rate return to a standardized shock in oil prices. Third, we examine the presence of (possible) volatility transmission between oil prices and exchange rates using the test for non-causality-in-variance developed by Hafner and Herwartz (2006), as well as the test developed by Nakatani and Teräsvirta (2010).

The remainder of the paper is organized as follows. Section 2 reviews the main results of the theoretical and empirical literature on the oil prices -exchange rate nexus. Section 3 describes the methodology used. Section 4 presents the data and offers a preliminary analysis. Section 5 presents the models, and discusses the results of the econometric analysis. Finally, section 6 summarizes our conclusions.

2. Literature review

This section provides a discussion on the theoretical literature by reviewing the main channels of the effect of oil prices on the exchange rate. It also focuses on existing empirical studies.

2.1- Theoretical Literature

Oil prices affect exchange rates mainly through a two way transition mechanism which includes both supply and demand strands (Nikbakht 2009). On the supply side, oil price increases affect production negatively since oil is a basic factor of production. Any increase in the price of a production factor raises the cost of production of non-tradable goods and leads to an increase in prices of non tradable goods, and to an exchange rate appreciation. Contrarily, from the demand side, the exchange rate is indirectly affected through its relation with disposable income (Nikbakht 2009). Thus, a rise in oil prices reduces consumers spending power. This reduces the demand for non-tradable goods leading to a fall in their prices and ultimately depreciating the exchange rate.

This literature provides a theoretical nexus oil prices and exchange rate through many channels which permits to explain the impact of oil price on exchange rates (Benassy-Quere *et al*., 2007; Beckman and Czudaj, 2013). The main strands investigating the transmission mechanisms between oil prices and exchange rates, are terms of trade and balance of payments and international portfolio choice approaches.

Terms of trade channel: it is derived from the work of Amano and van Norden (1998) who suggest a model with two sectors: tradable and non-tradable. Both sectors use a tradable input which is oil, and a non-tradable input which is labour. Inputs are mobile between the sectors. The model also considers that the output price of the tradable sector is fixed internationally. Benassy-Quere *et al.* (2007) assume that if a rise of oil price affects the output prices of tradable and non-tradable sector, an increase of oil price can lead to either an appreciation or a depreciation of the exchange rate since it depends on the oil intensity of both sectors. As a result of this, the real exchange rate corresponds to the output price in the non-tradable sector. Indeed, in the case where the non tradable sector is more (less) energy intensive than the tradable one, its output price rises (falls) and real exchange rate appreciates (depreciates).

The balance of payments and international portfolio choices: it is also called the wealth transmission channel. The key idea originally initiated by Krugman (1983) and Golub (1983) is that oil price changes have an impact on international portfolio decisions and trade balances. This view acknowledges that higher oil prices will transfer wealth from oil importers to oil exporters. Specifically, Krugman (1980) employed a model to investigate the effect of an oil price increase on the US dollar. He showed that that the US dollar will appreciate in the short run whereas it will depreciate in the long run (Benassy-Quere, Mignon and Penot, 2007). He argued that differences in the response of foreign exchange markets to oil shocks seen in 1970's due especially by the portfolio choices of oil importing and oil exporting countries. Initially the relation would be positive because oil profits are invested in US dollar assets, but it might turn to negative in the long run since over time OPEC's spending rises, as a result of the wealth from higher oil prices, with a preference for manufactured products from industrial countries. If such OPEC imports come from countries other than the US, the US dollar will appreciate in the short run but not in the long run.

The elasticity approach: the impact of oil prices on the exchange rate depends on the elasticity of import demand of the importing country. Price elasticity of demand is a measure of the responsiveness of quantity demanded to a change in price (Jehle and Reny, 2011). If quantity demanded is highly responsive (not responsive) to a change in price, then demand is said to be relatively elastic (inelastic). When a nation's commodities prices (oil) rise, they become relatively more expensive in the global market (Nkomo, 2006). Hence importing countries will reduce their imports of oil. But, the evolution of imports depends on elasticity of imports. Indeed, if import demand of oil is highly inelastic, a rise in oil prices causes a depreciation in the currency of the importing country. An increase (decrease) in the oil price means that the importing country requires more (less) of its currency in order to buy the same amount of oil it used to buy before. Hence there would be deprecation (appreciation) in the currency of the importing country.

This interaction between oil prices and real exchange rate implies that this link is linear after the first oil shock (Hamilton, 1983). Besides, the literature showed that a nonlinear relationship can exist between open price and exchange rate. In this sense, Raymond and Rish (1997) estimated a model with Markov switching regime to evaluate and compare the impact of trends in rising and falling oil prices on fluctuations of the U.S. economic aggregate before and after the world war considering this model on two sub-periods. More recently, Akram (2004) finds that fluctuations of oil price affect the Norwegian exchange rate in a negative non-linear way, especially when oil prices are below 14 USD.

2.2- Empirical Literature

This section reviews empirical studies that have been conducted into the oil price-exchange rate nexus.

Many early empirical studies were conducted for advanced economies and used cointegration and causality analysis. Chaudhuri and Daniel (1998), Huang and Guo (2007), Benassy-Quere *et al.* (2007) found that a rise of oil price leads to an exchange rate appreciation. On the contrary Chen and Chen (2007) found that oil prices lead to depreciation of exchange rates in G7 countries. Norden (1998b) obtained mixed results. Akram (2002) explored the possibility of a non- linear relationship between oil prices and the Norwegian exchange rate. Their results revealed a negative relationship between oil prices and the value of the Norwegian exchange rate, and that it was relatively strong when oil prices were below 14 dollars and were falling. Ozturk *et al.* (2008) studied the link between international oil prices and the exchange rate in a small open industrial economy. The cointegration and Granger causality tests were used to analyze the relationship over the period of December 1982 to May 2006. They found out that international real crude oil prices Granger cause the United States (USD)/ Turkish Lira (YTL) real exchange rate.

More recently, many studies have adopted GARCH models and wavelets and copulas, and there has been an increase in studies conducted for emerging economies. Ghosh (2011) examined the oil price–exchange rate nexus for India. The authors used GARCH and EGARCH models and showed that oil price increases lead to a depreciation of the exchange rate. Reboredo and Rivera-Castro (2013) studied the relationship between oil prices and U.S. dollar using wavelet multi-resolution analysis. The results showed no evidence of a relationship prior to the global crisis, while in the post-crisis period, there was a negative dependence between oil prices and exchange rates. Aloui *et al.* (2013) used the copula-GARCH approach to examine the relationship between oil prices and the U.S. dollar exchange rates of 5 foreign exchange markets (the Euro zone, Canada, Britain, Switzerland, and Japan). They showed that oil price increases are associated with the dollar depreciation. Tiwari *et al.* (2013a) used a wavelet decomposition to test for linear and nonlinear causality within different frequency bands, and found no relationship at lower time scales. However, bi-directional causality was found at higher scales. Tiwari *et al.* (2013b) examined the effect of oil prices on the real effective exchange rate in Romania using a discrete wavelet transform approach. Their results showed that oil prices have a strong causal effect on real effective exchange rate in both the short and long run. Wu *et al.* (2012) performed a dynamic copula-GARCH analysis of the dependence between crude oil and USD exchange rate returns, and found that the dependence structure becomes negative and decreases continuously after 2003.

Oriavwote and Eriemo (2012) employed Johansen cointegration test and the Granger Causality test using Nigerian time series data for the period between 1980 and 2010. Their findings from the implementation of GARCH tests suggest persistence of the volatility between the real oil prices and the real effective exchange rate. Turhan *et al.* (2013) examined the effects of oil prices on the exchange rates in 13 emerging economies (Argentina, Brazil, Colombia, Indonesia, Mexico, Nigeria, Peru, the Philippines, Poland, Russia, South Africa, South Korea and Turkey). They showed that with the exception of Argentina and Nigeria, after the global crisis, oil price shocks lead to depreciation of the exchange rates. The generalized impulse response functions were employed to get the impact on three time horizons. Their findings showed that oil price dynamics impact on exchange rate changes over time and that the impact was more pronounced after the 2008 financial crises.

Salisu and Mobolaji (2013) investigated volatility transmission between oil price and US-Nigeria exchange rate by using a VAR-GARCH model accounting for structural breaks. Their results established a bi-directional spillover transmission mechanism between oil and foreign exchange markets. Buetzer *et al.* (2012) investigated whether oil shocks matter for global exchange rate configurations. Their paper was based on data on real and nominal exchange rates as well as on an exchange market pressure index for 44 advanced and emerging countries. Using VAR models they found no evidence that exchange rates of oil exporters systematically appreciate against those of oil importers aftershocks that raise the real oil price. However, oil exporters experienced significant appreciation pressures following an oil demand shock, which they tend to counter by accumulating foreign exchange reserves. Basher, Haug and Sadorsky (2010) also examined the relationship between oil prices, exchange rates and emerging markets stock prices via SVAR models over the 1988 to 2008 period. The authors studied the relationship between oil prices and exchange rates and offered limited support for the existence of such relationship between these variables. In addition they found that while responding negatively to a positive oil price shock, oil prices respond positively to a positive emerging market shock. Mendez-Caebajo (2010) studied the impact of oil prices on floating exchange rate of the Dominican peso during the 1990-2008 period. The vector error correction model was employed in investigating the relationship. The findings showed that a 10% rise in the price of gas coincides with a 1.2% depreciation of the peso in the long run and that the causality runs from gas prices to the peso.

More recently Nakajima *et al.* (2012) tested for Granger non-causality-in-mean and Granger non-causality -in-variance among electricity prices, crude oil prices, and the yen-to-US-dollar exchange rates in Japan using a cross-correlation function approach. They found no evidence of Granger-causality-in-mean from the exchange market, nor from the oil market to the power market. Similar findings were obtained from the Granger non-causality tests-in-variance. Besides, Jammazi *et al.* (2015), and Aloui *et al.* (2015) highlighted the asymmetric relationship between oil prices and exchange rates. Jawadi *et al.* (2016) used recent intraday data to measure realized volatility. Specifically, they investigated the instantaneous intraday linkages between oil price and US$/euro volatilities. They found a negative relationship between the US dollar/euro and oil returns indicating that a US$ appreciation decreases oil price.

3. Econometric methodology

In this study, our attention is not only focused on the relationships between returns of oil prices and exchange rates, but also on the causality-in variance (or in other words spillovers in risk). Indeed, the volatility of oil prices can affect the behavior of exchange rate volatility, which implies in this case that both oil prices and exchange rates are interrelated with respect to volatility. The oil prices and exchange rates time series tend to quickly interact with each other and thereby exhibit a volatility transmission structure known as volatility spillover. Recently, the study of causality in variance has gained considerable attention both among academics and practitioners because of its economic and statistical significance. Indeed, changes in variance are said to reflect the entrance of information and the extent to which the market evaluates and assimilates new information. In this context, we investigate in this paper the presence of volatility spillover (or in other words causality in variance) between oil prices and exchange rates return series using the test for non-causality-in-variance developed by Hafner and Herwartz (2006).

3.1- Test for Asymmetric non-causality

In the real world, whether through information phenomenon or from another reason, the behavior of oil price changes is asymmetric which can induce asymmetric causal effects[4]. It is asymmetric in the sense that positive and negative shocks may have different causal impacts. The conventional Granger non-causality test (GC) cannot distinguish between the causal impact of positive and negative shocks. Therefore, following Hatemi (2012), tests for asymmetric non-causality (positive and negative) are conducted here to examine the possibility of asymmetric causal relationships between exchange rate and oil price. Hatemi suggests that tests for non-causality should be implemented by using cumulative sums of

[4] In the economic theory Akerlof (1970), Spence (1973), and Stiglitz (1974) have presented arguments for the existence of asymmetric effects.

positive and negative components of the underlying variables. The idea of transforming data into both cumulative positive and negative changes originates from Granger and Yoon (2002). More specifically, assuming a causal relationship between two integrated variables, $y_{1,t}$ and $y_{2,t}$, Hatemi proposed a random walk process of the following format:

$$y_{1,t} = y_{1,t-1} + \zeta_{1,t} = y_{1,0} + \sum_{i=1}^{t} \zeta_{1i} \qquad (1)$$

$$y_{2,t} = y_{2,t-1} + \zeta_{2,t} = y_{2,0} + \sum_{i=1}^{t} \zeta_{2i} \qquad (2)$$

, where $y_{1,0}$ and $y_{2,0}$ represent initial values. Hatemi then defined positive and negative shocks respectively as

$\zeta_{1i}^{+} = \max(\zeta_{1i}, 0); \zeta_{1i}^{-} = \min(\zeta_{1i}, 0); \zeta_{2i}^{+} = \max(\zeta_{2i}, 0); \zeta_{2i}^{-} = \min(\zeta_{2i}, 0)$ These shocks can then be expressed as $\zeta_{1i} = \zeta_{1i}^{+} + \zeta_{1i}^{-}$ and $\zeta_{2i} = \zeta_{2i}^{+} + \zeta_{2i}^{-}$.

The critical values of the test for asymmetric non-causality are obtained using a bootstrap algorithm with leverage corrections.

3.2- Test for non-causality in variance

Two approaches have been suggested in the literature for testing for non-causality-in-variance. The former is a two-step methodology developed by Cheung and Ng (1996) and is based on the cross correlation function (CCF) of squared univariate GARCH residual estimates. The corresponding CCF-based Portmanteau test is likely to suffer from significant over sizing in small samples when the volatility processes are leptokurtic. The latter has been introduced by Hafner and Herwartz (2006) who provide a new way for testing for the volatility spillover effect. This test is based on a Lagrange multiplier (LM) statistic that overcomes the shortfalls of Cheung and Ng's method, and is easily implementable in applied studies. Specifically, the test for non-causality in variance of Hafner and Herwartz (2006) require estimating univariate GARCH models. To test for the null hypothesis of non-causality in variance between returns i and j, the following model is put forth as:

$$\varepsilon_{it} = \xi_{it}\sqrt{\sigma_{it}^{2} g_{t}} \quad ; \; g_{t} = 1 + Z_{jt}^{'}\pi \quad ; \quad Z_{jt} = \left(\varepsilon_{jt-1}^{2}\,,\; \sigma_{jt-1}^{2}\right)^{'} \qquad (3)$$

, where $\sigma_{it}^{2} = w_{t} + \alpha_{i}\varepsilon_{it-1}^{2} + \beta_{i}\sigma_{it-1}^{2}$ denotes the conditional variance ξ_{it}, standardized errors of the GARCH model; ε_{it} the error terms of GARCH model. Under the null hypothesis, we test whether the π coefficient in (3) is significantly different from zero or not, implying that there is no causality in variance if the null is not rejected. Hafner and Herwartz (2006) propose the following LM test in order to determine the volatility transmission between the series:

$$\lambda_{LM} = \frac{1}{4T}\left(\sum_{t=1}^{T}(\xi_{it}^{2} - 1)Z_{jt}^{'}\right)V(\theta_{i})^{-1}\left(\sum_{t=1}^{T}(\xi_{it}^{2} - 1)Z_{jt}\right) \qquad (4)$$

$$V(\theta_{i}) = \frac{k}{4T}\left(\sum_{t=1}^{T} Z_{jt}Z_{jt}^{'} - \sum_{t=1}^{T} Z_{jt}x_{it}^{'}\left(\sum_{t=1}^{T} x_{it}x_{it}^{'}\right)^{-1}\sum_{t=1}^{T} x_{it}\, Z_{jt}^{'}\right) \qquad (5)$$

, and $k = \frac{1}{T}\sum_{t=1}^{T}(\xi_{it}^{2} - 1)^{2}$

The asymptotic distribution of λ_{LM} depends on the number of misspecification indicators in $Z_{jt}^{'}$ If for instance there are two misspecification indicators then the test will have an asymptotic chi-square distribution (see Hafner and Herwartz, 2006, for further details).

4. Data and preliminary analysis

Our data include daily WTI crude oil price and eight exchange rates expressed in dollar (USD). All data are sourced from the (http//www.eia.com) and (http//www.Oanda.gov). The sample covers a period from January 01, 2001 until December 29, 2017, leading to a sample including 4435 observations. For each exchange rate and crude oil, the continuously compounded return is computed as $r_t = 100 \times \ln(p_t/p_{t-1})$ for $t = 1,2, \ldots, T$, where p_t is the price on day t.

Summary statistics for crude oil and exchange market returns are displayed in Table 1 (Panel A). From these tables, (WTI) is the most volatile, as measured by the standard deviation of 2.39%, while USD/AED is the less volatile with a standard deviation of 0.019%. Besides, we observe that USD/AED has the highest level of excess kurtosis, indicating that extreme changes tend to occur more frequently for the exchange rate. In addition, all exchange market returns exhibit high values of excess kurtosis. To accommodate the existence of "fat tails", we assume student-t distributed innovations. Furthermore, the Jarque-Bera statistic rejects the null of normality at the 1% level for all exchange rate and crude oil. Moreover, according to the efficient unit-root test of Elliott *et al.* (1996) [5] all exchange market return series and oil price are found to be stationary in level (Panel C). Finally, they exhibit volatility clustering, revealing the presence of heteroskedasticity and strong ARCH effects.

[5] We have also carried out the Kwiatkovski–Phillips–Schmidt–Shin (Kwiatkowski *et al.* 1992) test, recently extended by Carrion-i-Silvestre and Sanso (2006), and we have obtained very similar results, *i.e.* the stationarity of all variables in level.

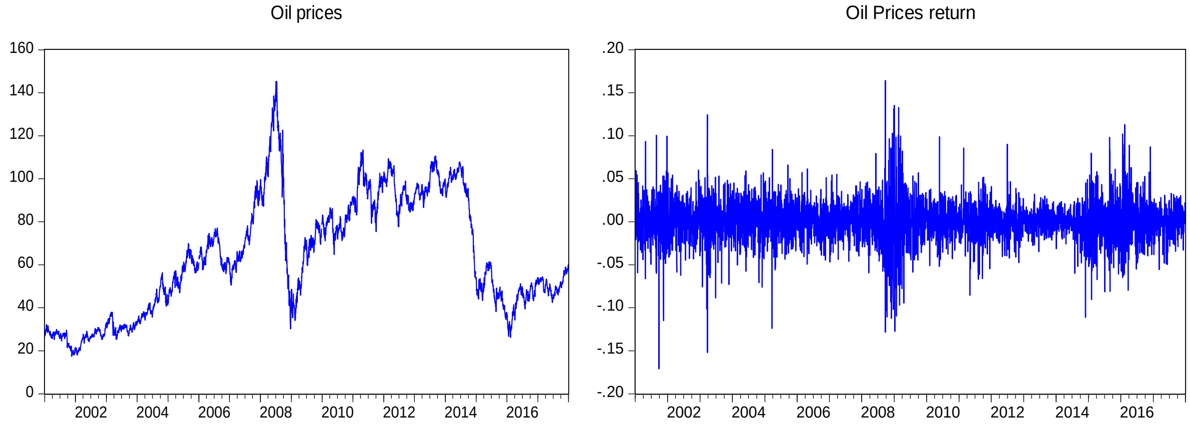
Table 1. Summary statistics for all series (returns)

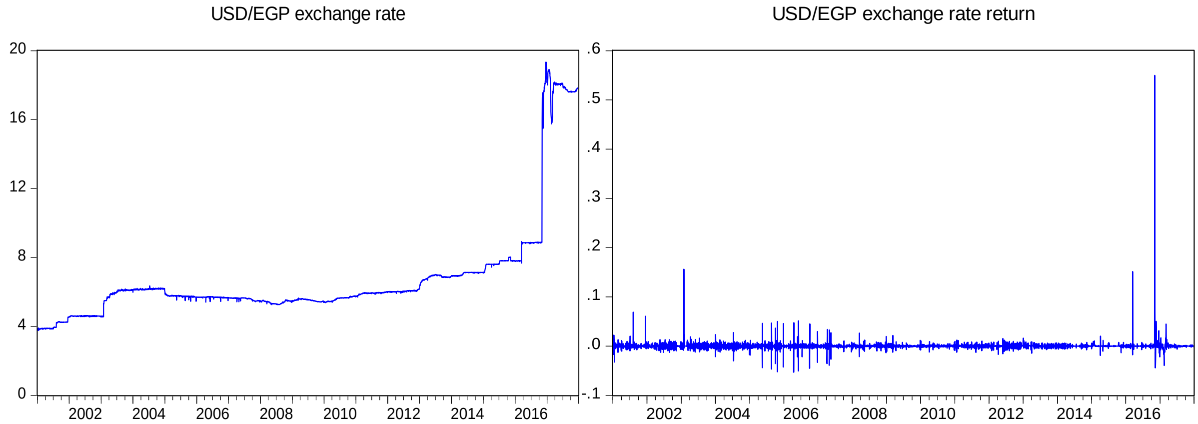
	WTI	USD/TND	USD/MAD	USD/JOD	USD/EGP	USD/AED	USD/QAR	USD/SAR
				Panel A: descriptive statistics				
Mean	1,70E-04	1,32E-04	-2,72E-05	-9,97E-08	3,46E-04	8,04E-09	-1,55E-06	-1,52E-07
Max	1,64E-01	1,48E-01	6,13E-02	1,33E-02	5,50E-01	7,25E-03	6,92E-02	5,69E-03
Min	-1,71E-01	-1,51E-01	-5,40E-02	-1,25E-02	-5,31E-02	-6,32E-03	-6,89E-02	-5,05E-03
Std. Dev	2,39E-02	1,71E-02	7,78E-03	1,31E-03	1,04E-02	1,91E-04	3,17E-03	3,97E-04
Skewness	-7,91E-02	-9,71E-02	1,03E-01	1,13E-01	3,45E+01	3,77E+00	-2,85E-01	2,59E-01
Kurtosis	7,83E+00	3,54E+01	8,33E+00	2,35E+01	1,76E+03	7,62E+02	1,28E+02	6,31E+01
Jarque-Bera	4,30E+03	1,94E+05	5,25E+03	7,74E+04	5,69E+08	1,06E+08	2,87E+06	6,68E+05
probability	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
				Panel B: Serial correlation and LM-ARCH tests				
$LB(20)$	46.608**	4313.29**	489.121**	635.319*	452.971**	1453.93**	1077.84**	726.669*
$LB^2(20)$	1932.53*	4240.21**	864.986**	763.778*	13.9556	1146.95**	739.38***	2277.1**
ARCH 1-10	54.909**	170.74***	46.60***	58.375**	13.489*	227.18***	1.8091***	175.08**
				Panel C: Unit Root tests				
ADF-GLS test statistic	-21.21	-10.86	-11.58	-12.602	-14.08	-24.24	-23.14	-12.52

Notes: Crude oil and exchange market returns are in daily frequency. Observations for all series in the whole sample period are 4435.. ***, **, and * denote statistical significance at 1%, 5% and 10% levels, respectively. $\mathbf{LB(20)}$ and $\mathbf{LB^2(20)}$ are the 20th order Ljung-Box tests for serial correlation in the standardized and squared standardized residuals, respectively. The ADF-GLS test statistic implements the efficient unit-root test suggested by Elliott *et al.* (1996).

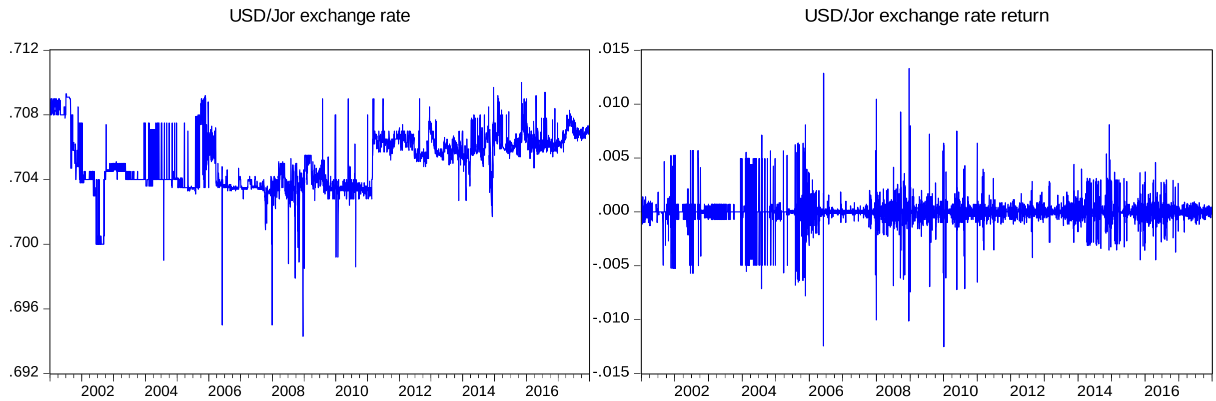
Fig.1 illustrates the evolution of oil prices and exchange rates over the period from January 1, 2001 to December 29, 2017. The figure shows significant variations in the levels during the turmoil, especially at the time of Lehman Brothers failure (September 15, 2008), and at the European sovereign debt crises. Specifically, when the global financial crisis triggered, there was a decline for all prices. The figure shows that all exchange rates and crude oil have trembled since 2008 with different intensity during the global financial and European sovereign debt crises. Moreover, the plot shows a clustering of larger return volatility around and after 2008. This means those exchange rates are characterized by volatility clustering, *i.e.*, large (small) volatility tends to be followed by large (small) volatility, which indicate the presence of heteroskedasticity. This market phenomenon has been widely recognized and successfully captured by ARCH/GARCH family models to adequately describe exchange market return dynamics. This is important because the econometric model is based on the interdependence of the exchange markets in the form of second moments by modeling the time varying variance-covariance matrix for the sample.

Figure 1. Oil prices and exchange rate behavior (raw series and returns) from January 1, 2001 until December 29, 2017 for selected MENA countries

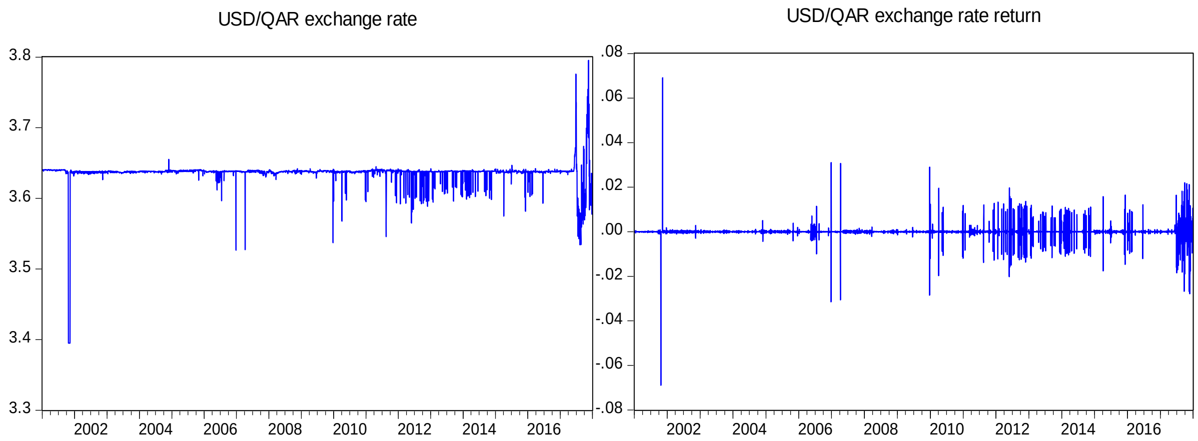




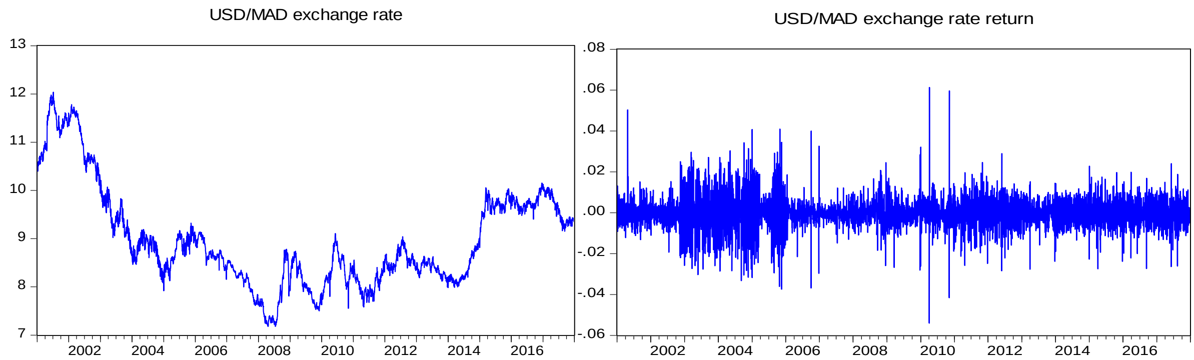
Egypt



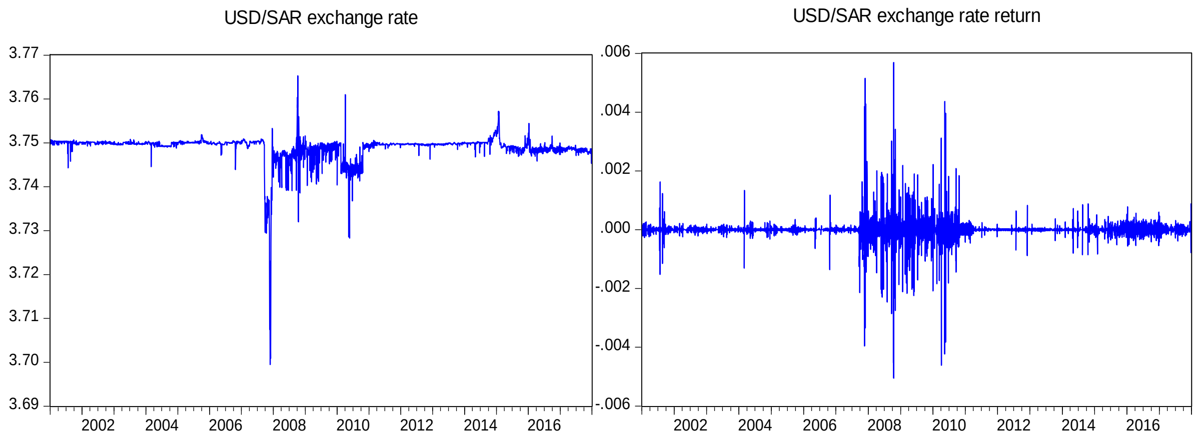
Jordan



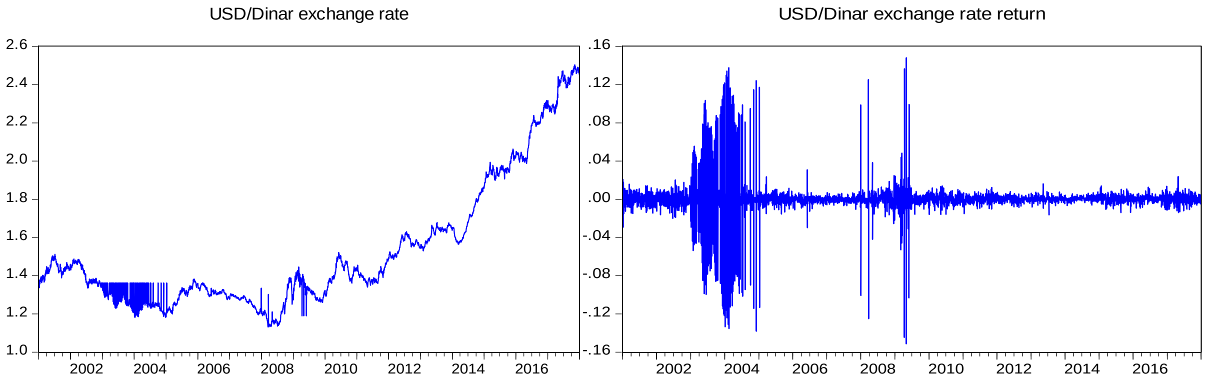
Qatar



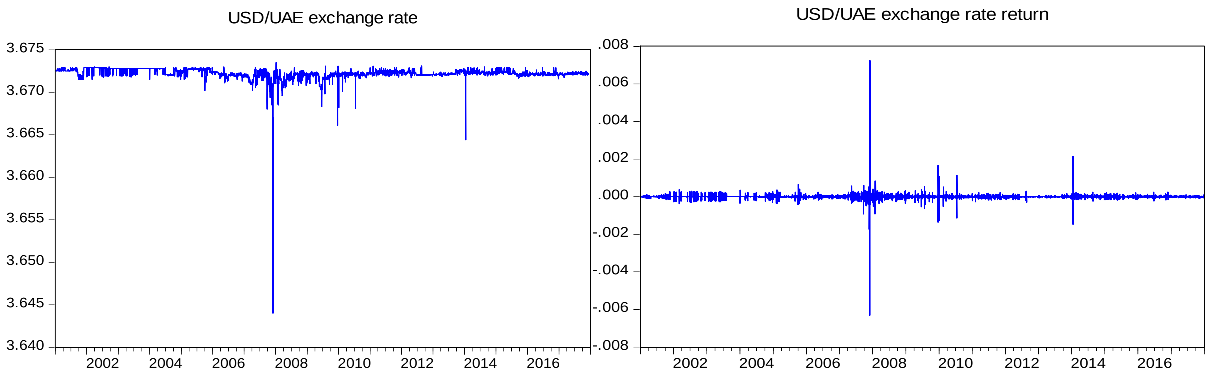
Morocco



Saudi Arabia



Tunisia



UAE

5. Empirical Results

Here we investigate the interdependences existing between oil prices and exchange rates in 7 MENA countries over the January 1, 2001 to December 29, 2017 period. For this purpose, we use a combination of methodologies such as tests for asymmetric non-causality, asymmetric generalized impulse-response functions, and volatility spillover tests for a better understanding of the relationships existing between these variables. This section is organized in three parts. First, we test for the existence of asymmetric non-causality between oil prices and exchange rates return. Second, asymmetric generalized impulse-response functions are calculated in order to assess the reaction of each exchange rate returns to a standardized shock in oil prices Third, we examine whether oil prices uncertainty/volatility is transmitted or not to exchange rates.

5.1 Results of tests for asymmetric non-causality

We now test for the (possible) asymmetric causality relationship between oil price and exchange rate return. Indeed, the behavior of the oil price return changes can be asymmetric which can entail an asymmetric causal that may vary with the sign of oil price changes. We use Hatemi-J (2012) non-causality test to explore how the positive and negative changes in oil price return affect exchange rate returns. A Gauss code produced by Hatemi-J (2012) is used to conduct the asymmetric non-causality test based on bootstrap critical values[6]. The results

[6] The code is available on line.

of asymmetric test for causality are presented in Table 5-1. Cumulative positive (P+, E+) and cumulative negative shocks (P−,−) are used.

Table 5-1. Asymmetric non-causality test for positives values (P+, E+) and negatives values (P−,−)

	Positives values $(\mathbf{P}+, E+)$		Negatives values $(\mathbf{P}-, E-)$	
	Test statistic	**Bootstrap CV at 5%**	**Test statistic**	**Bootstrap CV at 5%**
Egypt	1.86	6.18	4.85	10.14
Jordan	4.77	10.42	6.03	9.87
Qatar	0.23	6.19	4.3	12.04
Morocco	1.81	9.85	2.53	9.05
Saudi Arabia	**11.13****	9.94	**14.2****	9.83
Tunisia	**10.18****	9.78	0.34	6.7
UAE	2.31	11.87	1.3	11.3

Note: The bold face numbers indicate the rejection of the null hypothesis[7] at the 5% level of significance (**) .

According to the results presented in table 5-1, there are only two countries for which the test statistic appears significant: Tunisia only for positive values, and Saudi Arabia both for positive and negative values. The results of the test for asymmetric non-causality reveal that, in Tunisia and Saudi Arabia when prices are rising, oil prices cause change in exchange rates. However, when prices are falling, oil prices cause change in the exchange rate only in Saudi Arabia. These findings are very helpful for policymakers and traders in a strategic investment decision-making perspective.

5.2 Results of asymmetric generalized impulse-response functions

To investigate the dynamic response of each exchange rate returns to a standardized shock in oil prices we employ generalized impulse response graphs. In contrast with impulse response functions for structural models, generalized impulse responses do not require that we identify any structural shocks. Accordingly, generalized impulse responses cannot explain how exchange rate reacts to an oil prices shock. Instead, generalized impulse responses provide a tool for describing the dynamics in time series model by mapping out the reaction of exchange rate to a one standard deviation shock to the residual in oil prices. In what follows we separate the effects of either negative or positive values of the oil price on the exchange rate. Therefore, to examine the impact of a positive or negative shock, the asymmetric generalized impulse response is implemented. Specifically, Hatemi (2014), suggests that variables can be fragmented into positive and negative components in order to get asymmetric generalized impulse response functions (AGIR function). We trace out the AGIR functions of each exchange rate (positive and negative value) to a one standard deviation shock in oil price for all four time frames separately in Figures 3 and 4 (see Appendix). Figure 3 reports the response for the exchange rate represented in cumulative positive changes together with the 95% confidence, whereas figure 4 illustrates the response for the variables in the cumulative negative format jointly with the 95% confidence.

Figure 3 (reported in Appendix) exhibits the reaction for the exchange rate to positive changes together with the 95% confidence interval. The positive variations on the oil price have significant impact on the exchange rate returns of Tunisia and Saudi Arabia. Indeed, for

[7] Note that the null hypothesis of the Granger non-causality test is that oil price does not Granger cause exchange rate ($P^+ \nRightarrow E^+$).

these countries, the exchange rate return is influenced by the oil price returns. An oil price increase is followed by a rise in exchange rate. Consequently, the effect of oil price shock is an exchange rate depreciation. For the other MENA countries, the positive variations on the oil price do not have any significant impact on the exchange rate.

Figure 4 (reported in Appendix) outlines the reaction of the exchange rate in the combined negative configuration with the 95% confidence interval. It clearly emerges from these estimations that, only for Qatar and Saudi Arabia, the total negative progressions of the exchange rate are statistically significant to any negative variation in the crude oil price. In particular, in response to an oil price shock, for Qatar and Saudi Arabia, generally, a negative shock on the oil price leads to a positive effect on the exchange rate (depreciation) during the first day. This effect decreases then slowly before reaching its long-term level. The reaction of exchange rate following this shock vanished in five or six days to return quickly to its normal level.

5.3 Results of tests for non-causality in variance

We now examine the (possible) presence of volatility transmission between oil prices and exchange rates, that is, we test whether an increase or a decrease in oil price volatility affects or not the exchange rate volatility. Few studies have so far investigated volatility co-movements and spillovers among oil prices and exchange rates. Here, we implement the test for non-causality in variance of Hafner and Herwartz (2006) (hereafter HH-test). In order to investigate the robustness of the results, we also employ the test for non-causality in variance developed by Nakatani and Teräsvirta (2010) (hereafter NT-test). This test also relies on a LM statistic obtained from a univariate GARCH model, and is robust to mis-specified zero conditional correlations. Table 5-2 summarizes the results of the two volatility spillover tests.

Table 5-2 Results for the volatility spillover test

	HH-test		**NT-test**	
	Test Stat	P-Value	Test Stat	P-Value
Egypte	23.17***	00	22.51***	00
Jordan	122.4***	00	123.6***	00
Qatar	32.7***	00	31.36***	00
Morocco	37.9***	00	37.6***	00
Saudi Arabia	52.68***	00	54.17***	00
Tunisia	20.23***	00	20.43***	00
UAE	27.8***	00	27.6***	00

*** indicate statistical significance at the 1 level of significance.

For all countries, the null hypothesis of no volatility spillover from oil prices to exchange rates is rejected. This finding clearly shows that there is a risk transfer from oil prices to exchange rates at the 1% significance level. Overall, our analysis yields significant evidence of volatility spillovers from oil markets to exchange rate markets. This information is important for an investor. Indeed, by understanding how historical risk of oil prices affects exchange rates, investors can anticipate/forecast the riskiness of exchange rate.

6- Conclusion

While asymmetries of foreign exchange rate and crude oil price have been the subject of voluminous research in the literature, little evidence exists on the (possible) asymmetric effects of oil price shocks on exchange rate fluctuations in the Middle East and North Africa region. This paper has tried to fill the gap. Specifically, we have considered daily time series data covering the period from January 1, 2001 to December 29, 2017, for the crude oil (WTI) and nominal exchange rate of some selected MENA countries, (Morocco, Egypt, Jordan, Tunisia, UAE, Qatar and Saudi Arabia). We have adopted a three-step econometric methodology. First, we have implemented the test for asymmetric non-causality developed by Hatemi-J (2012). Second, following Hatemi-J (2014) we have calculated generalized impulse response functions to investigate the dynamic response of each exchange rate return to a standardized shock in oil prices. Third, we have examined the presence of (possible) volatility transmission between oil prices and exchange rates using the test for non-causality-in-variance developed by Hafner and Herwartz (2006), as well as the test developed by Nakatani and Teräsvirta (2010).

Our empirical results indicate that foreign exchange market and crude oil exhibit asymmetric and nonasymmetric in the return series. Additionally, the findings show asymmetric response of return to positive and negative shocks. Therefore, the results point to the importance of applying an appropriately flexible modeling framework to accurately evaluate the interaction between exchange market and oil price. Furthermore, the results suggest that there is a risk transfer from oil prices to exchange rates. Overall, our analysis yields significant evidence of volatility spillovers from oil markets to exchange rate markets.

Our findings seem to be important to researchers and practitioners and especially to active investors and portfolio managers who include in their portfolios equities from the foreign exchange markets. Moreover, our findings lead to important implications from investors' and policy makers' perspective. They are of great relevance for financial decisions of international investors on managing their risk exposures to exchange rate and oil price fluctuations and on taking advantages of potential diversification opportunities that may arise due to lowered dependence among the exchange rates and crude oil.

Finally, taking into account the effect of oil price shocks on exchange rate, most MENA countries, namely the oil exporters, are called to further diversify their economies and not be limited to oil budget, in order to avoid any adverse effects of a significant drop in oil prices on their currencies and thus on their economic performance. Such diversification should be studied to also solve other economic problems in the MENA region, namely unemployment.

References.

Akerlof G., 1970. “The Market for Lemons: Quality Uncertainty and the Market Mechanism”, Quarterly Journal of Economics 84, 485-500

Akram, Q. Farooq., 2004. “Oil Prices and Exchange Rates: Norwegian Evidence.” The Econometrics Journal, 2004, 7(2) p476

Akram, Q.F., 2004. “Oil Prices and Exchange Rates: Norwegian Evidence.” The Econometrics Journal, Vol. 7, No. 2, 476-504

Akram, Q.F., 2009. “Commodity prices, interest rates and the dollar”. Energy Economics 31, 838-851.

Aloui, C. & Jammazi, R., 2015. "Dependence and risk assessment for oil prices and exchange rate portfolios: A wavelet based approach," Physica A: Statistical Mechanics and its Applications, Elsevier, vol. 436(C), pages 62-86.

Aloui, R., Ben Aıssa, M.S., Nguyen, D.K., 2013. “Conditional dependence structure between oil prices and exchange rates: A copula-GARCH approach”. Journal of International Money and Finance 32, 719-738.

Amano, Robert A. and Simon van Norden., 1998. “Exchange Rates and Oil Prices.” 5HYLHZ of International Economics, 6 (4)p. 683.

Aziz M I A., 2009. “Oil Price and Exchange Rate: A Comparative Study between Net Oil Exporting and Net Oil Importing Countries”. ESDS International Annual Conference 30th November, Institute of Materials, London.

Basher, S.A., Haug, A.A., Sadorsky, P., 2012, “Oil prices, exchange rates and emerging stock markets”. Energy Econ. 34, 227–240.

Basher, Syed A., Alfred, A. Haug, and Perry Sadorsky., 2010. “Oil Prices, Exchange Rates and Emerging Stock Markets”. University of Otago Economics Discussion Papers No. 1014, New Zealand

Bashir, U, Yu Y, Hussain M, Zebende GF, 2016. " Do foreign exchange and equity markets co-move in Latin American region? Detrended cross-correlation approach", Physica A 462, 889-897.

Beckmann, J., Czudaj, R., 2013. “Is there a homogeneous causality pattern between oil prices and currencies of oil importers and exporters?” Energy Economics 40, 665-678.

Bénassy-Quéré, A., Mignon, V., Penot, A., 2007. “China and the relationship between the oil price and the dollar”. Energy Policy 35, 5795–5805.

Benhmad, F., 2012. “Modeling nonlinear Granger causality between the oil price and U.S. dollar: a wavelet based approach”. Econ. Model. 29, 1505–1514

Brahmasrene, T., Huang, J. and Sissoko, Y., 2014. “Crude oil prices and exchange rates: causality, variance decomposition and impulse response”, Energy Economics, Vol. 44, pp.407–412

Buetzer S, Habib MM, Stracca L., 2012. “Global exchange rate configurations: Do oil shocks matter?” European Central Bank Working Paper No. 1442.

Carrion-i-Silvestre, J., & Sanso, A., 2006. "A guide to the computation of stationarity tests. Empirical Economics, 31(2), 433–448.

Chaudhuri, K, Daniel, B., 1998. “Long-run Equilibrium Real Exchange Rates and Oil Prices”. Economics Letters 58 (2), 231–238.

Chen, Y., Rangarajan, G., Feng, J., Ding, M., 2004. “Analyzing multiple nonlinear time series with extended Granger causality”. Physics Letters A, 324, 26–35.

Chen, S.S., Chen, H.C., 2007. “Oil prices and real exchange rates”. Energy Economics 29, 390-404.

Cooper, Ronald. “Changes in Exchange Rates and Oil Prices for Saudi Arabia and Other OPEC Members”, 1994, 20(1), p 109.

Cheung, Y.W. and L.K. Ng (1996), A causality in variance test and its application to financial market prices, Journal of Econometrics, 72, 33-48.

Da Silva, *et. al.* (2016), " Quantifying the contagion effect of the 2008 financial crisis between the G7 countries (by GDP nominal)", Physica A 453, 1-8.

Diks, C., Panchenko, V., 2006. “A new statistic and practical guidelines for nonparametric Granger causality testing”. Journal of Economic Dynamics & Control 30, 1647–1669.

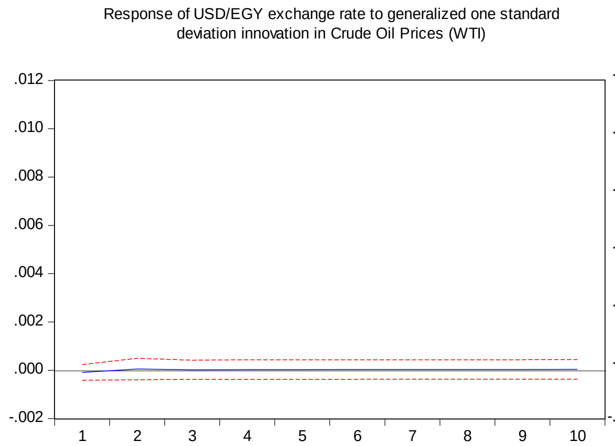
Drine, I. and Rault, C., 2006. "Testing for inflation convergence between the Euro Zone and its CEE partners", Applied Economics Letters, 13 (4), 235-240.
Drine I, and Rault C., 2005. "Can the Balassa–Samuelson effect explain long-run exchange rate movements in OECD countries". Applied Financial Economics 15:519–30.
Elliott, G., Rothemberg, T., & Stock, J. 1996. Efficient tests for an autoregressive unit root. Econometrica, 64(4), 813–839.
Ghosh, S., 2011. “Examining crude oil price – exchange rate nexus for India during the period of extreme oil price volatility”. Appl. Energy 88, 1886–1889
Golub, S., 1983. Oil prices and exchange rates. The Economic Journal 93, 576-593.
Granger, C.W., Yoon, G., 2002. “Hidden Cointegration”. Department of Economics Working Paper. University of California, San Diego.
Guedes E., Dionísio P.J., Ferreira, Zebende F, 2017. " DCCA cross-correlation in blue-chips companies: A view of the 2008 financial crisis in the Eurozone", Physica A 479, 38-47.
Hafner, C.M. and H. Herwartz, 2006, “A Lagrange multiplier test for causality in variance” , Economics letters, 93, 137-141.
Hamilton, J., 1983, “Oil and the macroeconomy since World War II”. Journal of Political
Hatemi-J, A. 2012. “Asymmetric causality tests with an application”, Empirical Economics, 43(1), 447-456.
Hatemi-J, A. 2014. “Asymmetric generalized impulse responses with an application in finance”. Economic Modelling, 36, 18–22.
Huang, Y., Guo, F., 2007. “The role of oil price shocks on China’s real exchange rate”. China Economic Review 18, 403-416.
Hussain M, Zebende GF, Bashir U, Donghong D, 2017,. " Oil price and exchange rate co-movements in Asian countries: Detrended cross-correlation approach", Physica A 465, 338-346.
Jammazi, R., & Lahiani, A., & Nguyen, D., 2015. "A wavelet-based nonlinear ARDL model for assessing the exchange rate pass-through to crude oil prices," Journal of International Financial Markets, Institutions and Money, Elsevier, vol. 34(C), pages 173-187.
Jawadi, F., & Louhichi, W., Ben Ameur, H., and Cheffou A. 2016. " On oil-US exchange rate volatility relationships: An intraday analysis " Economic Modelling, Elsevier, vol. 59, pages 329-334.
Jehle, Geoffrey, A, and Philip J. Reny., 2011. “Advanced Microeconomic Theory”, 3rd edition, London: Financial Times Prentice Hall.
Kin, S., & Courage, M., 2014. “The Impact of Oil Prices on the Exchange Rate in South Africa”. Journal of Economics, 5(2), 193-199.
Krugman, P., 1983. “Oil shocks and exchange rate dynamics”. In: Frenkel, J.A. (Ed.), Exchange Rates and International Macroeconomics. University of Chicago Press, Chicago.
Kwiatkowski, D., Phillips, P., Schmidt, P., & Shin, Y, 1992. "Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?". Journal of Econometrics, 54(1–3), 159–178.
Lizardo, R-A. and Mollick, A-V., 2010. “Oil price fluctuations and U.S. dollar exchange rates.” Energy Economics, 32, pp. 399-408.
McCown, T. A., Plantier, L. C., Weeks, J., 2006. “Petrodollars and global imbalances”. Occasional Paper. Department of the Treasury Office of International Affairs. Washington D.C.
Mendez-Carbajo D., 2010. “Energy dependence, oil prices and exchange rates: The Dominican economy since 1990”. Empirical Economics, 40(2): 509-520.
Nakatani, T., Teräsvirta, T., 2010. “An Alternative Test for Causality in Variance in the Conditional Correlation GARCH models”. mimeo, Stockholm School of Economics.
Nakajima T., Hamori S., 2012 “Causality-in-mean and causality-in-variance among electricity prices, crude oil prices, and yen–US dollar exchange rates in Japan”, Research in International Business and Finance, *26 (2012), pp: 371–386.*
Nikbakht, L., 2010. “Oil prices and exchange rates: the case of OPEC”. Bus. Intell. J. 3, 83–92.
Nkomo, J C. 2006. “The Impact of Higher Oil Prices on Southern African Countries”. Journal of Energy Research in Southern Africa, 17(1) pp. 10-17

Oriavwote, V.E., Eriemo, N.O., 2012. “Oil prices and the real exchange rate in Nigeria”. Int. J. Econ. Financ. 4, 198–205
Ozturk, I., Feridun, M. and Kalyoncu, H. 2008. “Do oil prices affect the USD/YTL exchange rate: Evidence from Turkey”. Economic Trends and Economic Policy, 115, 49- 61.
Raymond, J. E. and R. W. Rich 1997, “Oil and the macroeconomy: a Markov state-switching approach”, Journal of Money, Credit and Banking, 29, 193-213, erratum 29, 555.
Reboredo, J.C., 2012. “Modelling oil price and exchange rate co-movements”. Journal of Policy Modeling 34, 419 440.
Reboredo, J.C., Rivera-Castro, M.A., 2013. “A wavelet decomposition approach to crude oil price and exchange rate dependence”. Economic Modelling 32, 42-57.
Reboredo, J.C., Rivera-Castro, M.A., Zebende, G.F., 2014. “Oil and US dollar exchange rate dependence: A detrended crosscorrelation approach”. Energy Economics 42, 132-139.
Salisu, A. a., Mobolaji, H., 2013. “Modeling returns and volatility transmission between oil price and US-Nigeria exchange rate”. Energy Economics 39, 169-176.
Spence M., 1973. “Job Market Signalling”, Quarterly Journal of Economics 87, 355-374.
Stiglitz J., 1974. “Incentives and Risk Sharing in Sharecropping”, Review of Economic Studies 41, 219-255.
Sul, D., Phillips, P., Choi, C. 2005. “Prewhitening Bias in HAC Estimation”, Oxford Bulletin of Economics and Statistics, 67, pp.517-46.
Tiwari, Aviral K., Dar, A.B., Bhanja, N. 2013b. “Oil Price and Exchange Rates: A Wavelet Based Analysis for India.” Economic Modelling. 31(1), 414-422
Tiwari, Aviral K., Dar, A.B., Bhanja, N. and Shah, A. 2013a. “Stock Market Integration in Asian Countries: Evidence from Wavelet Multiple Correlations”. Journal of Economic Integration. Vol.28 (3). 441-456.
Turhan, I., Hacihasanoglu, E., Soytas, U. 2013, “Oil prices and emerging market exchange rates”. Emerging Markets Finance and Trade, 49(S1), 21-36.
Wu, C.-C., Chung, H., Chang, Y.-H., 2012. “The economic value of co-movement between oil price and exchange rate using copula-based GARCH models”. Energy Economics 34, 270-282.

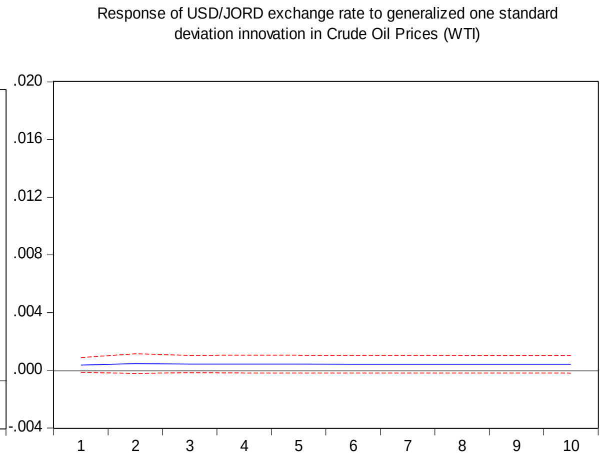
Appendix

Plots from asymmetric generalized impulse-response functions

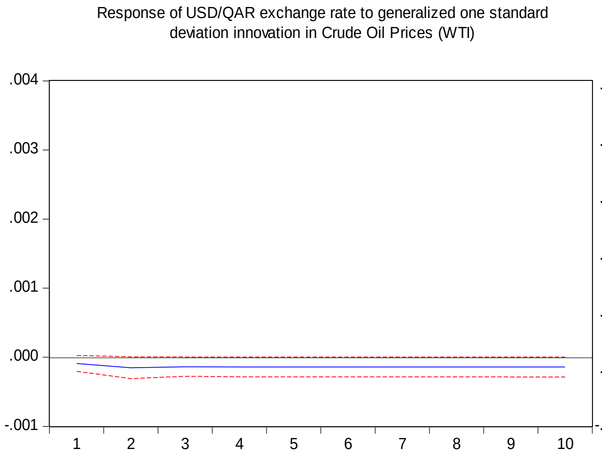
Figure 3. Impulse responses to a generalized standard deviation innovation in crude oil price: (positive value)



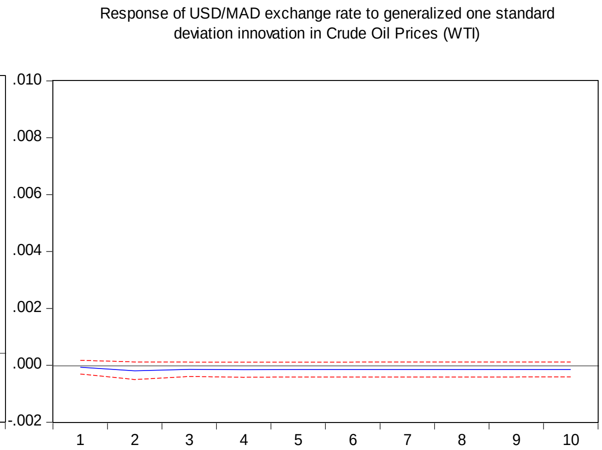
Egypt



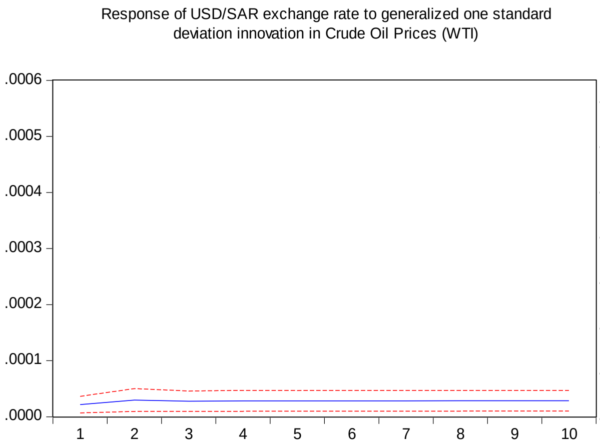
Jordan



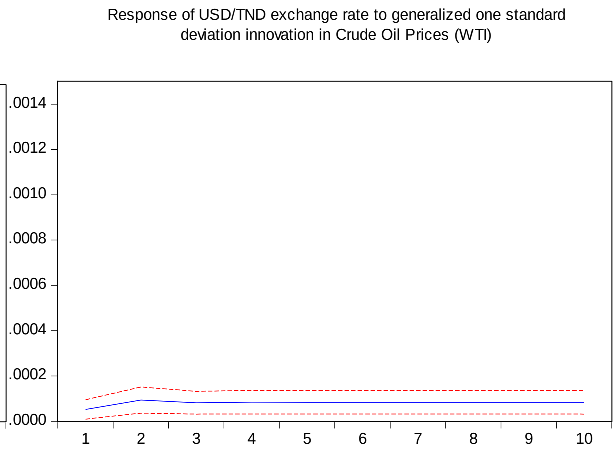
Qatar



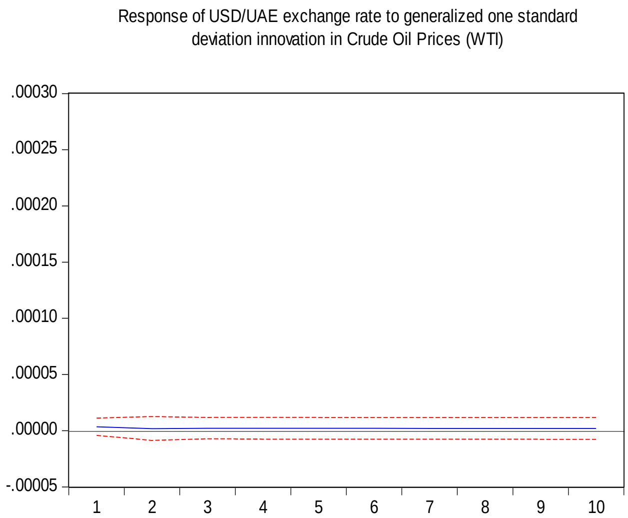
Morocco



Saudi Arabia

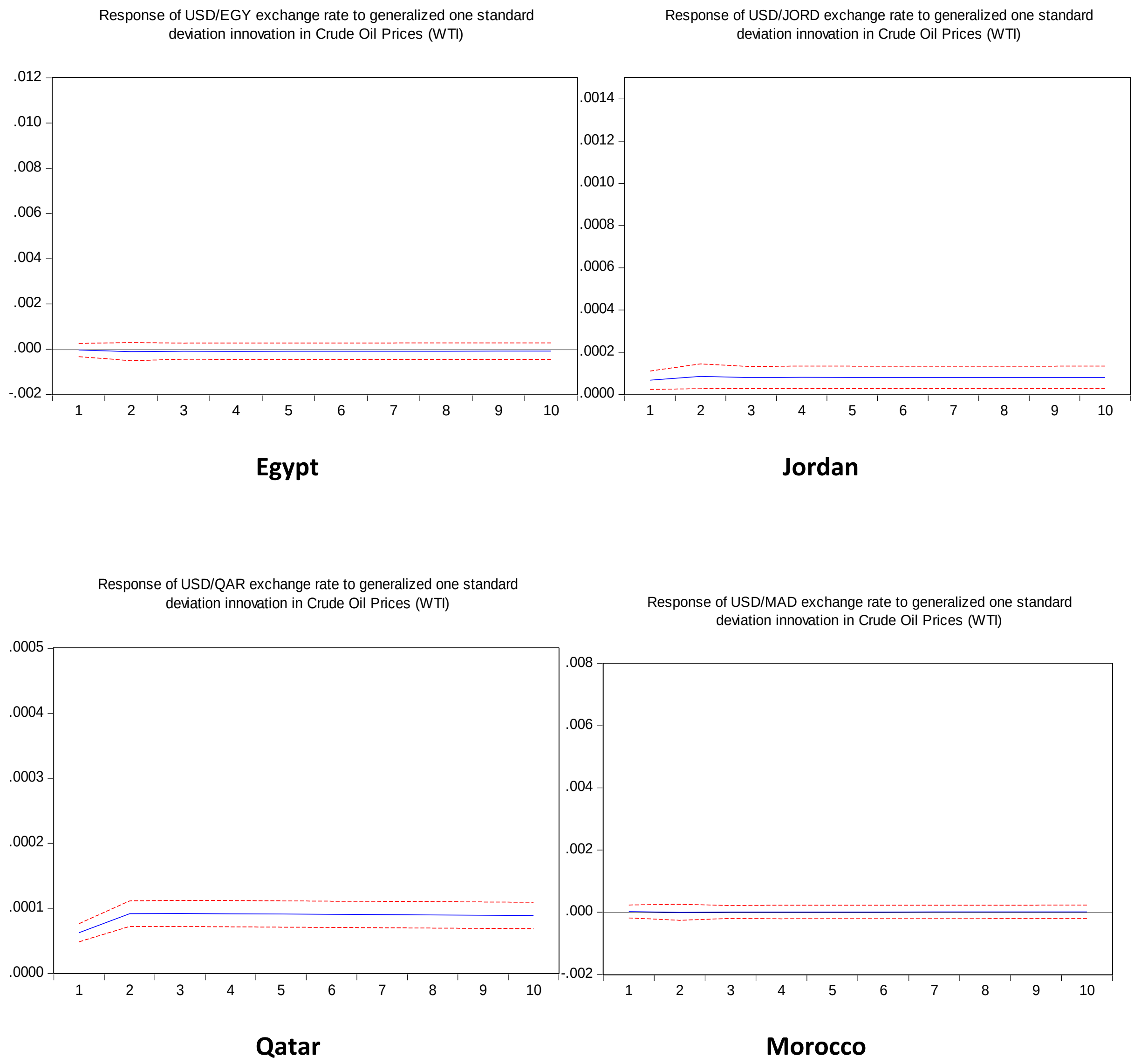


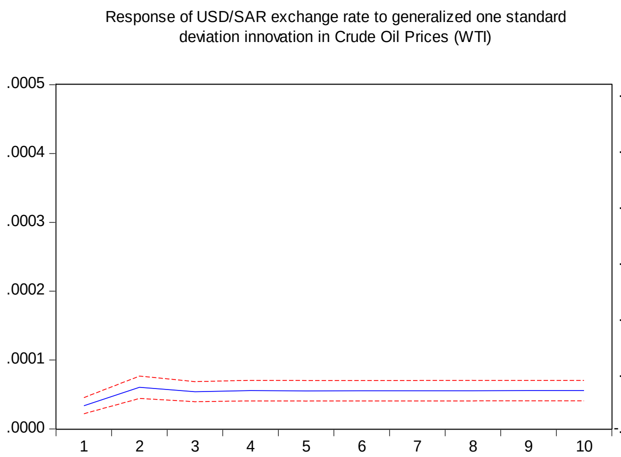
Tunisia



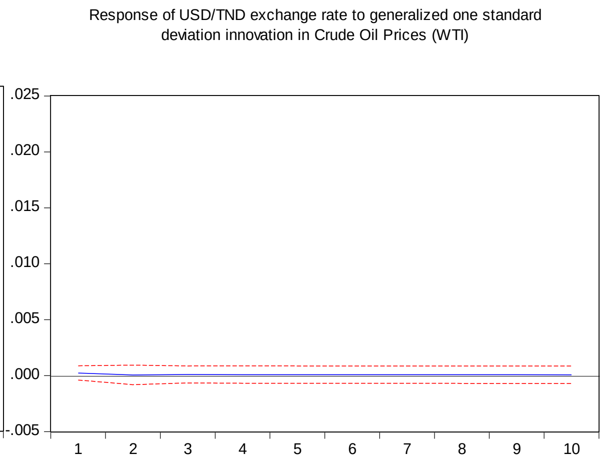
UAE

Figure 4 Impulse responses to a generalized standard deviation innovation in crude oil price (negative value)

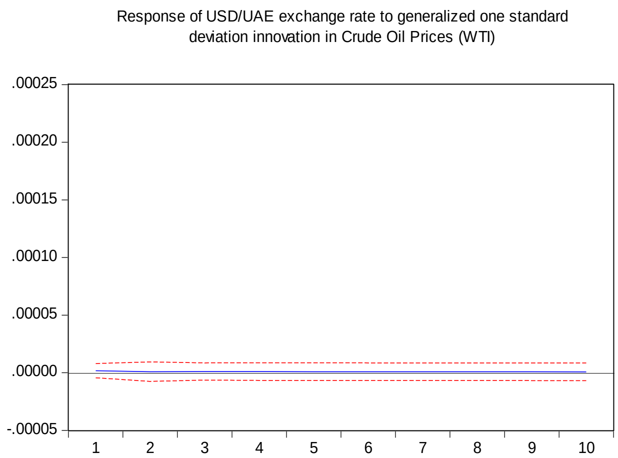




Saudi Arabia



Tunisia



UAE