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Another Look at the Interaction Between Oil Price Uncertainty and Exchange Rate Volatility: The Case of Small Open Economies

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Abstract: Several studies considered oil price as exchange rate determinants. The novelty of our paper is to test if the lagged oil price are statistically significant predictors of Moroccan and Tunisian exchange rate. We consider a stricter GARCH specifications (linear versus nonlinear, symmetric versus asymmetric, power versus level shift) to verify whether lagged rather contemporaneous oil price have a predictive content for future exchange rates. Our results show that the effects of shocks to oil price can immediately translate in changes in exchange rates and are short-lived in Morocco and long-lived in Tunisia. This linkage reacts more to good news than bad news in Morocco and conversely for Tunisian case. Additionally, establish an unstable interaction between the considered variables across all estimates with preponderance of the effect of switching regime effect (threshold and level shift).

Keywords: Oil price; exchange rate; volatility; GARCH specifications.

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1. Introduction

During the period from 1971 to 2009, the crude of oil has fluctuated widely. The demand and supply are the cause of these price increases. These high prices of petroleum products may lead to harmful consequences of such economy especially in the developing countries. Several studies have been developed using different specifications involving interaction of oil prices to the exchange rate.

This topic has a great interest in international economics and a special attention from academics. Of course, the attention given to the oil price uncertainty is due to the tensions which can have on exchange movements and then exchange policies. This means that an important discussion for the difficulty to identify whether oil prices are able to forecast the changes in exchange rate.

Several studies have considered that oil price uncertainty is a key determinant of exchange rate in short run like Narayan et al. (2008), Ghosh (2011), Zahid et al. (2011) and Mansor (2011). To verify this point, they built a new indicator replaces the simple change of oil prices in accordance with fluctuations in the exchange rate used the variance between the yield variation in crude prices and that of the real exchange rate. We standardized the unanticipated changes in real prices for the conditional variance of real exchange rate movements following a Generalized Autoregressive Conditional Heteroskedasticity process. This indicator serves to emphasize the role of oil price volatility in determining the volatility of real exchange rate. They found a negative and significant relationship between fluctuations in oil prices and the movements of their national currencies vis-à-vis the dollar.

From the review of theoretical works, we note that the flowing results in terms of the link between oil prices and real exchange rates tend to vary by country, model specifications and empirical approaches. It is also noted that despite the large number of studies on this subject and the different types of empirical methods that were used to study the dynamics of exchange rate variability following the evolution of oil prices (VAR models and conditional variance models), there's still analytical gaps especially methodological.

It is also noteworthy that most of these studies have been made to the Canadian economy, Nigerian (Olomola and Adejumo, 2006) and to our knowledge no empirical study has treated the case of Morocco or Tunisia. These countries can be also vulnerable to oil price shocks, especially because Morocco's energy dependence is met by a large volume of imports. Indeed, for Tunisia, the volume of imports and exports are almost equal with difference of 0.1 (Bouoiyour and Selmi, 2012).

Furthermore, the novelty of our study is to test whether the lagged oil price can be described as predictors of exchange rates movements, i.e. the exchange rate should reflect fluctuations in oil price. We note also that we thought not to include other determinants of exchange rate in the considered models because the predictive ability disappears if we use other economic fundamentals (Ferraro et al., 2011).

In this study, we try to make explanation of an interesting topic which is the response of exchange rate after a shock in oil price. This paper will offer a new perspective on the effect of oil price uncertainty on changes in exchange rate in small open economies.

Hence, the remainder of this paper proceeds as follows: Section 2 is a roadmap of the paper. Section 3 describes the data sets that we use to evaluate the linkage between oil price uncertainty and exchange rate volatility. Section 4 presents our empirical results in terms of forecasting performance for Morocco and Tunisia. The last section concludes our paper.

2. Roadmap for the paper: Can lagged oil price forecast changes in exchange rate?

In this study, we consider a stricter specifications to verify whether lagged rather than contemporaneous oil price have predictive content for future exchange rate volatility. More precisely, the main objective of this paper is to test the linkage between oil price uncertainty and exchange rate volatility in terms of forecasting performance. More precisely, we investigate whether oil price shocks have a stable interaction with Moroccan and Tunisian exchange rates using GARCH specifications taking into account several effects (symmetric versus asymmetric, linear versus nonlinear, power versus level shift).

2.1. Linear versus nonlinear

This interaction between oil prices and real exchange rate implies that this link is linear after the first oil shock (Hamilton, 1983). So, we have not a threshold at which the real exchange rate will react differently to price per barrel. Indeed, to explain the nonlinear effect in the relationship between oil prices and the exchange rate, Raymond and Rish (1997) conducted a model with Markov switching regime to evaluate and compare the impact of trends in rising and falling oil prices on fluctuations of U.S. economic aggregate before and after the world war applying the model chosen on two sub-periods. In our study, the nonlinear effect in the linkage between oil prices and exchange rate can be explained by distinguishing between the effect of the increases and decreases in oil prices and the exchange rate using GARCH model.

2.2. Symmetric versus asymmetric

The direct link between oil prices and the exchange rate after the oil shock of 1973 was described as symmetrical. But, the against oil shock 1979 is an innovation that can dramatically change the relationship. However, monetary policy can contribute to the asymmetry of the relationship. To the extent that exchange rate policy responds asymmetrically to changes in oil prices, monetary policy can itself demonstrate asymmetry vis-à-vis oil prices as one of its main determinants are the exchange rate. In this context, Loreillet (2010) argues that “the monetary authorities tend to opt for a restrictive policy in case of rising prices. However, it is more reluctant to be accommodative at lower prices. This reality highlights the phenomenon of asymmetry”.

2.3. Power versus level shift

The level shift and the power effects describe the impact of trends in rising and falling oil prices on fluctuations of exchange rate before and after each sub-period. Using these effects, we can analyze a broader class of transformations of the linkage between these two series. Therefore, Brooks et al. (2000) stated that “absolute changes in an asset’s price will exhibit volatility clustering and the inclusion of a power term acts so as to emphasize the periods of relative tranquility and volatility by magnifying the outliers”. In the same context, Lucey and Tully (2006) announced that the models with power effect are not always desirable. Despite this, there is a question whether the power effect in forecasting exchange rate by the level of oil price is more desirable than the level shift.

3. Data and methodology

We focus on two small open economies, namely Morocco and Tunisia, to investigate whether lagged changes in oil prices interact significantly with changes in exchange rate. To do this, we estimate several GARCH specifications taking into account various effects: linear versus nonlinear, symmetrical versus asymmetrical and power versus level shift. We use data across the period from second quarter 1972 to fourth quarter 2010. The data of oil prices are the spot price of oil collected from Energy Information Administration (EIA) of the United States. For the real exchange rates, the data are from the Econstats and the International Monetary Fund (IMF).

As the object of our work is which effects (symmetrical, asymmetrical, linear, nonlinear, power or level shift) that can affect more the pass through of oil price shocks on changes of exchange rate in terms of forecasting performance, we start by a descriptive analysis of the evolution of returns of exchange rate and the lagged return of oil price in

Morocco and Tunisia. Figure 1 allows highlighting the first correlations between these two series that will interest us throughout this study. We clearly observe a large and permanent volatility for oil prices and exchange rates. To estimate the short-run relationship between these two latter, we would use the returns of exchange rate in real terms are denoted r_{RER_t} while the lagged return of oil prices is denoted $r_{OIL_{t-1}}$.

$$r_{RER_t} = \text{Log}(RER_t) - \text{Log}(RER_{t-1}) \quad (1)$$

$$r_{OIL_{t-1}} = \text{Log}(OIL_{t-1}) - \text{Log}(OIL_{t-2}) \quad (2)$$

To examine the linkage between exchange rate return and lagged oil price return, we rely on models from the study of Mansor (2011). First, we start by a linear link which is written as follows:

$$r_{RER_t} = \alpha + \beta r_{OIL_{t-1}} + \mu_t \quad (3)$$

We argued below that this link can be linear and symmetrical. Among the models that take into account the symmetrical and linear effects are those that were introduced by Engle (1982) and Bollerslev (1986). These models do not include a cyclic behavior, sudden shocks and asymmetric volatility series. We can say that these specifications are restrictive. The most popular linear and symmetrical model in the economic and financial literature is the standard GARCH introduced by Bollerslev in 1986. This latter can be written as follows:

$$\sigma_t^2 = \omega + \sum_{i=1}^q \alpha_i \mu_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 \quad (4)$$

Where ω : the reaction of shock, α : ARCH term, β : GARCH term, μ : normal innovation.

The power effect is also a symmetrical GARCH extension advanced by Ding, Granger and Engle (1993) but this model is nonlinear which analyze a broader class of transformations. It can be written as follows:

$$\sigma_t^\varphi = \omega + \sum_{i=1}^q \alpha_i |\mu_{t-i}|^\varphi + \sum_{j=1}^p \beta_j \sigma_{t-j}^\varphi \quad (5)$$

Where ω : the reaction of shock, μ : normal innovation, γ : leverage effect, φ : power parameter.

Moreover, this relationship can be nonlinear reflecting the existence of regimes in which the real exchange rate will react differently to changes in oil prices. Various specifications can describe the asymmetrical and switching regime effects, more precisely, the behavior of the conditional variance based on good or bad news.

Among these models, we can advance the Exponential GARCH initiated by Nelson (1991), expressed as follows:

$$\log(\sigma_t^2) = \omega + \alpha_1 \left| \frac{\mu_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\mu_{t-1}}{\sigma_{t-1}} + \beta_1 \log(\sigma_{t-1}^2) \quad (6)$$

Where ω : the reaction of shock, α : ARCH term, β : GARCH term, γ : leverage effect.

Then, we can add the models with threshold effect which are piecewise linear models that describe the reaction of conditional variance after any shock or after structural breakpoints. Among these models, we can specify the T- GARCH model initiated by Zakoin (1994) expressed as follows:

$$\sigma_t^2 = \omega + \sum_{i=1}^q (\alpha_i |\mu_{t-i}| + \gamma_i |\mu_{t-i}^+|) + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 \quad (7)$$

Where μ : normal innovation, μ^+ : innovation after positive shock, γ : leverage effect.

The nonlinear effect or switching regime can also be measured using models with level shift which are characterized by a volatility process containing jumps introduced by Duan (1995).

$$\sigma_t^\varphi = \omega + \sum_{i=1}^q \alpha_i (\mu_{t-i} - \kappa_i)^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^\varphi \quad (8)$$

Where ω : the reaction of shock, γ : leverage effect, φ : power parameter, κ : level shift.

Our finding is to make explanation of the main question of this work “Can lagged oil prices forecast exchange rate?”. The following section focuses on regression where realized oil price is used to predict the exchange rate variability.

4. Application and results

The recent debate on the question of whether oil price can have symmetric, asymmetric, linear, nonlinear, power and level shift effects on the exchange rate motivates us to consider such models able to capture these various effects in our forecasting experiment.

Before estimating the linkage between lagged return of oil price ($r_{OIL,t-1}$) and real exchange rate returns ($r_{RER,t}$), we begin by examining the descriptive statistics of the two series. From Table 1, it is clear that the Jarque-Bera test rejects the null hypothesis of a normal distribution for the normal distribution of the returns of exchange rate and of oil prices for Morocco and Tunisia. Returns of exchange rates and oil prices show a negative

asymmetry for both countries, thus admitting a symmetric distribution. Kurtosis is greater than 3 indicating that the distribution of each series is flatter than the Gaussian distribution.

Then and as our main goal in this work is to compare the performance of forecasting ability of various specifications taking into account symmetric versus asymmetric and linear versus nonlinear affects and evaluate whether forecast instabilities are important between exchange rate and oil price.

Table 2 summarizes the results from estimates the GARCH extensions (Standard GARCH, Exponential GARCH (E-GARCH), Threshold GARCH (T-GARCH), Power GARCH (P-GARCH) and Nonlinear GARCH with level shift (NGARCHK)) indicating successively the linear and symmetric, asymmetric, nonlinear, power and level shift effects to compare its impact on the relationship between oil prices and the exchange rate in terms of forecasting performance. It is clear from these results that the price of oil has a statistically significant impact on the exchange rate across all estimates except for linear and symmetric effect (standard GARCH), which has an insignificant impact. This is necessarily due to the diversity of oil shocks across the considered period from 1972 to 2010 (first petroleum shock in 1973, second petroleum shock in 1976 and Asian crisis in 1997etc...).

This effect is negative, i.e. an increase of lagged changes in oil price leads to a decrease of changes in exchange rate. This result can be explained, according to Bouoiyour and Selmi (2012), by three ways of explanation: First, higher oil prices reduce the amount of income that consumers have left to spend on other goods and services, and increase then the cost of oil importing countries. Second, increasing oil prices are often indicative of inflationary pressures. However, in our case, central banks of Morocco and Tunisia try to control the inflation by increasing interest rate which also directly impact the discount rate and then decrease share prices. Third, the price of oil is determined by the level of demand and that of supply. Hence, an increase in oil demand by importers without largest reserves can lead to much higher future oil prices (Henriques and Sadorsky, 2008). So, to meet their growing needs of energy, these countries face constraints from oil supply side.

We should also add that the leverage effect (Y) is positive in Morocco and negative in Tunisia, which would imply that the effect of good news is more intense than the bad news in Tunisia. However, the linkage between lagged oil price changes and exchange rate return reacts more to good news than bad news in Morocco.

Therefore, the forecasting model which links the lagged oil price return to exchange rate return outperform the switching regime effect, especially threshold and level shift effects. Hence, we notice a preponderance of the level shift effect on the interaction linking the two

series. Figure 2 confirms these latter results for the different GARCH models used to capture the response of exchange rate to the lagged oil price changes in the short run. We show that across all considered effects, the persistence of conditional volatility linked oil price to exchange rate is more important in Tunisia than Morocco. In Tunisia, we find a long memory process in conditional variance, especially for the level shift case which is able to capture more the structural breakpoints (Bullent, 2009).

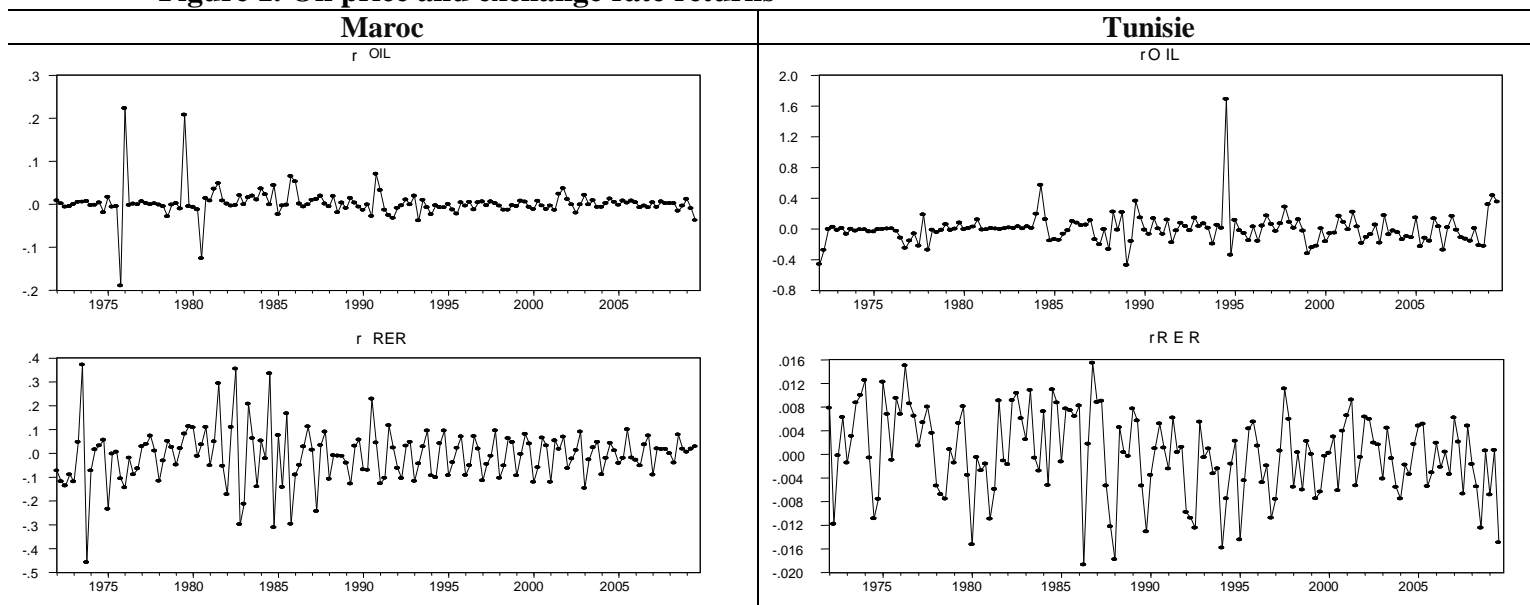
Briefly, we forecast the existence of significant linkage between lagged oil price and changes in exchange rate which is not strong across several GARCH specifications taking into account various effects, especially using the models able to capture the structural breaks in the process of volatility. We establish also a short-lived interaction between the two series in question in Morocco and long-lived link in Tunisia.

5. Conclusion

In this paper, we try to identify the predictive power of lagged oil price on changes in exchange rate. The standardly drawn implications are that (i) the exchange rate should reflect the contemporaneous fluctuations in oil prices (Bouoiyour and Selmi, 2012); (ii) the lagged oil prices are significant predictors of exchange rates (Ferraro et al., 2011). In this study, we try to verify if the latter hypothesis is true and if the contemporaneous or lagged changes in oil price affect more or less the exchange rate variability.

Hence, our goal is to compare the forecasting ability of models with symmetric, asymmetric, linear, nonlinear, power and level shift effects and evaluate whether forecast instabilities are important in terms of the linkage between lagged oil price and returns of exchange rate. Moreover, the forecasting models used outperform the specifications with threshold and the level shift effects. Regarding to other effects (symmetric, linear and power), the evidence is not very clear. Furthermore and comparing our results to those of the study of Bouoiyour and Selmi (2012), we verify that in Morocco and Tunisia, lagged rather than contemporaneous oil price have a predictive content for future exchange rates. We establish an unstable interaction between the considered variables across all estimates which is short-lived in Morocco and long-lived in Tunisia.

Figure 1. Oil price and exchange rate returns



Source: IMF and Econstats.

Table 1. Descriptive statistics

	Morocco		Tunisia	
	r_{RER_t}	$r_{OIL_{t-1}}$	r_{RER_t}	$r_{OIL_{t-1}}$
Mean	0.002108	-0.009578	0.000154	-0.016411
Median	-0.000911	0.005325	0.000302	-0.007197
Maximum	0.223285	0.371892	0.015442	1.801679
Minimum	-0.189833	-0.457978	-0.018702	-1.950234
Std. Dev.	0.035028	0.113403	0.007059	0.262951
Skewness	-0.718556	-0.037817	-0.271471	-0.391274
Kurtosis	26.22971	5.875501	12.757867	35.04450
Jarque-Bera	52.05869	3469.433	31.0155	6550.074

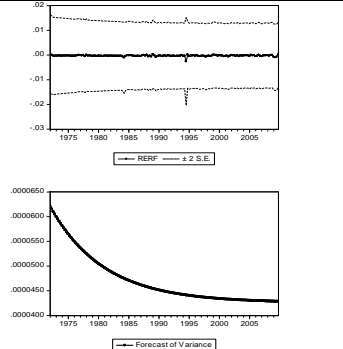
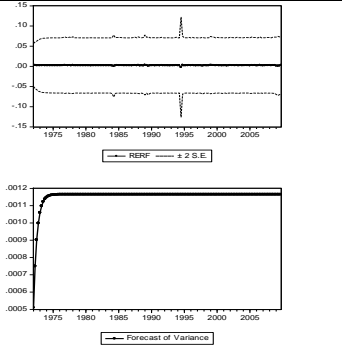
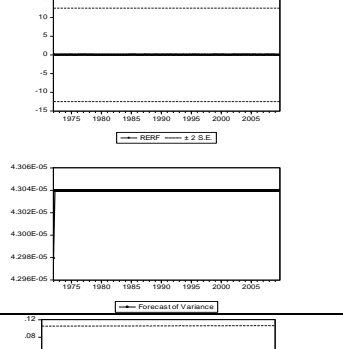
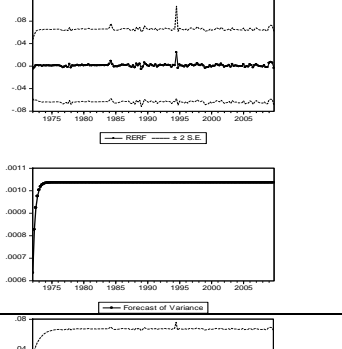
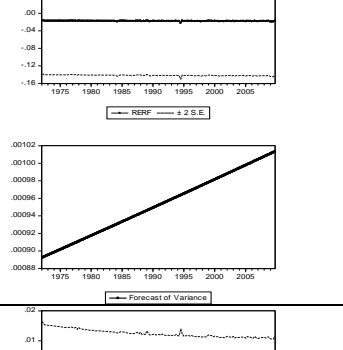
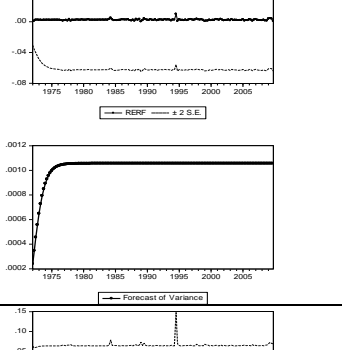
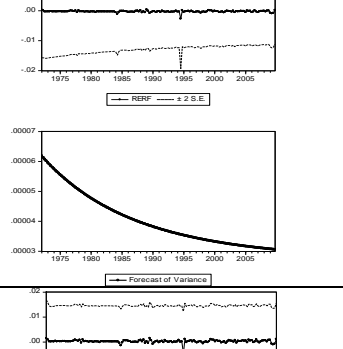
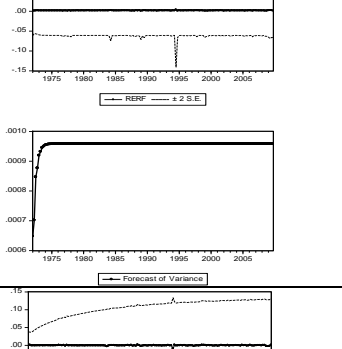
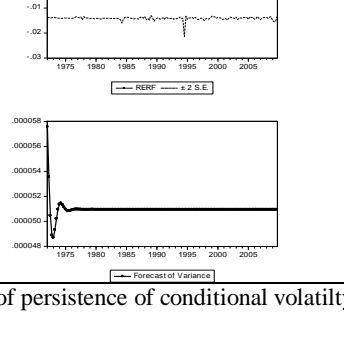
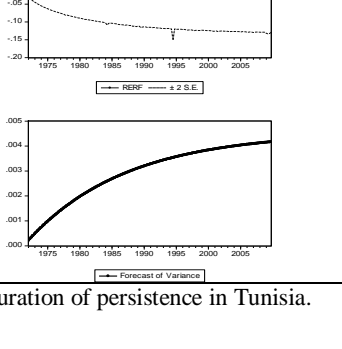
Note: r_{RER_t} : return of real exchange rate ; $r_{OIL_{t-1}}$: lagged return of oil price.

Table2. Parameters of estimates: GARCH extensions

	Morocco					Tunisia				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>Mean equation</i>										
<i>C</i>	-0.0004* (-0.5984)	-0.0002* (-0.6368)	-0.7932*** (-8.2231)	0.0024*** (3.2120)	-0.0003 (-0.6335)	-0.00* (-1.60)	-0.0003* (-1.202)	-0.000 (-0.65)	-0.000 (-0.5)	0.0651 (0.52)
<i>r_{oil}</i>	-0.13E06 (-1.3852)	-0.0010* (-1.3243)	-0.0024* (-1.1184)	-0.0011* (-1.4646)	-0.0015* (-1.3261)	-8E05 (-0.0257)	-0.002* (-1.091)	-0.003* (-1.10)	-0.003* (-1.5)	-0.003* (-1.305)
<i>Variance equation</i>										
<i>w</i>	1.18E-06 (0.5068)	-0.1137*** (-3.7207)	1.93E-05* (3.2155)	0.0799* (1.7688)	4.96E-07 (0.3444)	9.15E-07 (0.4601)	-0.0169 (-0.7142)	4.05E-07 (0.5807)	-5.6E-05 (-0.4470)	-10.08E-04 (-0.3522)
<i>α</i>	0.0406 (0.8149)	-0.0718** (-2.8839)	-0.7976*** (-8.4554)	0.3925*** (3.3753)	-0.0410* (-1.1547)	0.0356 (0.7758)	-0.0994*** (-3.4841)	-0.0603 (-0.0046)	-0.0261 (-0.4184)	-0.0031 (-0.4944)
<i>β</i>	0.431*** (10.741)	0.6835*** (6.1749)	1.1999*** (3.1031)	0.3072** (2.2289)	0.7024* (1.2101)	0.541*** (11.950)	0.7913*** (4.9116)	0.907*** (17.314)	0.819*** (22.778)	-0.0094* (-1.4452)
<i>γ</i>	-	0.0440** (2.8756)	3.12E-05* (2.8477)	-	0.0253 (0.0933)	-	0.0478*** (11.5686)	-0.0433 (-0.9233)	-	-0.0070 (-0.5336)
<i>κ</i>	-	-	-	-	0.0074 (0.9839)	-	-	-	-	0.0058 (0.0674)

Note: Standard deviations are in parentheses, ***, **, *: significant at 1%, 5%, 10%; For detailed analysis of GARCH specifications, see Bouoiyour et al. (2012); (1): estimates of GARCH model for Moroccan case; (2): estimates of E-GARCH model for Moroccan case; (3): estimates of P-GARCH for Moroccan case; (4): Estimates of T-GARCH for Moroccan case; (5): Estimates of NGARCHK for Moroccan case; (6): estimates of GARCH model for Tunisian case; (7): estimates of E-GARCH model for Tunisian case; (8): estimates of P-GARCH for Tunisian case; (9): Estimates of T-GARCH for Tunisian case; (10): Estimates of NGARCHK for Tunisian case.

Figure 2. Response of exchange rate to lagged oil price changes

	Morocco	Tunisia
<p>GARCH :</p> $\psi_M = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j = 0.47$ $\psi_T = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j = 0.58$	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.007004 Mean Absolute Error 0.005620 Mean Abs. Percent Error 99.91888 Theil Inequality Coefficient 0.941808 Bias Proportion 0.003041 Variance Proportion 0.922488 Covariance Proportion 0.074471</p>	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.034808 Mean Absolute Error 0.015800 Mean Abs. Percent Error 123.0713 Theil Inequality Coefficient 0.934160 Bias Proportion 0.000017 Variance Proportion 0.970157 Covariance Proportion 0.023625</p>
<p>E-GARCH:</p> $\psi_M = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j + \gamma = 0.52$ $\psi_T = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j + \gamma = 0.70$	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.006987 Mean Absolute Error 0.005597 Mean Abs. Percent Error 96.92334 Theil Inequality Coefficient 0.948896 Bias Proportion 0.000091 Variance Proportion 0.903896 Covariance Proportion 0.096022</p>	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.034974 Mean Absolute Error 0.016908 Mean Abs. Percent Error 116.4420 Theil Inequality Coefficient 0.922819 Bias Proportion 0.001118 Variance Proportion 0.835152 Covariance Proportion 0.163690</p>
<p>P-GARCH :</p> $\psi_M = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j = 0.50$ $\psi_T = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j = 0.79$	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.019249 Mean Absolute Error 0.017970 Mean Abs. Percent Error 952.3803 Theil Inequality Coefficient 0.772607 Bias Proportion 0.869921 Variance Proportion 0.112270 Covariance Proportion 0.017809</p>	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.034832 Mean Absolute Error 0.015878 Mean Abs. Percent Error 122.6440 Theil Inequality Coefficient 0.930152 Bias Proportion 0.000037 Variance Proportion 0.945588 Covariance Proportion 0.054378</p>
<p>T-GARCH :</p> $\psi_M = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j + \gamma = 0.55$ $\psi_T = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j + \gamma = 0.84$	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.007001 Mean Absolute Error 0.005616 Mean Abs. Percent Error 98.98670 Theil Inequality Coefficient 0.945439 Bias Proportion 0.002248 Variance Proportion 0.919831 Covariance Proportion 0.077921</p>	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.034817 Mean Absolute Error 0.015684 Mean Abs. Percent Error 110.8784 Theil Inequality Coefficient 0.954287 Bias Proportion 0.000288 Variance Proportion 0.985819 Covariance Proportion 0.013882</p>
<p>NGARCHK :</p> $\psi_M = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j + \gamma = 0.66$ $\psi_T = \sum_{i=1}^q \alpha_i + \sum_{j=1}^p \beta_j + \gamma = 0.98$	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.006998 Mean Absolute Error 0.005622 Mean Abs. Percent Error 102.3601 Theil Inequality Coefficient 0.917775 Bias Proportion 0.000701 Variance Proportion 0.842981 Covariance Proportion 0.156318</p>	 <p>Forecast: RER Actual: RER Forecast sample: 1972Q1 2009Q4 Included observations: 152 Root Mean Squared Error 0.034915 Mean Absolute Error 0.015507 Mean Abs. Percent Error 98.09979 Theil Inequality Coefficient 0.969938 Bias Proportion 0.005789 Variance Proportion 0.936913 Covariance Proportion 0.057298</p>

Note: ψ_M : the duration of persistence of conditional volatility in Morocco; ψ_T : the duration of persistence in Tunisia.

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